GREEN IUPAC 2026

September 8-12
Lisbon, Portugal

11th IUPAC International Conference on Green Chemistry

Book of Abstracts

IUPAC

Sociedade Portuguesa de Química

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

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https://www.greeniupac2026.org/

Lectures and Oral Communications

Day 1, Tuesday, September 8 | Rectorate of NOVA University of Lisbon

14:00 – 16:05	**Registration**	
16:05 – 17:10	**Welcome Reception**	Room: Rectorate Hall
17:10 – 19:00	**Opening Ceremony**	Moderator: Ana Aguiar-Ricardo

Green Chemistry: Science for Peace and Sustainability

Round Table: Paul Anastas, Mary Garson, Buxing Han, Javier García Martínez, Martyn Poliakoff, Omar M. Yaghi

Day 2, Wednesday, September 9

8:00 – 8:30	**Registration**	Room: Rectorate Hall
8:30 – 9:15	**Plenary Lecture - PL 1**	Room: Rectorate Auditorium (Aud A/B)

Omar M. Yaghi
From Scarcity to Abundance

Chair: Paul Anastas

9:30 – 10:30		Room: Rectorate Auditorium (Aud A/B)

Topic: AI in Green Chemistry — Chair: Kjell Jorner

KN1 **Plasma Chemistry: Promising Tool for Electrifying Chemical Reactions**
Annemie Bogaerts

OC1 **Deep Eutectic Solvents for a Sustainable Chemical Future: From Molecular Design to Industrial Applications**
Sergio de la Huerta, María A. Escobedo, Alberto Gutiérrez, Valentín Diez, Sara Santamaria, Alba Pérez, Alberto Gutiérrez, Pedro A. Marcos, Alfredo Bol, S. Aparicio

OC2 **Earth-Abundant Aluminum Formate (Alf) as a Sustainable Decarbonization Solution: A Multiscale Computational Study using DFT, MD and MC Simulations**
F. Malik, H. Naaz

9:30 – 10:30		Room: School of Law - Amphitheatre A

Topic: Green Synthesis, Catalysis & Green Solvents — Chair: Aurelia Visa

KN2 **Artificial Photosynthesis Mediated by Ionic Liquids**
Jairton Dupont

OC3 **A Greener Path to Syngas by RWGS with Imidazolium-Based Ionic Liquids as Recyclable Reaction Media**
P. H. García-Ríos, S. Koranchalil, M. Nielsen, A. Riisager

OC4 **NADES as Sustainable Extraction Media for Environmental Samples**
M. Rodrigues, J. Vrouwenvelder, Geert-Jan Witkamp, Susana Carvalho, Andreia Farinha

9:30 – 10:30 Room: School of Law - Room 3

Topic: Green Chemical Engineering & Technology Chair: José Nuno Canongia Lopes

KN3 **Sustainable Water Treatment in Healthcare: Green Chemistry for Gadolinium Remediation using Magnetic Nanoparticles**
E. Pereira, D. Tavares, J. Sousa, R. Freitas, B. Henriques, T. Trindade, R. Fernandes, J. Rocha

OC5 **Efficient Mineralization of Fluoropolymers using Subcritical Water**
H. Hori, J. Hamaura, H. Saito, A. Manseri, B. Ameduri

OC6 **Eco-Friendly Nanocellulose Modification Enhances Biobased Unsaturated Polyester Resin Performance**
O. Pantić, P. Spasojević, V. Panić, M. Marković, V. Pavlović, M. Nikolić, S. Savić

9:30 – 10:30 Room: School of Law - Room 5

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Giovanni Polli

KN4 **Green Design of Bio-Based Platform Chemicals via Organic Carbonate**
F. Aricò

OC7 **WO_3/SO_3H-C Catalysts for 5-HMF One-Pot Production**
A. Tonelli, S. Hermans

OC8 **Tunable Ruthenium Catalysts for Hydrogen Production from Formic Acid: Governing Reactivity through Ligand Architecture**
C. Joseph, J. Edor, R. Mphephu, T. Mphuti, P. Moyo, A. Swarts

9:30 – 10:30 Room: School of Law - Room 7

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Michael George

KN5 **Green Synthesis of Porous Materials and Their Application in Gold Recovery**
Li Peng

OC9 **Colloidal Synthesis of Photocatalytic Quantum Dots Heterostructure**
Dechao Chen, Qin Li

OC10 **Green Synthesis of Bio-Based Co-Polymers for Food Packaging Applications**
M. Pacheco-Romeralo, Y. Flores, E. Hernández-Martínez, A. Martínez de Ilarduya, C. Sammon, S. Torres-Giner

9:30 – 10:30 Room: School of Law - Room 123

Topic: Green Energy Chair: Isabel Marrucho

KN6 **Synthesis, Structural Variations, and Solar Water Splitting Performance of Tantalum Oxynitride**
M. Hojamberdiev

OC11 **From Castor Oil to Sodium-Ion Batteries: Sustainable PA11-Based Hybrid Membranes for Energy Storage**
A. Mirandona-Olaeta, A. Fidalgo-Marijuan, I. Ruiz de Larramendi

OC12 **Electropolymerized Donor–Acceptor Polymer Films for Porous Energy Materials**
A. Palma-Cando, F. Niebisch, I. Rendón-Enríquez, G. Brunklaus, K. Brinkmann, T. Riedl, U. Scherf

10:30 – 11:00 **Coffee Break** Room: Rectorate Hall

11:00 – 11:45 **Plenary Lecture - PL 2** Room: Rectorate Auditorium (Aud A/B)

Qin Li Chair: Buxing Han
Sustainable Quantum Materials through the Lens of Carbon Dots

12:00 – 12:30 Room: Rectorate Auditorium (Aud A/B)

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Yanfei Zhao

OC13 **Greener and Regioselective Strategies for the Functionalization of Cellulose into Dicarboxymethyl Derivatives**
J. Bernardino, L.M. Ferreira, R. Chagas

OC14 **Mild Chemical Recycling of PLA: Hydrolytic Depolymerisation Enabled by Metal Carbonates**
F. Buco, C. Moreno-Marrodàn, F. Brandi, L. de Chiara, F. Real-Fernandez, F. Liguori and P. Barbaro

12:00 – 12:30 Room: School of Law - Amphitheatre A

Topic: Green Chemical Engineering & Technology Chair: Rui Loureiro

OC15 **Selective Biosorption of Yttrium and Europium from Mercury-Contaminated Water using Encapsulated Macroalgae**
Thiago Silva, Thainara Viana, Nicole Ferreira, Eduarda Pereira, Gil Gonçalves, Bruno Henriques

OC16 **Sustainable Olefin Metathesis using Spectroscopic Monitoring and Organic Solvent Nanofiltration**
S. Tela, A. Szymczyk, J. G. Crespo, C. A. M. Portugal

12:00 – 12:30 Room: School of Law - Room 3

Topic: Green Chemical Engineering & Technology Chair: Ana Luisa Fernando

OC17 **Adenosine Monophosphate as a Versatile Biomolecular Tool for Greener Synthesis of Plasmonic Nanomaterials**
J. Fernández-Lodeiro, A. Fernández-Lodeiro, C. Fernández-Lodeiro, J. Pérez-Juste, I. Pastoriza-Santos, S. Graña, T. Fernández-Cabada, S. Tanco, F. Novio, Julia Lorenzo, C. Lodeiro

OC18 **Integrated Biomass Mapping for Wildfire Prevention and Sustainable Bio-Oil Conversion**
Ana R.P. Gonçalves, Rui Galhano Dos Santos, Gabriel Goyanes, Vasco Miranda, Manuel Ribeiro

12:00 – 12:30 Room: School of Law - Room 5

Topic: Carbon Dioxide Utilization Chair: Ana Nunes

OC19 **Catalytic Valorization of Carbon Dioxide – New Pathways Towards Sustainability**
A. Proszowska, P. Rybowicz, Y. Vitushynska, T. Polczyk, A. Łamacz, A. Adamski

OC20 **Simultaneous Waste Remediation and Carbon Capture Via CO_2 Mineralization Over Industrial Basic Wastes**
A. Allegri, A. Catalano, A. de Angelis, E. Roccaro, M. C. Bignozzi, S. Albonetti

12:00 – 12:30 Room: School of Law - Room 7

Topic: Green Energy Chair: José Esperança

OC21 **Green Binder-Solvent Systems for Iron Prussian Blue Anodes in Aqueous Sodium-Ion Batteries**
N. Nieto, M. Gonzalez, I. Irizar, M. Navarro-Segarra, V. Palomares, J.P. Esquivel

OC22 **Non Thermal Plasma Assisted Catalytic CO_2 Valorisation to Methanol**
M. Khatibi, A. Osatiashtiani, P. T. Williams

12:00 – 12:30 Room: School of Law - Room 123

Topic: Green Chemical Education Chair: Amy Cannon

OC23 **Engaging High School Students through Implications Systems Thinking Approach in Chemistry**
I. Ribau

OC24 **Driving Systemic Change through Global Networks: The Green Chemistry Commitment Program**
J. L. Vidal, M. P. Duarte, O. Villanueva, A. S. Cannon

12:30 – 14:00	**Lunch**	Room: Rectorate Hall
14:00 – 14:45	**Plenary Lecture - PL 3**	Room: Rectorate Auditorium (Aud A/B)
Walter Leitner **Catalysis for a Sustainable Energy-Chemistry Nexus: From Molecules to Systems**		Chair: Jairton Dupont
14:45 – 14:52	**Editorial Session - WILEY - ChemSusChem**, Halgard Staesche	
15:00 – 16:25		Room: Rectorate Auditorium (Aud A/B)
Topic: Green Synthesis, Catalysis & Green Solvents		Chair: Fábio Aricò

KN7 **Catalytic Upcycling of Carbon Renewables**
Wangyu Shi, Chenyang Chang, Carles Bo, Chang Qiao, Yue Ren, Leticia Peña Carrodeguas, Stepanie G. E. Amos and Arjan W. Kleij

IL1 **Chemistry for Sustainability – From Systems Thinking to Material Stewardship**
Stephen A. Matlin

OC25 **Photocatalytic Lignin Oxidative Valorization**
W. Bertoluzzo, F. Sanz Azcona, L. Orian, G. Licini

SG1 **Multifunctional Catalysts for the Continuous-Flow Valorization of Butanol Toward High-Value Chemicals and Jet-Fuel Precursors**
M. Pagliara, G. Squadrani, A. Gagliardi, G. Balestra, F. Cavani, T. Tabanelli

SG2 **Microwave Enhanced Michael Addition as a Sustainable Route to Levoglucosenone Based Amphiphiles**
M.J. Calandri, B. Benedetti, L. Charrier, D. O. Abranches, J. R. Sherwood, G. O. Lloyd, J. A. P. Coutinho, C. R. McElroy, A. Pellis

SG3 **Bio-Adipic Acid Production from the Hydrogenation of Muconic Acid on Biocarbon Supported Ni Catalysts**
J. Lozano, B. Khezri, Y. Cesteros

15:00 – 16:25	Room: School of Law - Amphitheatre A
Topic: Green Chemical Engineering & Technology	Chair: Eduarda Pereira

KN8 **Sustainable Depolymerization of Polyurethane Foam Waste in Ionic Liquids**
P. Lozano, R. Villa, F. Velasco, M. Nuño, C. Sotillo, S. Nieto, M. Macia, J. Dupont, E. Garcia-Verdugo

IL2 **Mixed Matrix Composite Membranes Design using Direct Spray-Coating Technique**
P. Ortiz-Albo, J. Tinevez, I. Kumakiri, J. Crespo, L.A. Neves

OC26 **Reducing Fluorinated Greenhouse Gas Emissions through Advanced Recovery Systems at the CERN LHC Experiments**
M. C. Arena, A. Bouzaiene, R. Guida, B. Mandelli, G. Rigoletti

SG4 **Self-Dispersible MDO/Crotonate Based Degradable Polymers using MPEG Macromonomers for Stabilization**
A. Marchand, A. Barquero, H. Sardon, J. Leiza

SG5 **Design of Hydrophobic DES for Critical Metal Recycling**
Maísa S. Pinheiro, Felipe Olea, João A. P. Coutinho, Nicolas Schaeffer

SG6 **Sustainable Thermochromic Materials for Smart Sensing Applications**
I. R. Silva, B. D. D. Cruz, N. Pereira, L. C. Fernandes, C.R. Tubio, M. Tariq, J. M. S. S. Esperança, G. Botelho, S. Lanceros-Méndez, D. M. Correia

15:00 – 16:25 Room: School of Law - Room 3

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Martin Hayes

KN9 **From Pine to Perfume: Sustainability-Driven Perfumery Ingredient Innovation**
Fabrice Robvieux

IL3 **Green Extraction of Propolis for Sustainable Preservation of Artisanal Cheeses**
Artem Drogalin, Aritson Tolentino, Paula Rodrigues, M. Natália D.S. Cordeiro, Miguel Vilas-Boas, João Reis, Soraia I. Falcão, Andreia F. Peixoto

OC27 **Enabling Greener Routes to Pharmaceutically Important Reactions through Solvent Replacement and Recycling**
K. Sharma

SG7 **Aiming for the SAN: Process Optimization of the Dissolution-Based Recycling of ABS**
V. de Paula, C. F. Araújo, P. S. S. Lacerda, F. H. B. Sosa, A. M. Ferreira, A. F. Sousa

SG8 **From Single-Circuit to Dual-Circuit COFs: Boron–Hydroxyl Microenvironment Engineering for Efficient Photocatalytic H_2O_2 Production**
Ran Sun, Renxi Zhang, Andrew E. H. Wheatley

SG9 **Oxygen Vacancy-Driven Oxidative Esterification of HMF over Au/La Catalysts**
A. Bueno, N. Viar, I. Gandarias, J.M. Requies

15:00 – 16:25 Room: School of Law - Room 5

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Shuliang Yang

KN10 **Coupling Flow Chemistry and Biocatalysis for Greener Manufacturing**
R. O. M. A. de Souza

IL4 **From Biorenewables to Bioactive Molecules and Drugs**
Svilen P. Simeonov

OC28 **Upcycling of HFOS into Value-Added Products: Construction of 2-CF3- and 3-CF3-Indoles**
J. Ichikawa, S. Mizuno, F. Yotsume, A. Saitoh, Y. Ishibashi, Y. Obitsu, T. Ueji, M. Inoue, R. Kasahara, H. Min, T. Fujita

SG10 **Optimising the Effectiveness of Zinc Oxide Nanoparticles in Sunscreen**
M. Mohebimorad, A.F. Patti, A.M. Funston, J.C. Warner, T.W. Turney

SG11 **Shrimp Shell Valorisation: An Integrated Biorefinery Approach to Bioactives and (Electro)Catalysts**
Inês S. Marques, Andreia F. Peixoto, Diana M. Fernandes

SG12 **Sustainable Mechanosynthesis of Metal Oxide Photocatalysts for the Removal of Organic Dye Pollutants**
E. Yucel, M. Ersoz

15:00 – 16:25 Room: School of Law - Room 7

Topic: Bioeconomy Chair: Antonio Patti

KN11 **Integrating Green Chemistry, Biotechnology and Downstream Processing for Biomass Valorisation**
F. Allais

IL5 **Green Thermochemical Routes for Sustainable Resource Valorisation**
Raquel Gonçalves, Yasmine Andrade, Sila Ozkan, Salma Dehhaoui, Maria Sousa, Raquel Pereira, Joana Madeira, Tânia Frade, Laura Ferreira, R. Galhano dos Santos

OC29 **Development of a New Green Metric: The Sustainable Impact for Extraction (Six Score)**
G. Capaldi, G. Grillo, C. Aimone, G. Mongardi, E. Calcio Gaudino, G. Cravotto

SG13 **Green Solvent Screening for Broccoli Leaf Phenolics and Flavonoids Extraction**
R. Carvalho, A. Sunna

SG14 **Sustainability Assessment of Acid-Based Demineralization of Insect Residues for Chitin Production using the Path2Green Framework**
L. Mersmann, V. G. L. Souza, A. Paiva , A.L. Fernando

SG15 **Upcycling Fruit Processing Co-Products into Functional Foods: A Circular Bioeconomy Approach to Product Development and Stability**
R. Nunes da Silva, I. Alves, M. J. Alegria, A. Fernandes, I. Fernandes, N. Mateus, V. de Freitas

15:00 – 16:25 Room: School of Law - Room 123

Topic: Green Chemical Education Chair: Teresa Casimiro

KN12 **Contribution of the "Sustainable Sciences: Resources, Materials and Chemistry" Master Programme Towards a Better Future**
V. G. Zuin Zeidler

IL6 **From Professional Development to Peer Mentoring: Empowering Educators to Teach and Practice Green Chemistry**
A. S. Cannon, J. L. Vidal, J. W. Moir, M. S. Hensley, O. Villaneuva

OC30 **Modernizing Chemistry Curricula: Spotlight on Green Chemistry and Systems Thinking**
L. Gilbert, D. A. Laviska

SG16 **Combination of Analytical Separation Methods for the Qualification and Quantification of Humins Produced During the Dehydration of Sugars to 5-HMF**
Marwa Charaf, Agnès Le Masle, Kim Larmier, Paul Hazemann, Damien Hudebine

SG17 **Chemical Characterization of Bio-Oil Obtained from the Micro-Pyrolysis of Corn Cob Residues**
Tuğçe Demir, Dayane M. Santos, Jaderson K. Schneider, Rui G. dos Santos, Elina B. Caramão

SG18 **Environmentally Conscious Energy Storage Devices from Marine-Derived Materials**
A. Ugalde, M. Navarro-Segarra, J.P. Esquivel

16:25 – 17:40 Room: Rectorate Hall

Poster Session 1 | Coffee Break

17:40 – 18:25 **Plenary Lecture - PL 4** Room: Rectorate Auditorium (Aud A/B)

Hajime Ito Chair: Javier Martínez
Mechanochemical Organic Synthesis for Sustainable Chemistry: Emerging Strategies and Future Directions

18:25 – 18:40 **Reaxys**, Marta Da Pian

18:40 – 18:47 **Editorial Session - Nature Reviews Chemistry**, Stephanie Greed

Day 3, Thursday, September 10

8:00 – 8:30 **Registration** Room: Rectorate Hall

8:30 – 9:15 **Plenary Lecture - PL 5** Room: Rectorate Auditorium (Aud A/B)

Lourdes F. Vega Chair: Margarida Costa Gomes
From Molecules to Infrastructure: A Green Chemistry Framework for Clean Energy and Large-Scale CCUS

9:30 – 10:30 Room: Rectorate Auditorium (Aud A/B)

Topic: Green Chemical Engineering & Technology Chair: Pedro Lozano

KN13 **Sustainable Materials from Waste: A Green Chemistry Approach**
Youssef Habibi

OC31 **Agro-Food Wastes as Eco-Innovative Solutions for Natural Dyeing Solutions for the 21st Textile Industry**
N. Teixeira, M. Pinho, N. Mateus, V. Freitas

OC32 **Valorization of Olive Branch-Based Cellulose Nanofibers in SA:XG/MOF Hydrogel Composites for Sustainable Agriculture**
S. Kemeç Aslan, D. Ünlü

9:30 – 10:30 Room: School of Law - Amphitheatre A

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Antonio Burtoloso

KN14 **Tunable Enzyme Cascades: A Modular Biocatalytic Platform for the Valorization of Biorefinery Furans**
J. Deska

OC33 **Upcycling Pom (Polyoxomethylele) By Poly(M-Phnenolsulphonic Acid Catalyst) PAFR II at PPM Levels**
Yoichi M. A. Yamada

OC34 **Accessible and Green Wet Impregnation Routes to Earth-Abundant Single-Atom Catalysts**
N. Allasia, A. Moutsiou, M. C. Ince, G. Vilé

9:30 – 10:30 Room: School of Law - Room 3

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Stephen Matlin

KN15 **Challenges for Scalable Continuous Thermal, Photochemical and Electrochemical Reactions**
Michael W. George

OC35 **Shining Light through Darkness: Unveiling a Novel Class of Resorcinarene-Based Deep Eutectic Solvents Via PXRD-Guided Mechanochemistry**
N. Marino, A. Paparella, V. Iuliano, C. Gaeta, C. Talotta

OC36 **Do We Really Need Three Days for Silica Nanospheres? Toward a Greener and Time-Efficient Synthesis**
V. Marsala, N. Heydari, L. Fusaro, C. Aprile

9:30 – 10:30 Room: School of Law - Room 5

Topic: Green Energy Chair: Mirabbos Hojamberdiev

KN16 **From Deep Eutectic Solvents to Biomass-Derived Leaching Systems: Towards Green Solvent Engineering for Sustainable Battery Recycling**
M. Awais, B. C. Jesus, M. Berrettoni, M. Fattobene, M. J. N. Correia, I. M. Marrucho

OC37 **Selective Lithium Extraction from Spent Cathode Via Reagent-Free Mechanochemical Reaction**
Seongryeong Kim, Haesung Jung

OC38 **Scale-Up of a Tandem Process for CO_2-Based E-Fuel Synthesis - From Batch to Continuous Operation**
Hannah Stieber, Stephan Popp, Walter Leitner, Gonzalo Prieto, Andreas J. Vorholt

9:30 – 10:30 Room: School of Law - Room 7

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Kevin Lam

KN17 **Brilliant Cresyl Blue Electropolymerization in Deep Eutectic Solvents for Copper Corrosion Inhibition**
C.M.A. Brett, J.M.S. Almeida, A.-M. Chiorcea-Paquim

OC39 **Lanthanides Extraction using Hydrophobic Eutectic Solvents: Influence of Hydrogen-Bond Donors**
R. Colhe, A. Tropres, M. Pinheiro, F. Olea, I. Vaz, J. Coutinho, N. Schaeffer

OC40 **Smart Materials for Dirty Waters: Reversible Aerogels Unlock Closed-Loop Heavy Metal Remediation for Catalytic Applications**
D. Gentile, M. Galimberti, V. Barbera

9:30 – 10:30 Room: School of Law - Room 123

Topic: Green Chemical Education Chair: Vânia Zuin

KN18 **Strategies and Tools for Achieving Quality Education (SDG 4) Through Green and Sustainable Chemistry Curriculum Reform**
Jane E. Wissinger

OC41 **Integrating Sustainable Multistep Synthesis and Mechanochemistry into Undergraduate Green Chemistry Education**
Mariana Peixoto, Teresa M. V. D. Pinho e Melo, Marta Pineiro

OC42 **Green Chemistry as a Central Area for Sustainability-Related Cross-Disciplinary and Multidisciplinary Networks**
L. Mammino

10:30 – 11:00 **Coffee Break** Room: Rectorate Hall

11:00 – 12:30 Room: Rectorate Auditorium (Aud A/B)

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Mihaela Florea

KN19 **New Biodegradable Materials Based on Nature-Sourced Polysaccharides**
Elena Poverenov

OC43 **Green Biocomposite Nanoparticles as Catalysts for Pollutants Degradation in Water**
R. Del Sole, L. Mergola, A. Serra, A. Buccolieri, D. Manno

OC44 **Atomic-Scale Manipulation of Zeolites for Sustainable Applications**
J. Zhang, S. Abdi, E. Shamma, M. Opanasenko, M. Shamzhy

OC45 **From Renewable FDCA-Derived Cyclic Carbonates to Non-Isocyanate Polyurethane and Applications**
G. Berluti, A. Gomez, H. Sardon, C. Jehanno

OC46 **From Residues to Resources: High-Value Furan Building Blocks from Pentose Sugars**
Shanmugam Thiyagarajan, Carlo Angelici, Daan S. van Es, Gert-Jan M. Gruter

11:00 – 12:30 Room: School of Law - Amphitheatre A

Topic: Carbon Dioxide Utilization Chair: Luisa Neves

KN20 **Phosphonium Porous Ionic Liquids Designed for Efficient Carbon Capture and Conversion**
Frederik Philippi, Margarida Costa Gomes

OC47 **Electrolytic CO_2 Mineralization with Desalination Brine: Advancing Sustainable Carbon Utilization**
Wei Han Tu, Ger Hui Chan, Shao Ing Wong, Wei Ping Chan, Grzegorz Lisak

OC48 **Hybrid MOF–Macrocycle Catalysts for CO_2 Valorization**
J. E. Sánchez-Velandia, J. Chiva, F. Esteve, F. Garcia-Cirujano, B. Altava, E. Garcia-Verdugo

OC49 **Tuning CO_2 Hydrogenation Selectivity on Ru Via Hierarchical Alumina Support Design**
K. Ledwa, A. Pawluk, M. Lippel Gothe, M. Pawlyta, M. Ptak, M. Grodzicki, P. Vidinha, L. Kępiński

OC50 **3D Printed Zeolite Composites as Highly-Effective Materials for CO_2 Capture and Methanation**
M. Popova, G. Theochari, S. Boycheva, N. Marinkov, D. Kovacheva

11:00 – 12:30 Room: School of Law - Room 3

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Konstantinos Triantafyllidis

KN21 **Green Construction and Applications of High-Performance Nanocatalysts**
Shuliang Yang

OC51 **Single-Atom Mxenes as Versatile Catalysts for Cinnamaldehyde Transformations**
B. Cojocaru, O.D. Pavel, D.G. Popescu, V.I. Parvulescu, A. Primo, H. Garcia

OC52 **Sustainability and Economic Boundaries of Micellar Catalysis in Fine Chemical Synthesis**
M. C. Ince, G. Vilé

OC53 **Low-Temperature Acetylene Hydrogenation over Palladium-MOF Catalyst**
A. Skorynina, M. Zhao, L. Simonelli, P. Concepcion

OC54 **Photocatalytic Synthesis of Indoles**
Gonçalo Vilela, João R. Vale, Carlos. A. M. Afonso

11:00 – 12:30 Room: School of Law - Room 5

Topic: Green Chemical Engineering & Technology Chair: Carlos Afonso

KN22 **From Light–Matter Interactions to Biohybrid Functionality: Carbon Based Photocatalysts for Sustainable Energy, Environment, and Health**
Maria J. Sampaio, Joana C. Lopes, Cláudia G. Silva, Fani Sousa, Joaquim L. Faria

OC55 **3D Printing of ZIF-8 for Ethane/Ethylene Separation**
G. Rincon, J. E. Sosa, H. Ortega-Ortiz, J. Carrillo, D. A. Nabarlatz, L. M. Esteves, L. Neves, J. P. B. Mota, R. P. P. L. Ribeiro

OC56 **Sustainable Catalytic Production of Bio-Based 1,5-Pentanediol and its Use in Furanic Polymers**
A. Barredo, A. Valle, J.M. Requies, M.S. Alam, A. Sangroniz, I. Agirre, I. Gandarias

OC57 **Chemical Upcycling of Used Cooking Oil to Green Polymers for Composites and Adhesives**
J. Janesch, J. Ralph Martin, M. Holzinger, T. Willim, W. Gindl-Altmutter, T. Rosenau

OC58 **Development of MOF-Derived Materials Towards Sustainable Processes**
Luís Cunha-Silva, Salete S. Balula

11:00 – 12:30 Room: School of Law - Room 7

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Svilen Simeonov

KN23 **New Polymers and Furan Derivatives from CMF**
Antonio C. B. Burtoloso

OC59 **ZIF-8 Synthesis in Bio-Based Organic Carbonates and End-Of-Life Applications in Water Treatment**
S. Vllahu, A. Sessa, P. Prete, R. Sportiello, F. Rossi, I. Lagzi, R. Cucciniello

OC60 **A Novel in-Situ Derivatization and Isolation Strategy for Natural Products**
M. A. G. Fortunato, J. Silva, C. Alves, F. Siopa, C. A. M. Afonso

OC61 **C–H Activation: First CH/CX Pd-Catalysed Coupling from Terpenes**
M. Di Matteo, T. Crovetto, L. F. Veiros, G. Poli, A. Pradal

OC62 **Ecofriendly Isolation and Characterization of Cellulose from Algerian Arundo Donax L. Via a Totally Chlorine-Free Multistep Process**
Ahmed Fouzi Tarchoun, Djalal Trache, Amir Abdelaziz

11:00 – 12:30 Room: School of Law - Room 123

Topic: Bioeconomy Chair: Francesca Kerton

KN24 **Green Processing Technologies in New Zealand's Bioeconomy**
O. Catchpole, J. Morel, T. Moreno, A. Mackenzie, S. Tallon, S. Marshall

OC63 **Synthesis of Tailored Biocompatible Block Polyesters by Means of [OSSO]-Type Catalysts**
Carmine Capacchione, Sara Esposito, Assunta D'Amato, Antonio Buonerba, Naym Blal, Daniela Guarnieri

OC64 **Diazo-Forming Enzymes – Catalytic Mechanism and Biocatalytic Applications**
Zhao-Xun Liang

OC65 **Closing the Loop with Insects: Key Transformations and Sustainable Solvent Applications**
Q. Tao, X. Wang, F. Nunes Henríquez, H. Ma, R. Du, C. M. Leong, M. Y Lui

OC66 **Microalgae – A Blue Perspective of Green Chemistry**
J. F. Leal, G. Bombo, M. L. S. Cristiano

12:30 – 14:00 **Conference Photo | Lunch** Room: Rectorate Hall

14:00 – 14:45 **Plenary Lecture - PL 6** Room: Rectorate Auditorium (Aud A/B)

Thalappil Pradeep Chair: Christopher Brett
The Unfinished Science of Water: From Clean Water to Microdroplets and Ice

14:45 – 14:52 **Editorial Session - Thieme - SCNOW (Sustainability & Circularity NOW)**, Fadwa Hawar

15:00 – 16:25 Room: Rectorate Auditorium (Aud A/B)

Topic: Bioeconomy Chair: Owen Catchpole

KN25 **Seafood By-Products as Feedstocks for a Blue Circular Bio-Economy**
F. M. Kerton

IL7 **From Sediment to Maritime Coatings: Harnessing the Sustainable and Circular Potential of Marine-Derived Actinomycetes**
S. P. Gaudêncio

OC67 **Advancing Circular Resources Management: Experimental Evaluation of Nutrient Recovery Technologies from Wastewater**
V. Quintero-Prada, M. Combariza, H. Escalante, L. Castro, M. E. Suárez-Ojeda, D. Nabarlatz

SG19 **Green Surface-Engineered Nanocellulose from Raphia Farinifera Inflorescence for Mechanistic Control of Interfacial Chemistry in Sustainable Water Treatment**
E. Agboeze, I. P. Udeozo, H. O. Agboeze, V. A. Ofordile

SG20 **Sequencial and Simulataneos Extraction of Phenolic Compounds and Biopolymers from Sargassum Muticum using Alternative Solvents**
Bárbara C. Jesus, Maria Miquel-Gonzalez, Alice Martins, Isabel M. Marrucho

SG21 **Green Adsorbents for Sustainable Water Remediation: MOF-Derived Porous Carbons and Waste-Derived Chars**
D. S. S. Flores, C. M. R. Almeida, A. F. Peixoto, C. M. Granadeiro

15:00 – 16:25 Room: School of Law - Amphitheatre A

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Jaime Coelho

KN26 **Power Without Peril Electrosynthetic Access to Highly Reactive Intermediates**
Kevin Lam

IL8 **Toward a More Sustainable Production of Biopet: Terephthalic Acid Synthesis from Renewable Resources**
M. Florea

OC68 **Effect of the Synthesis Parameters on the Sustainable Production of Pet-Based Aerogels**
C. M. R. Almeida, P. C. Fernandes, B. Jorge, T. Cardoso, D. Gonçalves, P. N. Simões, A. C. Fonseca, L. Durães

SG22 **Biomass-Derived Wood Fibre-Iron Complex in Green Visible Light-Assisted Water Pollutant Remediation**
Gabriela A. Corrêa, Mário M.Q. Simões, Susana L.H. Rebelo

SG23 **Electrochemical Lactonization of Ketones Enabled by Anodic Oxidation of Benzoates**
Duarte B. Clemente, Jaime A.S. Coelho

SG24 **Effect of Polyol-Based Biosolvents on Laccase-Driven Depolymerization of Poly(Vinyl Alcohol)**
Mariana I. S. Aguiar, Daniela L. Espínola, Maria Inês C. Santos, João A. P. Coutinho, Ana P. M. Tavares, Frederik R. Wurm, Andreia F. Sousa, and Ana M. Ferreira

15:00 – 16:25 Room: School of Law - Room 3

Topic: Green Chemical Engineering & Technology Chair: Youssef Habibi

KN27 **Interface-Selective Disassembly of Multi-Material Assemblies Via Electrical Pulse Stimulation for Inner-Loop Circular Economy**
C. Tokoro

IL9 **From Molecules to Particles: An Integrated Approach to Decarbonize Pharmaceutical Development**
F. Ataide, R. Loureiro, R. Mendonça, C. Moura

OC69 **Sustainable Valorisation of Chestnut Shells Through Green Extraction**
J. Lains, B. Ferrás, Y. Manrique, M. F. Barreiro, M. M. Dias, R. J. Santos, A. Ribeiro, I. M. Martins

SG25 **Shaping ZIF-8 in Chitosan – In-Situ Growth and Powder Dispersion for Enhanced CO_2 Capture**
Thiago O. Carvalho, Tiago J. Ferreira, Joana Pais, A. B. Paninho, A. V. M. Nunes, José M.S.S. Esperança, Isabel A.A.C. Esteves

SG26 **Continuous Flow Synthesis of Primaquine Diphosphate an Anti-Malarial Drug**
F. M. Akwi, P. Watts

SG27 **Zero-Carbon Seawater Desalination with Electricity Cogeneration Via Process Intensification and Genetic Algorithm Optimisation**
R. Thakran, A. K. Jana

15:00 – 16:25 Room: School of Law - Room 5

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Rui Galhano

KN28 **Catalytic Upgrading of Lignin to Chemicals and Fuels**
A. Margellou, P. Soldatos, C. Pappa, N. Siddiqui, A. Tanimu, K. Triantafyllidis

IL10 **Hyperbaric Electrocyclization Reactions**
Rafael F.A. Gomes, Tiago Santos, Sabrina Cabral, Catarina Tchu Cipriano, Maria M. Marques, Carlos A.M. Afonso

OC70 **Green C-H Activation Reactions for the Synthesis of Potential Bioactive Thienopyridinone Derivatives**
Juliana P. Sousa, Francisco Ribeiro, Maria-João R. P. Queiroz

SG28 **Understanding the Presence of the Surface Coordinated Copper Hydrides for the Selective Hydrogenation of 5-Hydroxymethylfurfural**
Po-Wen Chung

SG29 **Thianthrenium Salts Enable Broad-Scope C–H Carbonylation for Carbon Isotope Labeling**
Vitus J. Enemærke, Rasmus S. Grarup, Prof. Troels Skrydstrup

SG30 **Biocatalytic Preparation of Esters Via Hemiacetal Oxidation: A Novel, Self-Sufficient and Industrially Viable Ester Production Route**
M. Zago, S. Ceccarossi, I. Serra, P. Branduardi

15:00 – 16:25 Room: School of Law - Room 7

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Rodrigo de Souza

KN29 **Collaborative Innovation in Biocatalysis for Green and Sustainable Chemistry**
Martin A. Hayes

IL11 **Exploring Green-Synthesized Metal–Organic Frameworks for Lead and Phenol Removal from Water**
M. Iosivoni, A. Popa, L. Lupa, B. Maranescu, N. Plesu, A. Visa

OC71 **Green Biocatalytic Protein Modification for Diagnostic and Therapeutic Applications**
S. Venkatachalapathy, Y. Wang, Y. Zhang, M. Rashidian, C. R. Wagner, M. D. Distefano

SG31 **Photocatalytic Hydrogels Derived from Food Waste for the Removal of Organic Contaminants**
B. Cerea, A. Gianoncelli, G. Ribaudo, I. Vassalini, I. Alessandri

SG32	**Polymer Film / Nanomaterial Modified Electrodes by Electropolymerization in Ternary Deep Eutectic Solvents and Application** J.M.S. Almeida, C.M.A. Brett
SG33	**Food-Inspired Oxidative Coupling of Caffeates: A New Tool for the Green Synthesis of Benzacridines** R. Pereira, N. Mateus, V. Freitas

15:00 – 16:25 Room: School of Law - Room 123

Topic: AI in Green Chemistry | Green Chemistry Education Chair: Jan Deska

KN30	**Machine Learning for Sustainable Chemical Sciences** T. Rodrigues
IL12	**Computer-Aided Safe and Sustainable by Design** Kjell Jorner
OC72	**Sustainability and Systems Thinking in the Laboratory Class** Thomas A. Logothetis
SG34	**Smart and Sustainable Azetidine Synthesis: Integrating Flow Chemistry with Machine Learning** J. Azuaje, F. Pereira, J. Antunes, L. Ferreira
SG35	**Green Chemistry and Teaching about Microplastics to Promote Ocean Literacy: Potencial Through the Steam Approach** J.R.P.M. Barros, B.F. Barcellos, D.A. Garcia, V.R. Terra, D.R. Sena
SG36	**Homogeneous Co(Ii) Cryptates for Light-Driven CO_2 Transformation: Optimisation and Scale-Up** R. T. Marques, S. Realista, R. G. Santos, P. N. Martinho

16:25 – 17:40 Room: Rectorate Hall

Poster Session 2 | Coffee Break

17:40 – 18:25 **Plenary Lecture - PL 7** Room: Rectorate Auditorium (Aud A/B)

Matthias Beller Chair: Arjan Kleij
Beyond Fossils: Engineering a Sustainable Economy through Green Catalysis

20:00 – 24:00 **Conference Dinner** at Estufa Fria (Lisbon)

Day 4, Friday, September 11

8:30 – 9:15 **Plenary Lecture - PL 8** Room: Rectorate Auditorium (Aud A/B)

Zhimin Liu Chair: Jane Wissinger
Upcycling of Plastic Waste into Chemicals

9:15 – 9:22 **Editorial Session - RSC Sustainability**, Alexandre John

9:30 – 11:00 Room: Rectorate Auditorium (Aud A/B)

Topic: Green Energy Chair: Maria Manuel Marques

KN31	**Sustainable Self-Chargeable Textile Energy Technologies Powered by Multifunctional Building Blocks** Clara R. Pereira

OC73 **Photothermal Supported Amine Adsorbents for CPVT-Driven Direct Air Capture Regeneration**
Yaohui Feng, Yingjie Huo, Wentao Xie, Tianshu Ge

OC74 **Bromide-Mediated Electrolysis Enables Green Hydrogen and Oxoacid Production**
Guilin Ruan, Avihay Ben-Shitrit, Sabrina Spatari, Avner Rothschild

OC75 **Phase Equilibrium Studies for Sustainable Efficient Sub-Zero Thermal Energy Storage**
Maria C.M. Sequeira, Timur Nikitin, Fernando J.P. Caetano, Hermínio P. Diogo, João M.N.A. Fareleira, Rui Fausto

SG37 **Benzyltoluene Hydrogenation Under Offshore Conditions in a Trickle Bed Reactor**
B. Subasi, A. Bösmann, P. Wasserscheid

SG38 **Tungsten Carbide-Based Catalysts for Hydrogen Evolution Reaction**
E. Galli, M. Delvecchio, S. Javaid, U. Iacobone, S. Patronelli, F. Bresciani, I. Vassalini

SG39 **Phase-Tunable Electrolytes Based on Ionic Hydrophobic Eutectic Systems for Supercapacitors**
I. G. Silva, M. F. Montemor, I. Marrucho

9:30 – 11:00 Room: School of Law - Amphitheatre A

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Vesna Najdanovic

KN32 **Paving New Avenues for Eutectic Systems in Chemical Industry**
Ana Rita C. Duarte

OC76 **Closing the Loop in Phosphorus Chemistry: Redox-Neutral Pathways from Phosphate Feedstocks**
Kai Schwedtmann, Marco Wenzel, Tobias Schneider, Jan J. Weigand

OC77 **Boronic Acid-Functionalized Multilayered Biomembranes for Ph-Driven Binding and Release of Catechol-Rich Anthocyanins**
L. Cruz, M. Cunha, V. de Freitas

OC78 **Sustainable Cu-Catalysts for Ester Hydrogenolysis: From Conventional to Mechanochemical Approach**
J. Aubrecht, K. Nderitu, S. Saha, M. Daturi, D. Kubička

SG40 **Sustainable Ethylbenzene Synthesis Via in Situ Hydrogen-Driven Styrene Hydrogenation**
P. Kumar, U.L. Stangar

SG41 **Cyclohexanone Oxidation with Acid-Functionalised SBA-15 Catalysts for Sustainable Adipic Acid Obtention**
L. Arrieche-Hernández, J. Granados-Reyes, Y. Cesteros

SG42 **Making the Elusive Tangible: Long-Lived Benzyl Cations Stabilized in Zeolites**
Francesco Orlando, Raúl Pérez–Ruíz, German Sastre, Antonio Leyva-Pérez

9:30 – 11:00 Room: School of Law - Room 3

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Li Peng

KN33 **Reinventing Hierarchical Zeolite Y Catalysts for Redefining Sustainable Biofuel Production**
M.Y. Choo, E.P. Ng, J.C. Juan

OC79 **Exploring the Potential of Solvent Free Synthesis Via Mechanochemistry**
M. Schnürch

OC80 **Ball Milling as a Green and Efficient Method for Nucleophile–Heteroallene Coupling**
P. Żak, K. Hanek, N. Pietras, B. Kaczmarek, D. Frąckowiak

OC81 **Semi-Hydrogenation of Internal Alkynes by Unconventional Methods and Application to Pheromone Synthesis**
Miquel Molina–García, Francesco Orlando, Judit Oliver–Meseguer, Marta Mon, Jordi Aragón, Antonio Leyva–Pérez

SG43 **Hypervalent Iodine-Mediated Synthesis of Sulfones using Organozinc Pivalates and Sulfinate Salts**
José C. Cunha, Gabriel G. Rocha, Stefan Bräse, M. Manuel B. Marques

SG44 **A Green Approach to 2-Arylquinolines Via Palladium-Catalysed C–H Activation**
Nuno Viduedo, Leonardo Pirvu, Ângelo Alves, Fábio Santos, M. Manuel B. Marques

SG45 **Single-Amine CO_2 Hydrogenation to Formic Acid: Process Simplification with NBIM and Heterogeneous Ru Catalysis**
Jiseong Baek, Hongjin Park, Sungho Yoon

9:30 – 11:00 Room: School of Law - Room 5

Topic: Green Chemical Engineering & Technology Chair: Luis Branco

OC82 **Valorization of Pine-Derived By-Products: Is Turpentine a Sustainable Herbicide?**
C. Lopes, S. Marcano, S. M. Cardoso, S. Silva, S. M. Bruno

OC83 **Process Analysis and Modelling of Sustainable In-Situ Oxygen Extraction from Lunar Regolith**
L. Colelli, N. Verdone, C. Bassano, G. Vilardi

OC84 **Inductively Heatable Catalysts for Ammonia Synthesis**
C. Wöllhaf, O. Kröcher

OC85 **Bayesian Parameter Estimation in Microkinetic Modeling of Anisole Hydrogenation over Ni/Al_2O_3 Catalysts**
Snehasis Dutta, Dmitry Yu. Murzin, David Kubička

OC86 **Nature-Derived Materials for Soil Moisture Sensing: A Green Chemistry Approach to Agriculture 4.0**
B.D.D. Cruz, A.S. Castro, N. Pereira, C.R. Tubio, M. Tariq, J.M.S.S. Esperança, P. M. Martins, S. Lanceros-Méndez, D. M. Correia

SG46 **Natural Solvents for Sustainable Polypropylene Recycling: Dissolution-Precipitation**
S. C. Aparício, I. Pires, M. Silaco, R. Galhano dos Santos, I. M. Marrucho

SG47 **Process Development for Hydrogen Production from Ammonia Decomposition at High Pressures**
P.C.C Araújo, J. E. C. Savoia, A. Y. Fernández, M. Rosset, R. M. B. Alves, C. A. O. Nascimento

SG48 **Design and Development of Multifunctional Materials for CO_2 Capture and Valorization**
B. Rocano-Merchan, A. Centeno-Pedrazo, J. Perez-Arce, Zoraida Freixa, E. J. Garcia-Suarez

11:00 – 12:30 Room: Rectorate Hall

Poster Session 3 | Coffee Break

12:30 – 14:00 **Lunch** Room: Rectorate Hall

14:00 – 14:45 **Plenary Lecture - PL 9** Room: Rectorate Auditorium (Aud A/B)

Morten Meldal, D. A. Wellings, J. D. Wade Chair: Mary Garson
Green Aqueous Solid Phase Peptide Synthesis Approaches

14:45 – 14:52 **Editorial session - Elsevier - Sustainable Chemistry & Pharmacy**, Fábio Aricò

15:00 – 15:50 Room: Rectorate Auditorium (Aud A/B)

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Rafael Gomes

OC87 **Green Chemistry in API Synthesis: A Case Study of Twin-Screw Extrusion for Continuous API Manufacturing**
A. Gołkowska, Z. Łukasiuk, A. Kosierb, H. Czapor-Irzabek, M. Nowak, B. Karolewicz

OC88 **Light-Driven "On-Demand Synthesis" of N/Br-Codoped Polymeric Carbon Dots at Ambient Temperature as Green Dual-Mode Photoinitiators**
G.Karakus, K.Kaya

IL13 **Biorenewable Solvents for Sustainable Chemical Processes**
V. Najdanović-Višak

15:00 – 15:50 Room: School of Law - Amphitheatre A

Topic: Green Synthesis, Catalysis & Green Solvents Chair: Andreia Peixoto

OC89 **Generation of Carbon-Centred Radicals for Giese Reaction**
Nuno R. Candeias

OC90 **Holistic Sustainable Syntheses with Readily Available Surfactants and Data Science**
M. J. Anderson, H. Basiri, S. Boobier, T. P. Carton, K. Foote, A. McCorry, J. Mottram, R. Napier, J. Odger, K. Sharma, I. W. Ashworth, J. Blacker, T. Hunter, N. Kapur, M. J. Waring, S. L. Warriner, M. H. Wright, B. N. Nguyen

IL14 **Ionic Liquid-Catalyzed Valorization of Renewable Carbon Resources into Chemicals**
Yanfei Zhao

15:00 – 15:50 Room: School of Law - Room 3

Topic: Green Chemical Engineering & Technology Chair: Ana Rita Duarte

OC91 **Development and Validation of a Simplified HPLC-UV Method for Confirmatory Analysis of Antibiotic Degradation Via e-Beam Irradiation**
G. R. Fernandez, J. P. Lazarte, T. G. Angeles, A. K. Gallardo, B. J. Barba, J. Madrid

OC92 **Repurposing Metabolic Waste: Preliminary Computational Insights into Metal Sequestration using Pyrrolic Biochromes**
S. Mathura

OC93 **Designing Recyclable Bio-Based Epoxy–Acid Thermosets for Sustainable Adhesive Applications**
F.E.N. Lahfaidh, N. Guigo

15:00 – 15:50 Room: School of Law - Room 5

Topic: Carbon Dioxide Utilization Chair: Isabel Esteves

OC94 **CO_2 Electrolysis Utilizing CO_2-Captured from Flue Gas to Close the Carbon Loop in the Steel Industry and Beyond**
N. Plankensteiner, N. Rauch, S. Bönisch, A. Seebacher, I. Kofler

OC95 **Towards a New Generation of Polyurethane Foams Enabled by CO_2 Based Cyclic Carbonates**
M. Bourguignon, B. Grignard, C.Detrembleur

OC96 **Methyl Formate Synthesis Via Ru-Based Heterogeneous Catalysis and Reactive Distillation**
Minji Kang, Sungho Yoon

15:00 – 15:50 Room: School of Law - Room 7

Topic: Bioeconomy Chair: Florent Allais

OC97 **Synthesis of Renewable Non-Isocyanate Polyurethanes from Algae Oil and its Fatty Acid Methyl Esters**
C. M. Kozak

OC98 **Lipophilic Composition of Prunus Lusitanica by GC–MS: Nutritional Quality and High-Value Metabolites**
N. C. P. Rodrigues, M. A. F. Faustino, D. C. G. A. Pinto

IL15 **Green & Sustainable Chemistry for Maximising Agricultural Productivity**
Antonio F Patti, Alessia Belgi, Eram Shaik, Andrea Robinson, Amit Arora

15:00 – 15:50 Room: School of Law - Room 123

Topic: Multidisciplinary Chair: Susana Gaudêncio

OC99 **Green Synthesis of a Bio-Based Guar-Gum Crosslinked Polymer Composite for Active Packing Applications**
Mohamed Keshawy, Ahmed E. Elhassany, Manar El-Sayed Abdel-Raouf

OC100 **Zeolite Catalyst Design for Lignin Valorization**
Lu Lin, Ping He, Yuanshuai Liu

OC101 **Valorisation of *Salicornia Sp.* as a Sustainable Source of Polysaccharides for Bio-Based Materials**
I. Meirinho, A.C. Carvalho, I. Martins, C. Nunes, R.L. Reis, T.H. Silva

15:50 – 16:25	**Coffee Break**	Room: Rectorate Hall
16:25 – 17:10	**Plenary Lecture - PL 10**	Room: Rectorate Auditorium (Aud A/B)
João G. Crespo **Membrane Engineering: What Else?**		Chair: Joaquim Faria
17:10 – 17:55	**Closing Session**	Room: Rectorate Auditorium (Aud A/B)

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Abstracts of Plenary Lectures

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FROM SCARCITY TO ABUNDANCE

Omar M. Yaghi

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From Scarcity to Abundance explores how reticular chemistry is transforming the way we discover, design, and make materials. Metal–organic frameworks and covalent organic frameworks offer an almost limitless space of possible structures and functions, a space that can increasingly be searched, predicted, and synthesized through AI, automation, and robotics. This emerging capability points toward an age of abundant materials, where the central challenge is no longer whether a useful material can exist, but how to identify the right one, make it reliably, scale it responsibly, and deploy it where it matters most. Navigating this new landscape will require new principles for selection, synthesis, characterization, data sharing, sustainability, and human judgment, so that abundance becomes not merely a measure of possibility, but a force for solving urgent problems in energy, water, health, and the environment.



SUSTAINABLE QUANTUM MATERIALS THROUGH THE LENS OF CARBON DOTS

Qin Li

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Quantum materials refer to materials with unique properties that cannot be described by classical physical laws; They enable us to access their quantum states. Carbon Dots is one of the sustainable quantum materials that offer circularity, low toxicity, resource efficiency, and high performance.[1,2] In particular, carbon dots provide high tunability through their surface functionalities, core structure constructs, and hybrid. In this talk, I will use a few of my team's studies to demonstrate the diverse methodologies to introduce unique functionalities to carbon dots, including the choice of precursor chemicals, the reaction methods [3], and hybrid systems. Their applications in catalysis such as alpha-CH_3 activation and C-C coupling [4], sensing for small organic molecules such as chloroform and volatile fatty acids [5, 6], and disease prevention in plants [7] will be discussed.

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Acknowledgments:

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CATALYSIS FOR A SUSTAINABLE ENERGY-CHEMISTRY NEXUS: FROM MOLECULES TO SYSTEMS

Walter Leitner[1,2]

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2. Institute for Technical and Macromolecular Chemistry, RWTH Aachen University, Aachen Germany

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The rapidly growing importance of renewable energy and carbon resources opens room for innovation as basis for chemistry of the future [1]. The lecture will provide recent examples of catalysis research from our laboratories and put them into the broader context of Green Chemistry. It will highlight opportunities for new production routes based on CO_2 as feedstock [2,3], for moving the design of new catalysts from analytical to predictive [4], and for catalysis operating adaptively in response to fluctuating energy supply [5]

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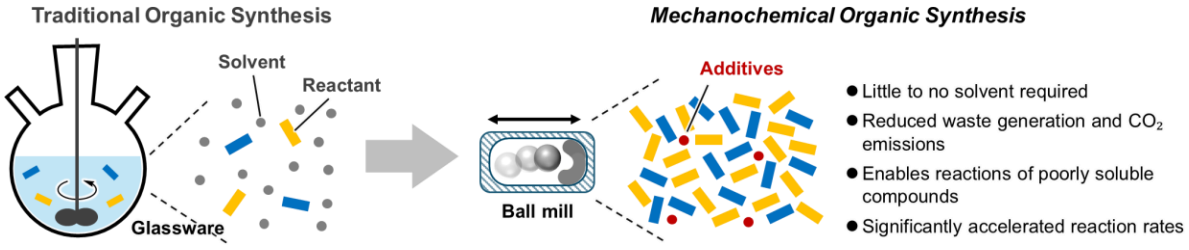
MECHANOCHEMICAL ORGANIC SYNTHESIS FOR SUSTAINABLE CHEMISTRY: EMERGING STRATEGIES AND FUTURE DIRECTIONS

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In conventional organic synthesis, reactions are typically conducted in glass vessels using organic solvents (Figure 1), requiring large solvent volumes and raising environmental concerns. Poor substrate solubility further limits reaction scope, and dilution often reduces reaction rates.In contrast, mechanochemical synthesis employs metal jars, where reagents and balls are vigorously shaken to drive reactions by mechanical force (Figure 1). In this lecture, I will present our recent advances in mechanochemical cross-coupling;[1] the generation and reactivity of organometallic species (including Grignard, organolithium, organocalcium, organobarium, organomanganese, and organosodium reagents);[2] high-speed Birch reductions; mechanoredox reactions using piezoelectric materials;[3] and polymer mechanochemistry.[4] These reactions reduce waste and CO_2 emissions, accelerate reaction rates, and enable transformations inaccessible in solution, opening new directions in organic synthesis.



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FROM MOLECULES TO INFRASTRUCTURE: A GREEN CHEMISTRY FRAMEWORK FOR CLEAN ENERGY AND LARGE-SCALE CCUS

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Bridging high-performance molecular design, the 12 Principles of Green Chemistry, and net-zero targets is vital for next-generation clean energy processes. This plenary lecture explores how integrating multi-scale computational tools, from quantum-scale DFT to advanced molecular thermodynamics and machine learning, supports sustainable carbon management [1,2]. Disrupting traditional trial-and-error paradigms, we introduce an "Inverse Design" methodology grounded in the trinomial framework of technology, environment, and economy [1]. This framework pre-screens and optimizes novel carbon capture and conversion pathways, simultaneously evaluating technical performance, environmental lifecycle metrics, and economic viability from inception to overcome the industrial "Valley of Death." The talk highlights three frontiers where our team applies this approach:

1. Next-Generation Solvents: Synchronizing experiments and molecular modeling to optimize atom-efficient amine-based deep eutectic solvents and novel CO_2-binding organic liquids, decoding water's critical impact on capture thermodynamics [3].

2. Optimal Adsorbents: Integrating microscopic and process-scale modeling to screen green solid adsorbents precisely tailored for high selectivity, minimal energy penalties, and affordable cost [2].

3. CO_2 Utilization Mechanisms: Deploying systematic machine learning screenings to discover tailored catalysts for accelerated electrochemical or photocatalytic reduction [4], alongside advanced pathways for carbon mineralization [1].

Ultimately, we will show how embedding this trinomial framework of technological readiness, economic viability, and environmental guardianship from inception ensures sustainable scale-up.

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THE UNFINISHED SCIENCE OF WATER: FROM CLEAN WATER TO MICRODROPLETS AND ICE

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Water, the molecule of life continues to excite scientists. My lecture will present examples from our work where fundamental insights into water have led to new scientific directions.

The first part of the lecture will describe the development of sustainable nanotechnologies for affordable and safe drinking water. We have discovered a family of nanomaterials capable of selectively removing toxic contaminants such as arsenic, iron, and uranium from water and translated them into deployable technologies. One such technology, AMRIT (elixir in Sanskrit), currently provides 80 million litres of contaminant-free water every day to more than 1.3 million people at a cost of only 2.1 paise (US$0.00026) per litre, among the lowest in the world, and has been approved for national implementation. We have shown that humanity's most fundamental needs can be addressed with advanced materials.

In the second part of the lecture I will focus on recent discoveries demonstrating that microdroplets of water are highly active chemical reactors. We have shown that common minerals, including quartz and ruby, spontaneously disintegrate into nanoparticles in charged water microdroplets through the combined action of intense electric fields, reactive chemical species, and mechanical forces, a phenomenon we have described as microdroplet mechanochemistry. Occurring within milliseconds rather than geological timescales, these processes effectively compress mineral weathering by many orders of magnitude. Recent studies further show that trace concentrations of ions can dramatically reduce the required potentials and that similar principles can be used for ambient synthesis, transformation, and dissolution of materials.

Together with emerging insights into the physics and chemistry of ice, which I will touch upon briefly, these discoveries suggest that water, across its many forms and interfaces, may provide a foundation for a new paradigm of sustainable chemistry and manufacturing, one that replaces extreme conditions with interfaces, confinement, electric fields, and ambient processes.

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BEYOND FOSSILS: ENGINEERING A SUSTAINABLE ECONOMY THROUGH GREEN CATALYSIS

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The use of renewables, waste, and carbon dioxide for the cost-effective and waste-free synthesis of materials, life science goods and all kinds of organic products can be an important part to achieve a circular economy in the future. In this respect, efficient catalytic reductive transformations of CO_2 offer interesting possibilities to replace existing industrial carbonylations. Nowadays, in the chemical industry, carbonylation processes constitute the largest applications of homogeneous catalysts and many bulk and fine chemicals are produced by such transformations. In the talk, various possibilities to use green CO from CO_2/H_2 mixtures, formic acid as CO surrogate or directly CO_2 will be shown. In addition, new catalytic conversions of (bio)waste and waste plastics to useful chemicals will be presented.

Crucial for all these reactions is the development of modern catalysts. By design, novel ligands and complexes have been synthesized, which allow for unprecedented efficiency in such transformations. Both industrially relevant processes as well as interesting reactions for modern organic synthesis will be presented.

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UPCYCLING OF PLASTIC WASTE INTO CHEMICALS

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For the sustainable development of our society, the utilization of renewable/recyclable resources has attracted worldwide attention. As a kind of recyclable carbon resources, spent plastics can be converted into chemicals, and provide alternative routes for chemical synthesis. Unlike petroleum-based chemical synthesis, the chemical upcycling of plastics toward value-added chemicals faces distinct challenges. The core scientific challenge lies in precisely activating chemical bonds to achieve their selective transformation. Recently, our group has conducted systematic research on the transformation of polyesters and nylons into value-added chemicals. To realize the selective upcycling of waste plastic feedstocks, we put forward reactive solvent-assisted catalytic protocols, in which reactive solvent simultaneously participates as a solvent, reactant and/or catalytic agent, thereby achieving significant progress [1-6]. For example, we presented a general strategy to degrade polyesters into carboxylic acids using halide-based ionic liquids, which achieved the selective cleavage of C_{alkyl}-O bond, resulting in formation of carboxylic acids and hydrocarbons [2]. In this presentation, I will introduce our recent work on chemical upcycling of polyesters and polyamides, and discuss the future development perspectives of chemical utilization of spent plastics.

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GREEN AQUEOUS SOLID PHASE PEPTIDE SYNTHESIS APPROACHES

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Peptide drugs are currently being explored by many pharmaceutical companies due to their modular construction and high specificity of interaction with their targets. This has the environmental disadvantage that traditional methods of peptide assembly produce vast amounts of toxic waste. This talk describes a novel green approach to peptide assembly, in which we couple Fmoc-amino acids in water to enable aqueous-based solid phase peptide synthesis. The method is based on a discovery that otherwise completely insoluble Fmoc-amino acids become soluble in water by formation of certain amine salts. Critical to the successful application is the development and use of new highly hydrophilic solid supports that are compatible with the aqueous conditions. Together this approach enables the most green and sustainable chemical peptide production. The presentation will describe both green polymer chemistry and sustainable peptide assembly.



MEMBRANE ENGINEERING: WHAT ELSE?

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This lecture discusses the development of synthetic membranes and their translation to engineered solutions, aiming to improve separation of different chemical and/or biological species and the regulation of their molecular transport.

Several study cases will be addressed illustrating how membranes can play a role in chemical and biological processes, reducing energy input and optimising the use of resources. A particular emphasis will be given to the development of membranes from natural, or biologically produced, biopolymers and their use for targeting specific solutes.

Process monitoring using non-invasive molecular probing will be also presented and discussed, as well as the use of machine learning approaches to infer process performance.

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PLASMA CHEMISTRY: PROMISING TOOL FOR ELECTRIFYING CHEMICAL REACTIONS

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Plasma technology is very promising for the electrification of chemical reactions, because it operates with electricity and can be quickly switched on/off, so it is very suitable in combination with renewable electricity [1,2]. The performance, however, greatly depends on the type of plasma reactor. Dielectric barrier discharges (DBDs) operate near room temperature, and are suitable for combination with catalysts, for in-plasma catalysis, where the reactive plasma species (radicals and excited molecules) can activate the catalyst, but the underlying mechanisms to reach plasma-catalyst synergy are still far from understood, and moreover, their energy cost for gas conversion applications is quite high. On the other hand, so-called warm or quasi-thermal plasmas, such as microwave, gliding arc and arc plasmas, operate at much higher temperatures (up to 6000K), so they cannot accommodate catalysts inside the reactor, but catalysts can be thermally activated in post-plasma catalysis. Furthermore, these warm plasmas have much lower energy cost.

Typical applications include CO_2 splitting, CH_4 conversion into olefins, H_2 and valuable carbon, the combined CO_2 and CH_4 conversion (dry reforming of methane, DRM) for syngas production, CO_2 hydrogenation or partial oxidation of CH_4 for oxygenates synthesis, N_2 fixation into NH_3 or NO_x for fertilizer production, and NH_3 cracking for green H_2 formation. In this lecture, I will describe the state-of-the-art of these applications, in terms of performance metrics (conversion and energy cost). Subsequently, I will present several examples from our Plasma Lab for Applications in Sustainability and Medicine – ANTwerp (PLASMANT), both on experiments and modeling, to gain more insights and improve the various applications.

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ARTIFICIAL PHOTOSYNTHESIS MEDIATED BY IONIC LIQUIDS

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Artificial photosynthesis represents a central challenge for green and sustainable chemistry,[1] as it requires the activation of thermodynamically stable CO_2 using solar energy while maintaining selectivity and material sustainability.[2] Conventional semiconductor photocatalysts are often limited by unfavorable band-edge positions, fast charge recombination, and dominant proton reduction. In this contribution, we present recent results from our research group on ionic-liquid (IL)-modified semiconductor photocatalysts,[3] focusing on IL@TiO_2, IL@Bi-based materials, and IL@Fe_2O_3, as a unified strategy to address these limitations.

We show that immobilization of tailored ILs at semiconductor surfaces generates structured interfacial nanoenvironments that modulate band energetics, enhance charge separation, and increase local CO_2 availability. For IL@TiO_2, ILs induce interfacial electronic restructuring that facilitates CO_2 activation under solar irradiation to generate CO. In IL@Bi-based systems, IL organization stabilizes reduced CO_2 intermediates and promotes selective two-electron reduction pathways to CO. IL@Fe_2O_3 further illustrates how ILs can mediate interfacial electron transfer and proton management, enabling visible-light-driven CO_2 reduction to formate/formic acid despite intrinsic limitations of hematite.

Across these systems, we identify IL anion basicity, hydration level, and interfacial organization as key parameters governing activity and product selectivity, enabling preferential formation of CO or formic acid/formate while suppressing parasitic hydrogen evolution. These findings establish IL-modified semiconductors as tunable platforms for artificial photosynthesis and provide general design principles relevant to the development of sustainable solar-driven CO_2 conversion processes.

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SUSTAINABLE WATER TREATMENT IN HEALTHCARE: GREEN CHEMISTRY FOR GADOLINIUM REMEDIATION USING MAGNETIC NANOPARTICLES

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The growing use of gadolinium (Gd)-based contrast agents in magnetic resonance imaging (MRI) and other industrial applications has led to their detection in aquatic systems, raising environmental concerns. This study explores the use of manganese ferrite ($MnFe_2O_4$) nanoparticles as a low-cost, magnetic sorbent for the removal of Gd from contaminated water, with a focus on both efficiency and operational feasibility [1]. Batch sorption experiments were conducted under controlled laboratory conditions, with operational parameters optimized using Response Surface Methodology (RSM). Results revealed that $MnFe_2O_4$ nanoparticles exhibited a high affinity for Gd, achieving over 90 % removal within 1 hour under optimal conditions (160 mg/L nanoparticle dosage and 1.5 µmol/L initial Gd concentration in waters with 15 g/L salinity). This performance was consistent across both low- and high-salinity conditions, indicating the potential for nanoparticles to be applied in diverse wastewater environments, including effluents from hospitals and diagnostic facilities. The nanoparticles allow easy sorbent recovery after treatment, making the process more scalable and sustainable. The findings support sustainable, Green Chemistry–aligned remediation of emerging contaminants and the development of cost-effective water treatment technologies.

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GREEN DESIGN OF BIO-BASED PLATFORM CHEMICALS VIA ORGANIC CARBONATE

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The transition from fossil-based chemistry to sustainable manufacturing requires the development of synthetic methodologies that integrate renewable feedstocks, environmentally benign reagents, and resource-efficient processes. Bio-based platform chemicals derived from lignocellulosic biomass, including furanic compounds, isosorbide, levulinic acid derivatives, sugar alcohols, and other oxygenated building blocks, represent key intermediates to produce next-generation polymers, fine chemicals, pharmaceuticals, and functional materials. However, their efficient transformation often relies on hazardous reagents, toxic solvents, and multistep synthetic protocols that diminish the overall sustainability of the process.

Within this context, our research focuses on advancing the green synthesis of bio-based platform chemicals by exploiting organic carbonates as green and versatile media and reagents. Dialkyl carbonates, particularly dimethyl carbonate (DMC), have been successfully employed as environmentally benign reagents, solvents, and reaction media for the synthesis and selective transformation of biomass-derived compounds, including *D*-sorbitol, *D*-fructose, galactaric acid, and related renewable feedstocks. These organic carbonates offer a safer alternative to conventional halogenated reagents while enabling highly selective, chlorine-free transformations under mild reaction conditions.

The synthetic methodologies developed are designed not only to utilize renewable feedstocks and safer reagents but also to minimize waste generation, reduce energy consumption, simplify product isolation, and improve overall process efficiency. Particular emphasis is placed on the preparation of high-value platform chemicals and functional intermediates with potential applications in bio-based polymers, green solvents, pharmaceuticals, and specialty chemicals. The greenness of the developed processes was evaluated using established green chemistry metrics that provide quantitative tools for reaction optimization and facilitating future scale-up and industrial implementation.



GREEN SYNTHESIS OF POROUS MATERIALS AND THEIR APPLICATION IN GOLD RECOVERY

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With the rapid development of artificial intelligence, the global demand for computing power has surged, accelerating hardware iteration and leading to a continuous increase in electronic waste (e-waste). Notably, e-waste contains abundant precious metals, particularly gold, which is indispensable in electronics due to its excellent conductivity, ductility, and chemical stability. Given the scarcity and non-renewability of natural gold resources, developing efficient and sustainable strategies for gold recovery from secondary resources is of great importance for resource sustainability and the circular economy. Porous aromatic frameworks (PAFs) and covalent organic frameworks (COFs), featuring tunable structures and high surface areas, have emerged as promising platforms for metal recovery. However, conventional functionalization strategies are limited by harsh conditions, low efficiency, and poor generality. Here, we report a facile host–guest strategy to functionalize porous frameworks by directly incorporating functional polymers. Using mild in situ polymerization, polydopamine (PDA) was confined within PAF-147, affording a composite with a high gold adsorption capacity (1700 $mg \cdot g^{-1}$) and excellent stability. The recovered material can be directly used as an efficient electrocatalyst for CO_2 reduction, achieving over 95% Faradaic efficiency for CO production across a wide pH range.[1] This strategy was further extended to COFs by introducing PDA into a TATP COF.[2] The resulting TATP/PDA exhibits an ultrahigh adsorption capacity (5220 $mg \cdot g^{-1}$), ultrafast kinetics (>99% removal within 30 s), and excellent selectivity in complex systems. The enhanced performance arises from synergistic adsorption and photo-assisted reduction enabled by PDA–COF interactions. Moreover, the gold-loaded material can be reused as a photocatalyst for hydrogen evolution.

These works provide an efficient strategy for gold recovery from e-waste and advances sustainable resource utilization.

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SYNTHESIS, STRUCTURAL VARIATIONS, AND SOLAR WATER SPLITTING PERFORMANCE OF TANTALUM OXYNITRIDE

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Among visible-light-responsive photocatalysts, tantalum oxynitride (TaON) is a promising visible-light-responsive semiconductor for solar water splitting due to its suitable band gap, favorable band edge positions, and chemical stability. However, its photoelectrochemical performance strongly depends on phase purity, defect chemistry, and compositional control, which are governed by synthesis conditions. In particular, uncontrolled oxygen and nitrogen incorporation during ammonolysis often leads to mixed phases, structural defects, and reduced charge transport efficiency. Therefore, precise control of synthesis parameters and compositional modification is important to optimize the optoelectronic and photoelectrochemical properties of TaON. In this work, two complementary strategies were employed to enhance the performance of β-TaON through selective synthesis and vanadium doping. First, the role of oxygen partial pressure during ammonolysis was systematically investigated to achieve phase-selective formation of β-TaON. Ta_2O_5 precursor was converted under a regulated ammonia atmosphere with controlled oxygen partial pressure at elevated temperatures. This approach enabled the selective formation of phase-pure β-TaON at an oxygen flow rate of 0.25 $L \cdot h^{-1}$, while avoiding undesired secondary phases, such as Ta_2O_5 or Ta_3N_5. Structural, morphological, and optical characterization confirmed that precise control of oxygen partial pressure is critical for stabilizing the β-TaON phase and minimizing defect formation. Second, vanadium doping was introduced as an effective strategy to tune the electronic structure and enhance charge transport in β-TaON. Vanadium-modified β-TaON was synthesized using controlled precursor composition followed by ammonolysis under optimized conditions established in the selective synthesis study. The results demonstrated that vanadium can be selectively incorporated into the β-TaON lattice up to an optimal concentration (up to 10 at.%) while maintaining phase purity. At appropriate doping levels upto 10 at.%, vanadium substitution modified the band structure, improved light absorption, and enhanced charge carrier separation. However, excessive vanadium incorporation led to secondary phase formation and deteriorated performance, highlighting the importance of controlled doping.

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CATALYTIC UPCYCLING OF CARBON RENEWABLES

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Biobased carbon sources provide platform precursors for sustainable processes directed at fine chemical, pharmaceutical and polymer synthesis.[1] In this respect, the development of suitable catalysts that improve the overall selectivity and activity profile of such processes are vital, with positive effects related to the overall carbon footprint, carbon circularity and chemical space that can be accessed. Our group has been active in this area for over 15 years developing catalytic approaches for the conversion of carbon dioxide, terpenes and fatty acids (as example feedstocks), creating new synthetic and material opportunities boosted by the use of renewable carbon.[2,3] This presentation will devote attention to selected families of products that can be derived from these carbon sources and will highlight some of the creative solutions that were developed towards stereoselective synthesis and more sustainable polymers.[4]

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SUSTAINABLE DEPOLYMERIZATION OF POLYURETHANE FOAM WASTE IN IONIC LIQUIDS

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Polyurethane foam (PUF) is a highly versatile class of polymers applied in numerous sectors, *e.g.* mattresses, coatings, adhesives, etc. The inherent chemical robustness of PUF significantly difficult their recycling and end-of-life management, impacting the environment (*e.g.* 40 million mattresses/year are discarded in UE, via landfilling or via incineration).[1]

In this work, it is reported for the first time a sustainable depolymerization approach of PUFs at temperatures below 100 °C *via* hydrolysis, alcoholysis, and/or aminolysis (Figure 1). This strategy is based on the combination of water-miscible ionic liquids (ILs) such as 1-butyl-3-methylimidazolium chloride ([Bmim][Cl]) and superbase catalysts (*e.g.*, 1,8-Diazabicycloundec-7-ene DBU), enabling the efficient recovery of recycled products for the re-synthesis of new PUF.[2,3] In contrast to traditional chemical depolymerization approaches described in the literature, which typically require organic solvents and harsh conditions (>300 °C) the proposed process provides a white solid product at moderate conditions. Finally, the recovered product is successfully used in the synthesis of new PUFs, demonstrating its potential for industrial implementation.[4]

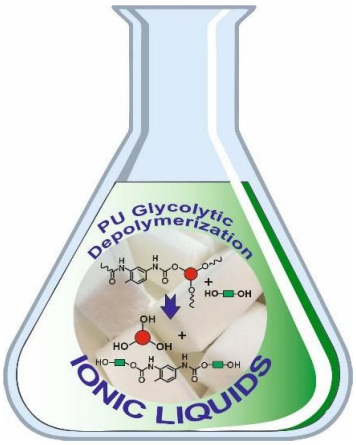


Fig. 1. Sustainable approach for PUF depolymerization in ILs.

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FROM PINE TO PERFUME: SUSTAINABILITY-DRIVEN PERFUMERY INGREDIENT INNOVATION

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The present presentation follows the sustainability-driven journey of perfumery ingredient discovery and development starting from pine-tree derived feedstock. Impact on people and planet will be evaluated using a holistic sustainability metrics tool EcoING Compass®[1] and quantitative full life cycle assessment (LCA).

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COUPLING FLOW CHEMISTRY AND BIOCATALYSIS FOR GREENER MANUFACTURING

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The combination of biocatalysis with continuous-flow technology has matured into a practical strategy for building synthetic routes that are more selective, safer, and less wasteful than their batch equivalents. This lecture presents our group's progress in designing continuous chemo-enzymatic processes, in which chemical and enzymatic transformations are coupled into uninterrupted, telescoped operations. Central to this work is the immobilization of enzymes such as lipases and laccases on 3D-printed polymeric supports, which allows tailored packed-bed reactors to be produced rapidly and reused across multiple campaigns while preserving catalytic activity. We discuss how these biocatalytic modules can be integrated with metal- and photo-catalyzed steps, including photodecarboxylation routes, to assemble cascades that would be difficult to operate in batch. Representative case studies drawn from pharmaceutical and fine-chemical targets illustrate the gains in productivity and stereoselectivity achieved under flow conditions. Throughout, performance is assessed not only by yield and selectivity but also by green chemistry metrics (E-factor, PMI, atom economy), providing an honest accounting of the environmental footprint of each route. We close by reflecting on the practical barriers to wider adoption of continuous chemo-enzymatic manufacturing, including reactor fabrication, process analytical technology, and the translation of laboratory results to scalable operations, drawing on our experience developing these platforms within a Brazilian academic and entrepreneurial setting.



INTEGRATING GREEN CHEMISTRY, BIOTECHNOLOGY AND DOWNSTREAM PROCESSING FOR BIOMASS VALORISATION

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The transition toward a sustainable bio-based economy requires the development of innovative processes capable of efficiently converting renewable resources into high-value chemicals and materials. In this talk, a selection of past and ongoing research projects dedicated to the valorisation of biomass and agro-industrial byproducts through integrated and sustainable processing strategies will be presented.

The work discussed focuses on the design of green chemistry and biotechnology-driven approaches, combining biocatalysis, chemo-enzymatic transformations and advanced downstream processing to access functional molecules from lignocellulosic biomass and other renewable feedstocks. Emphasis will be placed on the development of environmentally benign processes that maximize atom economy, reduce waste generation and operate under mild conditions, while remaining compatible with industrial constraints.

Through representative case studies, this talk will highlight how the coupling of green chemistry and biotechnological tools with smart separation and purification strategies enables the efficient transformation of complex bio-resources into valuable platform chemicals, bio-based building blocks and functional ingredients. Perspectives on process integration, scalability and future research directions toward sustainable chemical manufacturing will also be discussed.

Acknowledgments:

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CONTRIBUTION OF THE "SUSTAINABLE SCIENCES: RESOURCES, MATERIALS AND CHEMISTRY" MASTER PROGRAMME TOWARDS A BETTER FUTURE

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University programmes around the world are facing demanding times, particularly with the advent of technological innovations - such as artificial intelligence (AI) - raising questions about the kind of professionals we need to educate for the future, what content and contexts are relevant, the formats, methods and ways required to sustain these programmes [1]. In a context of interconnected multi-crises, in which Chemistry plays a key role in shaping a greener and more sustainable future, Leuphana University of Lüneburg in Germany has recently launched a new Master's programme in „Sustainability Science: Resources, Materials and Chemistry (M.Sc.)", which aims at enabling future professionals to acquire the knowledge necessary to prevent, address and propose chemistry-based solutions to the challenging yet stimulating realities they will face, whether in the academic, industrial, governmental or non-governmental sectors, amongst others [2,3]. Key topics such as digitalisation (the critical and responsible use of AI and other tools), planetary boundaries, renewable and finite resources, regenerative practices, real-life case studies, ethics and diversity - e.g. why gender is an important consideration when addressing chemical pollution - are addressed in line with the most up-to-date teaching approaches for the development of emancipatory and systems thinking, committed to the common good worldwide, in an inter- and transdisciplinary manner. In this presentation, the issues that underpinned the creation of this Master programme, the results achieved to date and the challenges faced and potentials will be addressed, with a view to establishing RD&I educating and capacity building pathways in Green Chemistry and Sustainable Chemistry [4].

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SUSTAINABLE MATERIALS FROM WASTE: A GREEN CHEMISTRY APPROACH

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In conjunction with the growing interest in developing circular economies through the substitution of fossil resources with more sustainable ones, renewable resources including biomass, industrial food byproducts, plastic wastes etc, are surfacing as potential, viable alternatives. In alignment with the principles of green chemistry, the consideration of these resources as secondary feedstocks is gaining interest and is expected to remain a focal point of attention in the forthcoming era of sustainable development. In fact, these waste streams are not only abundant, renewable, and sustainable but also offer a boundless potential to supplant or supplement fossil fuel resources. Consequently, the sustainable conversion of these resources into high high-value eco-friendly chemicals, polymers, and materials is evolving as a promising solution to address the expected scarcity of fossil resources and pressing concerns of sustainability and ecological stewardship.

Harnessing the vast potential of these renewable resources as chemical platforms to produce high-added value chemicals, polymers, and materials within the framework of novel, sustainable refinery and conversion concepts. These concepts involve the holistic transformation, processing, and valorization of all components to yield high-value, non-traditional applications. However, key challenges persist in optimizing environmental and economic sustainability through the integration of traditional and innovative technologies to identify more competitive and higher value applications. This presentation will provide a concise overview of a selection of illustrative examples from our research, highlighting the synergistic utilization of waste streams as renewable feedstocks for green chemical transformations. The development of novel polymeric materials with tailored architectures and properties will be showcased, along with their potential applications.

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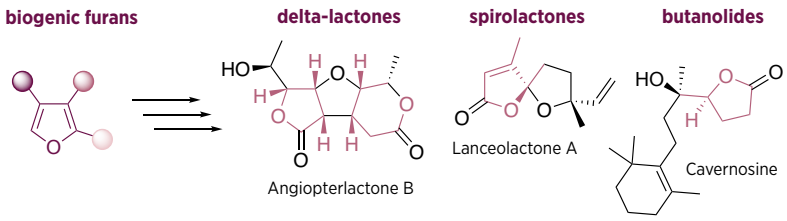
TUNABLE ENZYME CASCADES: A MODULAR BIOCATALYTIC PLATFORM FOR THE VALORIZATION OF BIOREFINERY FURANS

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Enzyme cascades are systems in which multiple biocatalysts act productively within a single reaction vessel, capturing the efficiency of metabolic multi-step logic while affording the chemist full control over each catalytic component. Their integration into synthetic sequences directly addresses several of the of Green Chemistry Principles. Most notably, by telescoping reactions into one pot, costly intermediate isolation steps are eliminated, waste streams are minimised, and overall solvent consumption is sharply reduced. The modular architecture of these networks makes them uniquely adaptable platforms for the sustainable synthesis of complex chiral molecules, from pharmaceutical intermediates to natural product scaffolds.[1]

This talk will highlight the potential of enzyme cascade designs in the valorization of biogenic furans, which are typically derived from the refinery of lignocellulosic biomass, and are therefore considered a promising renewable feedstock for functionalized chemical building blocks. Combining enzymatic oxygenations for the rearrangement of the furan core structure,[2] with asymmetric reductions to facilitate enantioselective synthesis, and redox self-sufficient borrowing hydrogen-type isomerizations, numerous different pathways can be addressed and various molecular scaffolds and complex natural products become readily accessible.[3-7]



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CHALLENGES FOR SCALABLE CONTINUOUS THERMAL, PHOTOCHEMICAL AND ELECTROCHEMICAL REACTIONS

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Photochemistry and electrochemistry are potentially very powerful tools for chemical manufacturing not least because energy is delivered to reacting molecules in an atom efficient manner, far more selectively than by bulk heating. Indeed, more than a century ago, Ciamician, presented a very powerful vision of where photochemistry could lead us [1]. Since then, photochemistry has become a major strand of chemical research in academia. By comparison, its impact on chemical manufacture remains comparatively modest because of a whole series of issues, mostly centred on the problems of carrying out large-scale photochemical reactions both efficiently and safely. In recent years we have been addressing some of the challenges of making photochemistry and electrochemical synthesis greener, more energy efficient and more widely accessible. This lecture will cover our approaches for linking and scaling up multi-step processes in the context of photo-, electro- and thermal- chemistry on a multi-kilogramme scale particularly focussed on continuous photo-redox and oxidative and reductive electrochemical processes enabling 1-10 kg/day productivity in Taylor Vortex reactors with a very small footprint [2-5]. Existing and new Process Analytical Technology (PAT) approaches are exploited in autonomous flow reactors with self-optimisation with the aim of improving sensitivity, specificity, dynamic range and the speed of data acquisition, to be coupled with AI innovations. We thank all coworkers, collaborators and funders especially EPSRC and industrial sponsors.

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FROM DEEP EUTECTIC SOLVENTS TO BIOMASS-DERIVED LEACHING SYSTEMS: TOWARDS GREEN SOLVENT ENGINEERING FOR SUSTAINABLE BATTERY RECYCLING

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This work presents an integrated approach based on two complementary green solvent platforms: deep eutectic solvents (DES) and biomass-derived leaching systems. Choline chloride-based DES were investigated as recyclable leaching media for the efficient extraction of valuable metals under mild conditions[1]. Building on this strategy, a fully bio-based solvent obtained from *Arbutus unedo* L. distillers' grains was developed, acting simultaneously as leaching medium and reducing agent[2]. The optimized bio-based system achieved lithium recoveries up to 85% with approximately 88% selectivity while minimizing Ni and Co co-leaching. Spectroscopic analyses indicated that naturally occurring polyphenols, organic acids and reducing sugars promote metal dissolution through synergistic redox and complexation mechanisms, enabling the subsequent recovery of high-purity Li_2CO_3 and $Mn(OH)_2$. Together, these complementary solvent systems demonstrate how green solvent engineering can advance low-impact hydrometallurgical recycling, contributing to circular and more sustainable recovery of critical raw materials from spent LIBs.

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BRILLIANT CRESYL BLUE ELECTROPOLYMERIZATION IN DEEP EUTECTIC SOLVENTS FOR COPPER CORROSION INHIBITION

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Corrosion inhibition of copper remains a major challenge due to the economic losses associated with material degradation [1]. Organic inhibitors, particularly nitrogen-containing compounds such as amines and azole derivatives, are widely used for copper protection [1], while electroactive redox polymer films have also been investigated as protective coatings [2,3]. Deep eutectic solvents (DES) are promising non-aqueous electrolytes for electrodeposition due to their low toxicity, high thermal stability, low volatility, biodegradability, and low cost [4]. In this work, brilliant cresyl blue (BCB) monomer solutions were prepared in three binary DES—ethaline, reline, and glyceline—with HNO3 as dopant to improve conductivity. The polyphenazine poly(brilliant cresyl blue) (PBCB) film was investigated as a corrosion-protective coating on copper electrodes using open-circuit potential measurements, Tafel plots and electrochemical impedance spectroscopy. Initially, the polymer film was electropolymerized directly on copper in DES without pre-treatment. Alternatively, copper electrodes were first passivated in hydrogen carbonate solution to prevent dissolution at potentials where phenazine monomer oxidation occurs, followed by PBCB formation by potential cycling in DES. Corrosion inhibition was evaluated in 0.10 M KCl solution. The highest protection efficiency (PE), 88.39% after 4 h of immersion, was achieved for PBCB films electropolymerized in ethaline DES on copper without prior passivation.

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STRATEGIES AND TOOLS FOR ACHIEVING QUALITY EDUCATION (SDG 4) THROUGH GREEN AND SUSTAINABLE CHEMISTRY CURRICULUM REFORM

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Since the publication of the *Twelve Principles of Green Chemistry* [1] twenty-eight years ago, educators have sought to incorporate examples into their laboratory and lecture curriculum to improve safety, reduce waste, and model innovative and responsible design of chemical products and processes. These efforts evolved over the years to recognize the green principles as effective tools to be partner with teaching the broader challenges of sustainable chemistry (including social, economic, and environmental considerations) and the application of systems thinking. Chemistry educators now have a plethora of materials, interactive visualizations, case studies, experiments, and networks available to support modernizing their instruction to best prepare students for careers that will contribute to a sustainable future.

This presentation will model the author's strategy for integrating green chemistry, the UN Sustainable Development Goals [2], and systems thinking into curriculum using the "plastics dilemma". Students recognize the importance of polymers/plastics in their lives as well as the harm they are causing to human health and the planet; most recently in the form of microplastics found in food and water supplies. Novel experiments, based on literature publications and emerging commercial technologies, demonstrate retaining student learning outcomes while incorporating real-world sustainability challenges related to polymer feedstocks, chemical synthesis, design for functionality, and end of life. A systems thinking approach also considers interconnected subsystems necessary to avoid unintended harmful consequences. The resources used enable curriculum reform for chemistry educators of all disciplines to advance quality education for sustainable development.

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NEW BIODEGRADABLE MATERIALS BASED ON NATURE-SOURCED POLYSACCHARIDES

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Nature-sourced biodegradable polymers can be utilized as active films, coatings and delivery systems. Such materials respond to customer demands for safe and healthy approaches and satisfy environmental concerns. Among biopolymers, polysaccharides are considered particularly promising candidates since they are sustainable, safe, and hypoallergenic materials that are also abundant and inexpensive. An important advantage of polysaccharides is that their defined chemical structure allows rational modification and precise tuning of their properties. We utilize covalent modifications and non-covalent approaches (sonochemical deposition, layer-by-layer design, nanoemulsification) to control physicochemical properties and functionality of the resulted biodegradable materials. In this lecture, we will present delivery systems based on modified polysaccharide derivatives that could encapsulate molecular cargoes of various polarities (from highly hydrophobic to ionic compounds) in aqueous and lipid environments and transport them through biological barriers, opening up numerous potential applications in various fields such as medicine, cosmetics, food and agriculture. In addition, we will present, polysaccharide-based active films and packages that can be used in food, agriculture and other applications. Finally, we will be presented polysaccharide-based edible coatings that can protect food products from physical, mechanical and microbial damages.



PHOSPHONIUM POROUS IONIC LIQUIDS DESIGNED FOR EFFICIENT CARBON CAPTURE AND CONVERSION

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Conventional technologies for selective CO_2 capture from complex gas mixtures remain energy intensive and difficult to couple with downstream conversion. New chemistries are therefore required to enable efficient capture while remaining compatible with catalytic transformation and favourable life-cycle impacts. Ionic liquids have emerged as a promising platform for integrated approaches. Their negligible volatility minimises solvent losses under continuous gas flow, while their tunability enables optimisation of chemical, thermal, and electrochemical stability under conversion conditions. Their potential for reuse and streamlined synthesis may further reduce environmental impact. However, different IL families involve trade-offs between stability, reactivity, and sustainability.

We demonstrate how tailored phosphonium-based ionic liquids can serve as robust platforms for integrated carbon capture and utilisation. Carboxylate anions with sufficient basicity activate the phosphonium cation toward CO_2 chemisorption, achieving high capture capacity and selectivity while maintaining fluidity [1],[2]. Moreover, bulky ions enable porous ionic liquids as stable suspensions of metal organic frameworks such as ZIF-8, enhancing gas absorption and facilitating catalytic or electrocatalytic transformations under mild conditions [3],[4]. Temperature- and pressure-dependent studies elucidate parameters governing absorption mechanisms and speciation equilibria, guiding reactivity models to predict competing pathways during CO_2 capture and conversion.

Overall, we established molecular design rules and identified promising ionic liquid families that balance competing performance requirements. These findings support practical, energy-efficient and environmentally friendly systems for applications including large-scale flue gas treatment and distributed biogas upgrading to biomethane.

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GREEN CONSTRUCTION AND APPLICATIONS OF HIGH-PERFORMANCE NANOCATALYSTS

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Metal–organic frameworks (MOFs) can accommodate diverse guest molecules, yet the in situ encapsulation of cationic mechanically interlocked species under mild conditions remains elusive. We report a green strategy that embeds a cationic [2]catenane (DA[2]C) into UiO-66-F_4 at room temperature in water, affording DA[2]C•4Cl/UiO-66-F_4 with outstanding detoxification activity (>99% conversion, >97% selectivity). Furthermore, we demonstrate for the first time that high-energy electron-beam irradiation enables ultrafast desilylation–coupling of HEB-TMS to produce GDY within seconds. The resulting Cu_2O/GDY achieves exceptional NO_3RR performance, with 94% Faradaic efficiency and an ammonia yield of 26,997 μg h^{-1} mg^{-1}. This work establishes scalable ultrafast GDY synthesis and underscores its promise in advanced catalysis.

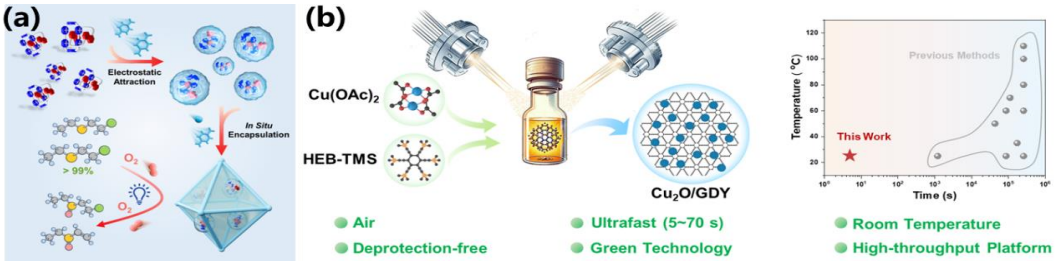


Fig. 1 (a) Room-temperature construction of [2]catenane@UiO-66-F4 photocatalyst in aqueous medium; (b) ultrafast electron-beam irradiation synthesis of graphdiyne (GDY).

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FROM LIGHT–MATTER INTERACTIONS TO BIOHYBRID FUNCTIONALITY: CARBON BASED PHOTOCATALYSTS FOR SUSTAINABLE ENERGY, ENVIRONMENT, AND HEALTH

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A detailed understanding of light–matter interactions is essential for advancing sustainable chemical and biomedical technologies. Heterogeneous photocatalysis has emerged as a versatile platform for energy conversion, environmental remediation, and selective chemical transformations, while increasingly interfacing with bio-inspired and therapeutic applications. Our research focuses on the design, modification, and application of semiconductor photocatalysts, particularly carbon nanotube and graphitic carbon nitride-based materials.

Photocatalytic systems are explored in water treatment, solar hydrogen generation, and the valorisation of biomass-derived substrates. Graphitic carbon nitride offers a robust and tunable framework with visible-light activity. Increasingly, carbon-based materials are integrated into hybrid platforms combining catalytic function with molecular recognition and delivery. Nanostructured carbons enable new strategies for controlled transport and interaction with complex biological environments [1]. Photocatalytic behaviour is assessed under realistic conditions, linking material properties to performance beyond idealised systems. This integrated approach supports the development of sustainable technologies for energy, environment, and health.

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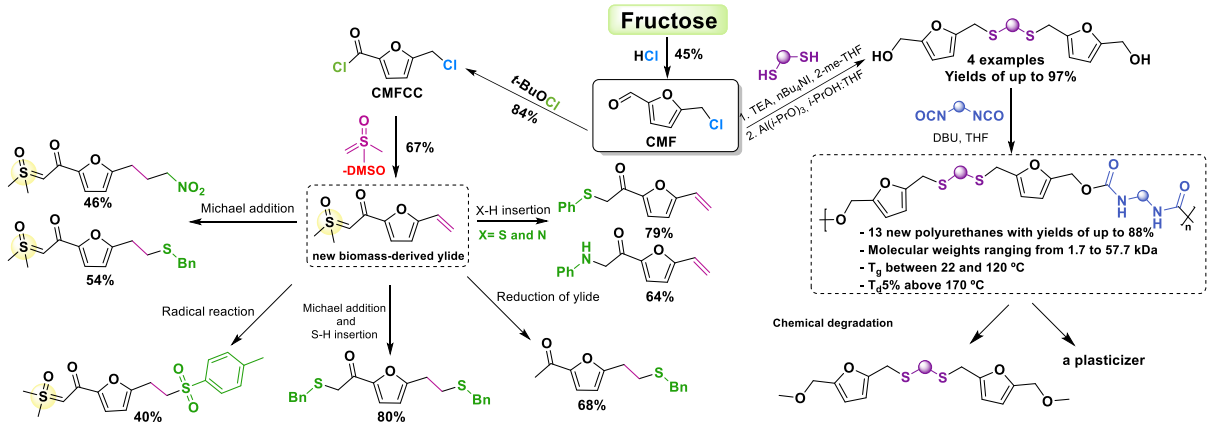
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NEW POLYMERS AND FURAN DERIVATIVES FROM CMF

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Furan derivatives from renewable carbohydrates have emerged as versatile platforms in sustainable chemistry, with 5-(chloromethyl)furfural (CMF) standing out due to its high reactivity and broad synthetic applicability.[1,2] In this work, CMF was explored as a central building block in two distinct synthetic routes. CMF was first converted into sulfur-containing diols via reaction with dithiols followed by reduction. These intermediates were subsequently used in polyaddition reactions with diisocyanates, affording a novel series of sulfur-containing polyurethanes. Chemical degradation studies indicated potential for recycling, reinforcing the sustainable character of these materials. In parallel, CMF was transformed into α-carbonyl sulfur ylides, via the corresponding acid chloride (CMFCC), in yields up to 67%. These intermediates demonstrated broad synthetic versatility, affording functionalized furan derivatives in moderate to good yields. Overall, this work demonstrates how a single biomass-derived intermediate, CMF, can be integratively employed to access both functionalized molecules and advanced polymeric materials. This approach expands the scope of furan chemistry and reinforces the role of biomass as a strategic renewable source for organic synthesis and materials science.



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GREEN PROCESSING TECHNOLOGIES IN NEW ZEALAND'S BIOECONOMY

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New Zealand is a producer and exporter of primary and secondary goods derived from biological materials. These include products from marine, agricultural, horticultural, forestry and fermentation sectors. The processing of raw materials from these sectors is evolving from being labour and energy intensive to automated and energy efficient, with an increased focus on secondary processing and utilisation of by-products from the primary processing to generate further value. In this presentation, the use of green chemical engineering technologies to process bioresources streams to added value is discussed, with a particular focus on two key research programs: the Bioresource Processing Alliance (BPA) and Cyber-Marine. The BPA is a multi-party research collaboration established to provide a best team, best equipment approach to adding value to biologically-derived byproduct streams through green processing technologies whilst simultaneously reducing environmental impact. Cyber-Marine is also a multi-party research program aiming to design the 'fish and aquaculture processing factory of the future' utilizing AI and a suite of advanced processing technologies to maximise value from landed catch and aquaculture species. In both programs, supercritical extraction is a key processing technology that is used in conjunction with other green processing technologies to extract and purify high value lipophilic bioactives for use as nutraceutical and functional food ingredients. Selected outcomes from both programs are discussed along with developments in the use of Gas eXpanded Liquids (CO_2 + high co-solvent) and dimethyl ether as an alternatives or adjuncts to supercritical CO_2 for extraction of bioactives that contribute to new Zealand's bioeconomy.

Acknowledgments:

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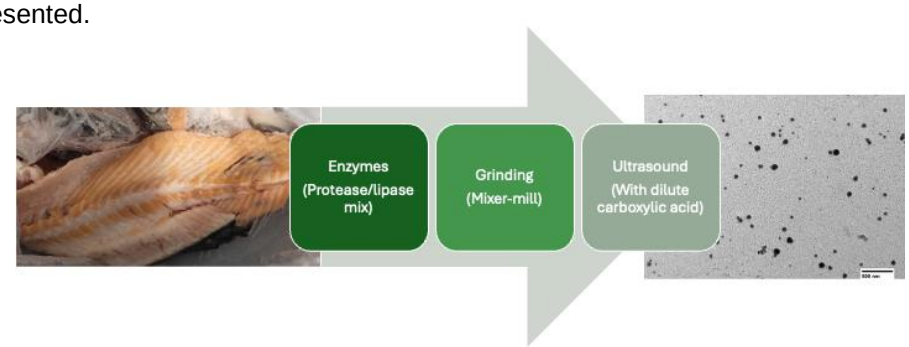
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SEAFOOD BY-PRODUCTS AS FEEDSTOCKS FOR A BLUE CIRCULAR BIO-ECONOMY

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Demand for fish and seafood has grown as the global population increases. Solutions are needed to address waste management issues related to seafood processing. Current disposal methods are environmentally damaging as they release greenhouse gases and/or cause ocean eutrophication. While waste bones are considered low value as they are inedible, they are a potential feedstock for hydroxyapatite (HAP). Our group has developed an industrially viable method to isolate collagen-containing HAP from Atlantic salmon (Salmo salar) waste using protease and lipase enzymes simultaneously in tap water.[1] To validate our method for industrial application, we successfully isolated >100 g of HAP by treating 15 salmon frames (backbones), and performed a simplified gate-to-gate life cycle analysis (LCA). The cleaned salmon bones were further transformed to HAP nanoparticles (nHAP) using a combination of mechanochemistry (ball-milling) and ultrasound. sHAP sonicated in 10% propanoic acid for 15 min produced stabilized nHAP particles with an average diameter of 32 nm via TEM data.[2] Once again, to prove this process is more sustainable and greener than existing methods, an LCA was performed. Compared with traditional routes to prepare bio-derived nHAP, our mechanochemical-sonochemical treatment has a 97% reduction in CO_2 emissions. This and our latest results will be presented.



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POWER WITHOUT PERIL ELECTROSYNTHETIC ACCESS TO HIGHLY REACTIVE INTERMEDIATES

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Highly reactive intermediates are among the most powerful tools in synthetic chemistry, yet their preparation and use have traditionally relied on hazardous reagents, unstable precursors and operationally demanding procedures. Synthetic organic electrochemistry offers an attractive alternative, enabling reactive species to be generated selectively and on demand, with electricity serving as a traceless reagent.

In this talk, I will present our development of safer, more sustainable and operationally practical electrosynthetic methods for accessing and exploiting highly reactive organic intermediates. Examples will include carbocations, cyanating and fluorinating species, isocyanates and diazo compounds. These approaches provide practical alternatives to conventional reagent-based methods, reducing inherent hazards while expanding synthetic utility and enabling new chemical disconnections.

I will also discuss the translation of these reactions from batch to scalable flow-electrosynthesis platforms, including the containment and immediate consumption of transient intermediates. Industrial collaborations and case studies involving GSK, AstraZeneca and Johnson & Johnson will illustrate the relevance of these methods to medicinal chemistry and process development. Collectively, this work demonstrates how electrosynthesis can transform highly reactive intermediates from hazardous liabilities into practical tools for modern organic synthesis.





INTERFACE-SELECTIVE DISASSEMBLY OF MULTI-MATERIAL ASSEMBLIES VIA ELECTRICAL PULSE STIMULATION FOR INNER-LOOP CIRCULAR ECONOMY

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Conventional recycling of multi-material assemblies relies on bulk crushing and thermal or chemical treatment, producing mixed fractions that hinder component-level reuse and energy-efficient recovery. An inner-loop circular economy requires selective separation at material interfaces so that each constituent is recovered at an equivalent functional quality. This study proposes interface-selective disassembly using high-voltage electrical pulse stimulation to induce controlled delamination without extensive comminution.

This method exploits the contrast between the dielectric breakdown strength and electrical resistance of adjacent materials. When the applied field exceeds the local breakdown strength, interfacial dielectric breakdown forms plasma channels that generate shock waves and mechanical stresses. Simultaneously, Joule heating develops according to the electrical resistance, weakening the adhesion through selective interfacial heating. These coupled electrical, thermal, and mechanical effects occur most readily at conductor-insulator interfaces and drive controlled delamination.

The approach was demonstrated for laminated lithium-ion battery electrodes and photovoltaic panels, including perovskite solar cell modules, and was further extended to CFRP and dissimilar material adhesive joints. In lithium-ion batteries, current collector foils and active materials were separated without heating or chemical reagents, and the recovered cathode active material retained high purity and chemical structure, enabling direct recycling. To address tightly encapsulated products where the pulse energy does not readily reach the internal interfaces, a stimulus-responsive dismantlable adhesive containing conductive nanoparticles was developed to trigger internal discharge under electrical pulse stimulation.

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CATALYTIC UPGRADING OF LIGNIN TO CHEMICALS AND FUELS

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Renewable aromatics and cyclic hydrocarbons represent biorefinery chemicals of paramount importance due to their wide range of applications as fuels/additives, solvents and polymer precursors. Lignin, originally regarded as side stream in pulp and paper industry and later in cellulosic ethanol processes, has become the preferred bio-source due to its phenolic/aromatic structure, yet with a lot of challenges to be addressed. Lignin itself has shown impressive reactivity and miscibility with phenol-formaldehyde and epoxy resins, but in this presentation, we will focus on downstream depolymerization and conversion to BTX aromatics (as platform chemicals) and alkyl-cycloalkanes (as drop-in fuel components). Fast pyrolysis and hydrogenolysis are two mature processes to convert lignin to phenolic and/or aromatic oil, depending on catalyst type and process conditions. Such phenolic bio-oils can serve as source of monomers/oligomers for the production of epoxy resins or can be hydrodeoxygenated towards (alkyl)cyclohexane hydrocarbon fuels. In this latter approach, we use simple and robust bifunctional (non-sulfided) catalysts, mostly based on nickel (Ni) as the hydrogenation metal. Co-hydroprocessing of lignin oils with hydrocarbons and crude oil may result in streams enriched in alkyl-cycloalkanes/aromatic and isoparaffins, suitable for gasoline, SAF or diesel fuels. Advanced characterization of lignin/oils/products and catalysts are necessary to understand and further optimize lignin upgrading towards potential upscaling and commercialization. Furthermore, recent results on chemical recycling/upcycling of phenol/lignin resins and related composite products/wastes (i.e. used furnitures) will be discussed.

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COLLABORATIVE INNOVATION IN BIOCATALYSIS FOR GREEN AND SUSTAINABLE CHEMISTRY

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Biocatalysis has evolved from a niche synthetic option into a widely applied technology for the preparation of chiral and non-chiral building blocks, intermediates and active pharmaceutical ingredients, with strong alignment to the principles of green and sustainable chemistry. Advances such as directed evolution, in silico enzyme design, high-throughput screening, automation and robotics have enabled the development of biocatalysts capable of meeting the demands of industrial process conditions. Even so, important limitations remain in the range of robust chemical transformations currently accessible through biocatalytic methods.

This presentation will highlight how external collaboration can accelerate the expansion of the biocatalytic toolbox and support more sustainable pharmaceutical manufacturing. Drawing on AstraZeneca's recent experience, it will discuss a diverse portfolio of academic collaborations established to address key scientific and technical gaps in biocatalysis, with the shared goal of enabling new reactivity and improving industrial applicability.

The talk will also place this work in the broader context of collaborative innovation platforms such as **BridgeHouse**, which brings together **AstraZeneca**, **Scania** and **RISE**, and innovative SMEs to advance sustainability-focused solutions. By connecting emerging companies with infrastructure, expertise and development support, such models help reduce time to impact and accelerate validation and scale-up toward industrial implementation. In areas including green chemistry and biocatalysis, these partnerships illustrate how cross-sector collaboration can translate scientific innovation into practical tools for a more sustainable pharmaceutical industry.

Together, these examples show that collaboration across academia, industry and innovation ecosystems is not only expanding the reach of biocatalysis, but also helping shape a more sustainable future for pharmaceutical process development.



MACHINE LEARNING FOR SUSTAINABLE CHEMICAL SCIENCES

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Machine learning has become an important tool in the chemical sciences. With improved hardware, storage capacity and algorithms, together with a wealth of publicly available data, one can now automate different tasks. For example, retrosynthetic analyses, the prediction of reaction products and process optimization have become viable and explored in recent years. In this talk, I will discuss how we have been using machine learning algorithms for reaction discovery and for the optimization of reaction conditions. Specifically, I will discuss use cases for LabMate.ML where we were not only able to optimize reaction conditions under low data settings but also uncover new chemical knowledge that remained hidden to expert chemists [1, 2, 3].

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SUSTAINABLE SELF-CHARGEABLE TEXTILE ENERGY TECHNOLOGIES POWERED BY MULTIFUNCTIONAL BUILDING BLOCKS

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The continuous growth of wearable electronics is creating new challenges for energy systems that must be light, flexible, safe and able to operate close to the human body. At the same time, the transition towards clean and sustainable energy technologies is driving the search for new materials and device concepts able to reduce dependence on conventional power sources. Textile supercapacitors are particularly relevant due to their high power density, fast charge–discharge response, long cycle life and mechanical robustness.[1] More recently, self-chargeable textile supercapacitors have opened new opportunities to integrate energy harvesting and electrochemical storage within the same device architecture. In particular, thermally-chargeable textile supercapacitors can be highlighted since they harvest thermal energy from temperature differences between the human body and the surrounding environment, converting it into electrical energy while simultaneously storing the generated energy for on-demand use.[1]

This keynote will present our recent advances in sustainable self-chargeable textile energy technologies, following a journey from the rational design and engineering of multifunctional electrode and electrolyte building blocks to textile integration and assembly into wearable-compatible prototypes through environmentally friendly and scalable processes [2–4]. The electrochemical performance, self-charging ability, upscaling potential and practical feasibility of the developed technologies for powering low-power electronic devices will be showcased.

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PAVING NEW AVENUES FOR EUTECTIC SYSTEMS IN CHEMICAL INDUSTRY

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In 2014, disclosing Natural Deep Eutectic Systems as solvents for the 21st century [1], many applications have been explored and the knowledge gathered combining fundamental and applied research grew exponentially. More than 10 years after the boom of research in eutectic systems started, in this presentation new avenues will be disclosed. Is there still room for innovation? There certainly is. These solvents consist in a mixture of two or more natural components which at a specific molar ratio, result in a liquid system, at room temperature, mainly due to hydrogen bond interactions, which cause a great depression in the melting point of the system. In this work we will disclose the potential of these systems to design safer diluents for chemical industry and conservation and restoration, based on the study of their physico-chemical properties. [2] Being used as diluents, could NADES replace toxic organic solvents in the formulation of natural varnishes? One of the main challenges conservators and restorers continue to face is the reliance on solvents that are toxic, flammable, hazardous, and potentially carcinogenic, but that are commonly used in the removal of aged varnishes and in varnish formulations (e.g., spirit varnishes). Hence, it urges their replacement for alternative greener ones. In a different application, NADES are also suggested as solvents for bitumen fractionation and recovery, demonstrating that the potential of green solvents goes further than what has been disclosed in the literature and the imagination is the limit.

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REINVENTING HIERARCHICAL ZEOLITE Y CATALYSTS FOR REDEFINING SUSTAINABLE BIOFUEL PRODUCTION

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Energy is indispensable in the 21st century especially the aviation sector faces increasing pressure to decarbonize, making sustainable aviation fuel (SAF) a critical biofuel for reducing lifecycle carbon emissions while remaining compatible with existing infrastructure. However, efficient catalytic conversion of bulky lipid-based feedstocks into hydrocarbon-like fuels remains a major challenge. Zeolite Y is a well-established solid acid catalyst owing to its large uniform micropores (0.73 nm), high surface area, and strong intrinsic acidity. Nevertheless, it purely microporous structure imposes severe diffusional limitations for bulky molecules, which resulting in low catalytic activity and rapid deactivation due to pore blockage. To address this issue, we have created hierarchical nanosized zeolite Y with 50 nm and uniform mesopores of 5.8 nm. It shows high acidity (1.73 mmol g^{-1}) with a Brønsted-to-Lewis acid ratio of 0.24. Catalytic evaluation via hydrogen-free deoxygenation of triolein at 380 °C demonstrated superior performance with 61% conversion and 69% hydrocarbon selectivity compared with 47% and 60% for conventional nanosized zeolite Y. The performance also improved significantly after loaded with Ni with more than 80% yield of hydrocarbon-like biofuel without significant loss of activity even after repeated reused. These results highlight Ni supported on hierarchical nanosized zeolite Y as a promising catalyst platform for biofuel processes involving bulky molecules. T for green biofuel production. The integration of nanostructured acidity engineering with scalable green biofuel production provides a catalytic paradigm that supports the United Nations Sustainable Development Goals 7 (Affordable and Clean Energy) and 13 (Climate Action).

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CHEMISTRY FOR SUSTAINABILITY – FROM SYSTEMS THINKING TO MATERIAL STEWARDSHIP

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Incorporation of systems thinking into chemistry was proposed for the first time in 2016 by the Chemists for Sustainability (C4S) group at the International Organization for Chemical Sciences in Development (IOCD). Subsequently, the introduction of systems thinking into chemistry education has become a worldwide movement and it has also been applied to exploring the interfaces between chemistry and other areas, including in relation to health, human security, resilience and sustainability. Chemistry's great success as the science of transformation of matter has led to an exponential increase in the total number of chemical substances known, and to rising amounts of anthropogenic mass in use globally, which has doubled every 20 years since 1900, while material extraction had accelerated since the year 2000 and overall tripled over the last 50 years. Impacts caused by resource extraction, processing, waste and pollution include biodiversity loss and water stress, as well as ocean acidification and global warming. In response to the unsustainable levels of anthropogenic transformation of matter that are depleting usable stocks of the Earth's minerals and damaging the physical and ecological Earth systems on which we depend, C4S has proposed that chemistry should adopt material stewardship as its mission to guide its contributions to sustainability. Key principles for this mission and examples of its use will be set out in the presentation.



MIXED MATRIX COMPOSITE MEMBRANES DESIGN USING DIRECT SPRAY-COATING TECHNIQUE

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The development of membranes has evolved over the last years as an effective CO_2 separation technology to fight environmental impact of post-combustion processes. In this regard, the upgrade of conventional polymers has been approached through different strategies to overcome their permeance-selectivity trade-off. Mixed matrix membranes (MMMs) combine the benefits of fillers within a polymeric matrix to increase the CO_2 perm-selectivity. More specifically, the coupling of metal-organic frameworks (MOFs) with high CO_2 sorption capacity and CO_2-selective plasticizers, such as ionic liquids (ILs), has the potential to further improve the mechanical stability of membranes and their performance concerning CO_2 transport. In this work, Pebax®1657-based membranes combining the MOF ZIF-8 and 1-Ethyl-3-methylimidazolium bis(trifluoro methane sulfonyl)imide ([EMIM][Tf_2N]) IL have been optimized in terms of materials loading in a self-standing framework. Then, their transition to a composite material using the spray coating technique has been addressed with a simple double-step protocol, avoiding the need of an intermediate gutter layer. Composite membranes as thin-film composite (TFC) membranes have the appeal of increasing the membrane permeance maintaining the selectivity from self-standing membranes. Here it is described the capacity of the spray coating technique to convert advanced MMMs into TFC-MMMs to further evaluate them in CO_2 separation processes.

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GREEN EXTRACTION OF PROPOLIS FOR SUSTAINABLE PRESERVATION OF ARTISANAL CHEESES

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Propolis is one of the products derived from beekeeping and whose commercial value is globally recognised.[1] In parallel, Portugal has a long-standing tradition in artisanal cheese production, recognised nationally and internationally for its cultural relevance and distinctive sensory characteristics. To uphold traditions, the BEE4CHEESE project is applying Green Chemistry principles to the valorisation of propolis as a natural preservative for artisanal cheeses. In this context, alternative extraction strategies were developed. Ultrasound-assisted extraction (UAE) was employed as a green technology, enabling reduced extraction times, lower energy consumption, and improved mass transfer. Different solvent systems were evaluated, including conventional solvents (ethanol and glycerol) and natural deep eutectic solvents (NADES), composed of biodegradable and food-grade components. NADES systems, particularly lactic acid/1,2-propanediol and menthol/1,2-propanediol, showed high extraction performance, yielding up to ~167 mg GAE/g of total phenolics and ~65 mg QE/g of flavonoids, comparable or superior to ethanol. Furthermore, the UAE process was successfully scaled up to 500 g of raw propolis, achieving extraction yields above 80%, demonstrating its feasibility for industrial application.[2] This scalability reinforces the potential of integrating green extraction technologies into sustainable agri-food value chains.

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FROM BIORENEWABLES TO BIOACTIVE MOLECULES AND DRUGS

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The production of biomass-based chemicals and the development of innovative technologies for biomass processing are expanding rapidly as the global economy transitions from fossil-based resources to more sustainable alternatives [1]. While this growth has been driven primarily by the demand for high-volume commodity chemicals used in materials and energy applications, the progressive depletion of fossil-derived feedstocks also necessitates the development of renewable sources of highly functionalized synthetic intermediates for the drug discovery and pharmaceutical industries. My talk will focus on the latest developments from our research group that combine transition metal catalysis with biogenic feedstock for the synthesis of complex bioactive scaffolds. Particular emphasis will be placed on the application of these methodologies to the scalable synthesis of marketed drugs, together with an assessment of the sustainability of the developed processes using green chemistry metrics. From the perspective of synthetic chemistry and catalysis, the talk will also cover the underlying reaction mechanisms, the scope and limitations of the methodologies, and the key factors governing their efficiency and selectivity.

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GREEN THERMOCHEMICAL ROUTES FOR SUSTAINABLE RESOURCE VALORISATION

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The shift towards sustainable chemical manufacturing requires innovative strategies for converting renewable biomass into high-value materials. This study presents a green chemistry approach for valorising lignocellulosic residues through thermochemical conversion methods that aim to maximise resource efficiency and minimise environmental impact. Agricultural and forestry by-products, including corncobs, nutshell biomass, pinewood shavings, coconut residues, and invasive woody species, are examined as renewable feedstocks for producing bio-oils and carbon-rich materials. Techniques such as microwave-assisted hydrothermal carbonisation, thermochemical liquefaction, and combined solvothermal–pyrolysis are employed to convert biomass into bio-oil intermediates and char. Process parameters like temperature, reaction time, catalyst concentration, and biomass-to-solvent ratios are optimised using Response Surface Methodology, allowing precise control of conversion yields. Further research assessed sustainable solvents for biomass liquefaction, achieving conversion efficiencies above 95%, demonstrating the potential for renewable solvent systems to enable cleaner processing. Moreover, integrated thermochemical pathways that combine mild solvothermal decomposition and pyrolysis facilitate the selective synthesis of high-value compounds, such as phenols and levoglucosenone, from lignocellulosic residues. The results highlight the promising role of integrated thermochemical technologies in transforming low-value biomass and industrial residues into advanced carbon materials and chemical intermediates, with applications across diverse industries. This approach supports circular economy initiatives by promoting waste valorisation, renewable feedstocks, and eco-friendly reaction systems within emerging biorefinery frameworks.

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FROM PROFESSIONAL DEVELOPMENT TO PEER MENTORING: EMPOWERING EDUCATORS TO TEACH AND PRACTICE GREEN CHEMISTRY

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Green chemistry education is critical for achieving a sustainable future, equipping the next generation of scientists to design products and processes that are inherently safer for human health and the environment. [1] By training future molecular designers to understand green chemistry concepts, toxicology and life-cycle impacts, education systems can better prepare a workforce capable of solving global challenges like climate change and resource depletion. However, many educators feel underprepared to teach these concepts due to a lack of formal training and systemic barriers like crowded curricula. [2]

To bridge this gap, Beyond Benign and its partners provide systemic support through structured professional development and collaborative peer mentoring. Professional development initiatives—including workshops, webinars, and online courses—build foundational content knowledge and pedagogical skills.[3] Simultaneously, global Communities of Practice (CoPs), such as the Green Chemistry Teaching and Learning Community (GCTLC), offer virtual spaces for peer-to-peer mentorship and the sharing of open-access, peer-reviewed resources. These collaborative environments effectively break educator isolation, increasing educator confidence and fostering a sense of belonging. [4] By evolving from isolated practitioners into a global CoP, educators are empowered to lead the reform necessary to prepare a scientific workforce dedicated to a healthier, safer world.

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FROM SEDIMENT TO MARITIME COATINGS: HARNESSING THE SUSTAINABLE AND CIRCULAR POTENTIAL OF MARINE-DERIVED ACTINOMYCETES

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Marine-derived actinomycetes from the Madeira Archipelago revealed a powerful and sustainable route to bioactive compounds with relevance for maritime industries.[1] Integrating LC–MS/MS-based metabolomics the identification of diverse meroterpenoids.[2] These metabolites, including the newly identified madeirone, exhibited strong antibiofilm activity, particularly against marine biofilm-forming bacteria, while showing minimal impact on microbial viability.[3] In addition, they demonstrated antimacrofouling effects, effectively inhibiting the settlement of *Mytilus galloprovincialis* larvae with low toxicity.[4]

Bridging discovery with biotechnological application, napyradiomycin- and marinone-based coatings were successfully obtained, demonstrating effective antifouling performance with minimal ecological impact.[5] This work highlights the circular potential of marine-derived actinomycetes, transforming ocean sediments microbial diversity into environmentally friendly solutions. The findings reinforce the importance of bioprospecting in underexplored marine ecosystems and position marine actinomycetes as key contributors to sustainable innovation in line with green chemistry principles.

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TOWARD A MORE SUSTAINABLE PRODUCTION OF BIOPET: TEREPHTHALIC ACID SYNTHESIS FROM RENEWABLE RESOURCES

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The sustainable synthesis of terephthalic acid (TPA), a key monomer in polyethylene terephthalate (PET) production, from renewable biomass-derived feedstocks remains a major scientific and technological challenge. This study will present recent advances in the selective oxidation of bio-based p-cymene, obtained from naturally occurring terpenes such as limonene and eucalyptol, into terephthalic acid using earth-abundant heterogeneous catalytic systems. Particular emphasis will be placed on manganese-based mixed oxide catalysts, including Mn–Fe and Mn–Co materials, as well as emerging MAX-phase catalytic platforms. The influence of critical reaction parameters, including oxidant nature, oxygen pressure, temperature, reaction time, and catalyst loading, on activity and selectivity toward terephthalic acid will be discussed together with mechanistic insights into the oxidation pathway. An unprecedented yield of 51% bio-based terephthalic acid under molecular oxygen was achieved over Mn–Fe mixed oxide catalysts, highlighting the potential of sustainable catalytic approaches for replacing fossil-derived p-xylene routes. The results demonstrate that catalysts prepared by co-precipitation exhibit enhanced catalytic performance due to the presence of strong acid sites and a high concentration of Co^{3+} species, which synergistically promote deep oxidation of p-cymene toward terephthalic acid.

The highly efficient and selective catalytic systems developed in this work provide new perspectives for the rational design of cost-effective, non-toxic, and earth-abundant catalysts for biomass valorization and sustainable polymer precursor production.

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FROM MOLECULES TO PARTICLES: AN INTEGRATED APPROACH TO DECARBONIZE PHARMACEUTICAL DEVELOPMENT

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Sustainability is one of Hovione's four strategic pillars, and it guides the way we design, develop, and improve our processes. To support this pillar, we are actively exploring and building a comprehensive toolbox of greener technologies across all segments — which include micellar chemistry (chemistry in water) , mechanochemistry, flow chemistry, solvent reuse/recycling and others — so that our teams can make more sustainable choices at every stage of development and manufacturing. Another key part of our commitment is developing tools that allow us to continuously monitor and improve process sustainability. One example is our internal ecolabeling system, inspired by established metrics in the literature.[1,2] This system combines three critical indicators — carbon footprint, process mass intensity (PMI), and process water intensity (PWI) — into a single, easy-to-interpret score that helps teams understand the impact in their processes, compare technology options, and identify the highest-value levers for improvement. Solvents represent the largest source of waste in drug manufacturing, whether in synthesis or downstream steps like spray drying and therefore they can also be looked at as an opportunity to improve a process sustainability. Spray drying uses substantial amounts of solvent, which are usually disposed of as waste despite their potential for recovery and reuse. In this presentation, we will share our approach to a more sustainable drug manufacturing process.



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HYPERBARIC ELECTROCYCLIZATION REACTIONS

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The control of chemical reactivity has traditionally relied on the fine-tuning of temperature, solvents, and catalysts. In parallel, ultra-high-pressure (UHP) reactors have emerged as a versatile tool capable of achieving reaction conditions up to several thousand atmospheres.[1] Originally applied in areas such as food preservation, UHP has found broad applications in organic synthesis, polymer chemistry, and enzymatic transformations. The effect of high pressure on chemical reactions is closely linked to the volume of activation (Δ‡V), with reactions exhibiting negative Δ‡V accelerating under UHP. This mechanistic sensitivity enables selective control over reaction pathways, enhancing both yield and regio- or enantioselectivity in cycloadditions, condensations, and domino reactions, even for sterically hindered or electronically deactivated substrates.[2] Among the reactions most impacted by UHP are intramolecular and hetero-Diels–Alder cycloadditions. Pressures above 10 kbar facilitate transformations that are otherwise challenging under ambient conditions, allowing the formation of complex cyclic scaffolds under milder temperatures and shorter reaction times. In this work we show that UHP promotes the formation of cylcopentenones from furanic scaffolds, thus enabling the use of electron-poor and hindered amines, as well as the use of poorly reactive dienophiles in Diels-Alder reactions (Figure 1).[3]

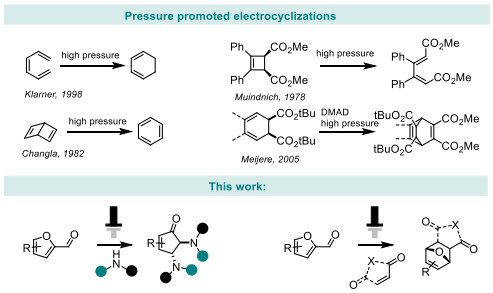


Figure 1. UHP promoted electrocyclization, including the ones explored in this work.

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EXPLORING GREEN-SYNTHESIZED METAL–ORGANIC FRAMEWORKS FOR LEAD AND PHENOL REMOVAL FROM WATER

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As clean water is crucial, lead (Pb) and phenol contamination are still significant issues because of their toxicity, persistence, and bioaccumulation, requiring effective removal even at trace levels. Adsorption is a simple, cost-effective, and efficient method aligned with green chemistry principles [1]. This study used environmentally friendly techniques to synthesize zinc- and copper-based phosphonate metal–organic frameworks (Zn HEDP and Cu HEDP) using hydroxyethylidene-1,1-diphosphonic acid (HEDP) [2]. These materials were subsequently functionalized with the ionic liquid trioctylmethylammonium chloride (Aliquat 336, Aliq.), yielding Zn HEDP-US Aliq. and Cu HEDP-US Aliq. Structural characterization showed that Aliquat 336 enhanced surface functionalization, charge density, and Pb(II) adsorption efficiency while preserving the crystalline framework, leading to capacity increases of 40.8% comparatively Zn HEDP with 27.65%, in the case of Cu HEDP respectively. Similar, the functionalization also enabled efficient phenol. Maximum adsorption capacity for Pb and phenol was evaluated using Langmuir, Freundlich, Redlich–Peterson, and Dubinin–Radushkevich isotherms, with parameters and R^2 determined, while adsorption kinetics followed a pseudo-second-order model [3]. The saturated phenol adsorbent materials can be electrochemically regenerated and reused in further treatment cycles of aqueous solutions without degrading the adsorbent material or losing their adsorption ability The electrochemical regeneration process involves two stages and the use of cost-effective electrodes (graphite and Al). Regeneration efficiency is high for solutions with concentrations below 0.025 mM (~90%). These findings demonstrate that ionic liquid-functionalized MOFs are efficient, reusable, and sustainable adsorbents for trace metal remediation, supporting ecologically friendly water purification in accordance with UN SDG 6.3.

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COMPUTER-AIDED SAFE AND SUSTAINABLE BY DESIGN

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Safe and sustainable by design is a concept which targets the inclusion of safety and sustainability already at the molecular design stage and has been advocated by the European Union. Computeraided molecular design based on computational methods, machine learning and artificial intelligence offers one pathway to realize this vision. Here, we will show progress towards this goal for the particular case of antioxidants.

Antioxidants are important chemicals used in a number of different applications, for example as preservatives for food, chemicals, plastics and rubbers [1]. We recently assessed the hazards of 500 natural and synthetic antioxidants and found large data gaps in persistence, bioaccumulation, toxicity, mobility and formation of toxic transformation products. Filling the data gaps with predictions, only 19 AOs were identified as not fulfilling any of the hazard criteria.

To find novel antioxidants that are safe and sustainable by design, we are developing computer-aided molecular design algorithms. Together with experimental partners, we are developing machine learning models for accurate and trustworthy prediction of toxicity, persistence and antioxidante function. Coupling these models with generative molecular design models, we can identify novel candidates that can then be synthesized and tested. As one step on the way, we have developed na interactive molecular design studio for antioxidants where domain experts can influence the molecular generation in real time [2]. Further developments will use reinforcement learning to capture the tacit human knowledge into scoring functions that can be used to guide training even without human input.

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BIORENEWABLE SOLVENTS FOR SUSTAINABLE CHEMICAL PROCESSES

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The replacement of conventional petroleum-derived solvents with sustainable alternatives is one of the key challenges in the transition towards greener chemical manufacturing. Biorenewable solvents, produced from renewable feedstocks, offer the potential to reduce environmental impacts while maintaining the performance required for chemical processing, analytical chemistry and bioprocessing. However, their wider adoption requires a better understanding of their physicochemical properties, extraction performance, analytical compatibility, phase behaviour and potential for recovery and reuse.

Our research investigates biorenewable solvents, including ethyl lactate, γ-valerolactone, glycerol and Cyrene, as sustainable alternatives to conventional petrochemical solvents. The work combines experimental studies with thermodynamic analysis to understand solvent properties, performance and applicability across chemical, bioprocessing and analytical systems. The overall aim is to generate the knowledge and data needed for rational solvent selection and the development of more sustainable processes.

Case studies present the use of these solvents for the extraction of valuable compounds from waste biomass and from aqueous process streams, as well as their application as greener substitutes for conventional organic solvents in high-performance liquid chromatography (HPLC). In parallel, the mutual solubility and liquid–liquid equilibrium behaviour of biorenewable solvent mixtures are being investigated to provide fundamental thermodynamic data for solvent selection, process design, solvent recovery and recycling.

By integrating extraction, analytical chemistry and phase-equilibrium studies, the research aims to establish a comprehensive framework for the development and implementation of biorenewable solvents across a wide range of sustainable chemical and bioprocessing applications.



IONIC LIQUID-CATALYZED VALORIZATION OF RENEWABLE CARBON RESOURCES INTO CHEMICALS

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CO_2 and spent polymers are renewable carbon resources rich on earth, and their chemical conversion into valuable chemicals is of great significance for green chemistry and sustainable development. Ionic liquids (ILs), entirely composed of organic cation and inorganic/organic anion, are highly designable and can be engineered with tailored features, thus showing promising applications in chemical reactions.

Our research focuses on developing IL-based catalytic systems to realize the clean and efficient transformation of CO_2 and spent polyesters in a green way, and has proposed several green approaches for accessing useful chemicals [1-7]. For example, we have synthesized several CO_2-reactive ILs that can chemically capture and activate CO_2 via forming anion-based carbonate/carbamate intermediates, thus further accomplishing its transformation to quinazoline-2,4(1*H*,3*H*)-diones, cyclic carbonates, and benzimidazolones under metal-free conditions [1-3]. We presented a hydroxyl carboxylate ILs-catalyzed protocol for depolymerization and transformation of the hydroxyl carboxylic acid-derived biopolyesters under metal-free and mild conditions, which can accomplish polyesters upcycling to various chemicals via hydrolysis, alcoholysis, and aminolysis [4]. In addition, we found that Pd/C in 1-butyl-3-methylimidazolium tetrafluoroborate works well for mediating the selectivity of the reaction of cyclic amines with CO_2/H_2, selectively producing N-formamides (at 120 ^oC) and N-methylamines (at 160^oC) in high yields just by varying the reaction temperature [5]. Moreover, 1,2-bis(N-heterocyclic)ethanes were for the first time obtained from cyclic amines and CO_2/H_2 via McMurry reaction of formamides coupled with subsequent hydrogenation.

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GREEN & SUSTAINABLE CHEMISTRY FOR MAXIMISING AGRICULTURAL PRODUCTIVITY

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Green and Sustainable Chemistry approaches have a major role in maximising agricultural productivity. The growing need for diverse food sources, more effective fertilisers, pesticides and herbicides with no detrimental human and environmental effects, greener surfactants and greener polymers for agriculture, all require an emphasis on green chemistry approaches.

Agricultural endeavours world-wide are primarily focused on food production. Globally, one third of food produced for human consumption is categorised as lost or waste, which equates to 1.3 billion tonnes per annum. This loss represents the waste of potentially valuable materials such as proteins, simple and complex carbohydrates and lignin, oils and secondary metabolite extractives. In this presentation, several relevant examples for valorising by-product or discarded biomass from food production will be presented.

A systematic approach first involves determining the chemical composition of the biomass by a variety of standard methods to identify potentially valuable components[1]. Following the identification of the more highly valued and accessible components (eg pectin, protein and peptides, pomegranate oil and other extractives) a number of processes for the extraction, purification and developing applications of selected components are described[2]. In all cases, Green and Sustainable Chemistry approaches were applied to give valuable products such as pectin, pomegranate oil, bioactive peptides and proteins from pulses for making films.

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DEEP EUTECTIC SOLVENTS FOR A SUSTAINABLE CHEMICAL FUTURE: FROM MOLECULAR DESIGN TO INDUSTRIAL APPLICATIONS

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Deep Eutectic Solvents (DES) are emerging as key enablers of sustainable chemistry, offering biodegradable, low-toxicity, and highly tunable alternatives to conventional solvents. This contribution presents an integrated AI-enhanced, multiscale digital–experimental framework for DES development, spanning molecular discovery, property prediction, process modelling, Safe-and-Sustainable-by-Design (SSbD) evaluation, Life Cycle Assessment (LCA), and experimental validation.

AI-guided molecular design—using machine-learning models trained on quantum-chemical descriptors, COSMO-RS data, and molecular dynamics simulations—rapidly explores formulation space and identifies safe, high-performance hydrogen-bond donor/acceptor pairs. These predictions feed into multiscale materials and process models and process-level digital twins, enabling simulation of viscosity, mass transfer, CO_2 absorption, pollutant binding, energy demand, and solvent regeneration under realistic conditions. In parallel, in silico SSbD and LCA benchmarking quantify safety and environmental impacts. Extensive experimental validation through thermophysical measurements, spectroscopy, rheology, target molecule(s)–DES interaction studies, CO_2 absorption tests, and extraction performance confirms the predictive workflow.

The resulting ecosystem supports high-value applications presented here including:

- PFAS removal and water purification
- CO_2 capture with task-specific DES
- Extraction of natural products (polyphenols, carotenoids, antioxidants)
- Protein recovery using edible, food-safe DES
- Nutraceutical and food-grade formulations

Overall, this AI-driven, multiscale, experimentally verified approach positions DES as a platform technology for future sustainable and industrially scalable chemical processes.



EARTH-ABUNDANT ALUMINUM FORMATE (ALF) AS A SUSTAINABLE DECARBONIZATION SOLUTION: A MULTISCALE COMPUTATIONAL STUDY USING DFT, MD AND MC SIMULATIONS

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The increasing levels of atmospheric CO_2, driven by anthropogenic activities, have intensified the global climate crisis, requiring sustainable and efficient carbon capture technologies. In this study, we investigated Aluminum Formate (ALF), an earth-abundant MOF, for selective CO_2 capture by integrating DFT, MD, and MC simulations. DFT calculations revealed a direct bandgap of 5.295 eV, confirming ALF's electronic stability, while Radial Distribution Function (RDF) analysis demonstrated its highly ordered crystalline structure [1] and potential for efficient CO_2 capture [2]. MD simulations showed structural compactness up to 450 °C, a critical attribute for industrial applications. MC simulations revealed strong CO_2 adsorption (ΔEads = −32.916 kcal/mol), driven primarily by electrostatic interactions with Al-OH functional groups, and high selectivity over nitrogen (N_2 = −8.00 kcal/mol) and water (H_2O = 5.845 kcal/mol). Comparative analysis with conventional adsorbents, including zeolites, activated carbon, and amine-based sorbents, further demonstrated ALF's adsorption performance, thermal stability, and moisture resistance [3]. Its low-cost synthesis, scalability, and minimal environmental impact also support its potential for large-scale carbon capture. This research aligns with UN SDG 13 (Climate Action) and SDG 9 (Industry, Innovation, and Infrastructure), highlighting the role of advanced materials in addressing environmental challenges. Overall, these findings support ALF as a promising material for innovative and sustainable carbon capture technologies.

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A GREENER PATH TO SYNGAS BY RWGS WITH IMIDAZOLIUM-BASED IONIC LIQUIDS AS RECYCLABLE REACTION MEDIA

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The mitigation of atmospheric CO_2 via Carbon Capture and Utilization (CCU) is an appealing strategy in the transition toward a circular chemical economy. Particularly, the homogenously catalysed Reverse Water-Gas Shift (RWGS) reaction is a noteworthy pathway for CO_2 valorisation, yet its industrial application is hindered by high energy requirements and the need of organic volatile solvents [1]. In this regard, ionic liquids (ILs) are more eco-friendly options for CCU as replacement for conventional organic solvents [2].

This study demonstrates the applicability of neat imidazolium-based ILs as the sole reaction medium for the catalysed RWGS reaction. Utilizing a Ru-pincer complex catalyst, the conversion of CO_2 to CO proceeds efficiently under milder conditions than traditional heterogeneously catalysed processes [3] A screening of imidazolium ILs identified 1-ethyl-3-methylimidazolium formate (EMIM For) as the most effective reaction media (**Figure 1**). By optimizing the CO_2:H_2 partial pressures from 10:10 to 1:30 bar, CO yields increased from 16% to 33% [4]. Moreover, the Ru-catalyst/IL system proved very stable having a preserved catalytic activity over seven consecutive recycling cycles at 10:10 bar (**Figure 1)**. Initial scalability experiments also confirmed that the system maintains its performance at upscaled volumes, providing a robust, benign and efficient strategy for sustainable syngas production.

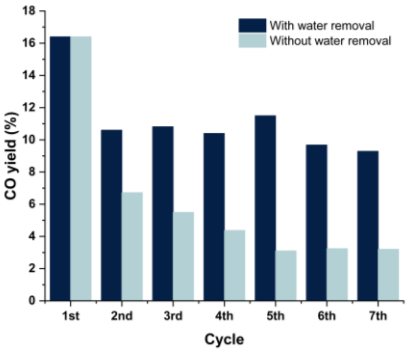


***Figure 1**. Recyclability of the EMIM For system for the RWGS reaction*

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NADES AS SUSTAINABLE EXTRACTION MEDIA FOR ENVIRONMENTAL SAMPLES

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Natural Deep Eutectic Solvents (NADES) have emerged as promising green solvents with a wide range of applications due to their tunable physicochemical properties. Formed by combining naturally compounds such as sugars, organic acids, and amino acids, NADES exhibit unique characteristics, including exceptional solubilization capacity for organic molecules, and adjustable viscosity. These versatile solvents have found applications in several areas of environmental chemistry, including sample preservation, compound solubilization, and environmental remediation [1–3]. Aquatic environments are increasingly impacted by the presence of contaminants of emerging concern (CECs). However, determining their concentrations in marine samples, such as sediments, remains challenging due to the complexity of these matrices and the dependence of conventional extraction methods on hazardous organic solvents. In this work, we explore the use of NADES as a green and straightforward approach for extracting target CECs from environmental samples and compare their performance with conventional extraction methodologies. Our results show that NADES outperformed the conventional method in both recovery efficiency and environmental sustainability, achieving an AGREE score of 0.67 compared with 0.28 for the conventional approach. These findings highlight the potential of NADES, particularly ChCl:U:W and B:U:W, as sustainable and cost-effective alternatives for monitoring CECs in marine samples.

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EFFICIENT MINERALIZATION OF FLUOROPOLYMERS USING SUBCRITICAL WATER

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Fluoropolymers have been widely used across a wide range of applications due to their exceptional stability against chemicals, heat, aging and UV light—properties that are difficult to achieve with other materials. Thanks to these unique features, fluoropolymers are utilized in numerous industries, from common industrial equipment to high-tech applications such as proton-exchange fuel cell membranes, piezoelectric devices, lithium-ion batteries, medical applications and specialized coatings. However, these materials today fall into the category of per- and polyfluoroalkyl substances (PFAS). As a result, effective waste-treatment technologies capable of completely breaking down these compounds are needed. One existing method is high-temperature incineration, but this process releases HF gas, which corrodes the firebricks of incinerators [1]. A more sustainable alternative would be to break down these materials into F^- ions (i.e., mineralization) using environmentally friendly techniques. The resulting F^- ions could then be combined with Ca^{2+} ions to produce CaF_2. Since CaF_2 serves as a fundamental raw material for the chain of fluorinated compounds, a system that converts fluoropolymers into F^- ions could support fluorine recycling—an increasingly important resource as global demand continues to rise.

Subcritical water is liquid water maintained under high pressure at temperatures between 100 °C and 374°C (critical temperature). Here, we demonstrate the efficient mineralization of fluoropolymers such as poly(vinylidene fluoride) (PVDF), poly(tetrafluoroethylene-*co*-hexafluoropropylene) copolymer, poly(ethylene-*co*-tetrafluoroethylene) copolymer (ETFE), fluoroelastomers (FKMs), and poly(tetrafluoroethylene-*co*-hexafluoropropylene) (FEP) copolymer using subcritical water [2-4]. Reactions for other advanced fluoropolymers will also be discussed.

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ECO-FRIENDLY NANOCELLULOSE MODIFICATION ENHANCES BIOBASED UNSATURATED POLYESTER RESIN PERFORMANCE

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The development of high-performance sustainable polymer composites requires improved interactions between biobased polymer matrices, such as unsaturated polyester resins (UPRs), and natural reinforcing materials, such as nanocellulose. This study presents an eco-friendly one-pot surface modification method of nanocellulose that enables its efficient incorporation into a fully biobased UPR while enhancing composite performance. The modification method relies on dimethyl itaconate, which acts both as a modification agent and as a reactive diluent, allowing the entire reaction mixture to be directly integrated into the UPR's prepolymer without additional purification steps or the use of hazardous solvents. FTIR analysis confirmed successful nanocellulose modification, while XRD showed that its semicrystalline structure was largely preserved. Composites containing modified nanocellulose exhibited significantly improved mechanical and thermal properties, including a 23% increase in tensile strength at 0.3 wt.% loading and consistently higher glass transition temperatures. This streamlined and scalable modification method improves nanocellulose dispersibility within the biobased polymer matrix and supports the development of sustainable, high-performance polymer composites.

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WO_3/SO_3H-C CATALYSTS FOR 5-HMF ONE-POT PRODUCTION

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Lignocellulosic biomass is a key renewable feedstock for the sustainable production of platform chemicals. Among them, 5-hydroxymethylfurfural (5-HMF) is a pivotal intermediate that can be sourced from its cellulosic fraction through a cascade process involving the synergistic effect of Brønsted and Lewis acid sites (Fig. 1) [1]. In this work, we report the development of bifunctional carbon-based acid catalysts for a one-pot cellobiose-derived 5-HMF production. The catalytic system consists of activated carbon (SX+ from NORIT, fraction < 50µm) functionalized with WO_3 patches and benzyl sulfonic moieties [2]. The acidic properties were characterized by NH_3-TPD (total acidity) and pyridine-FTIR (Brønsted/Lewis site distribution). The most active WO_3 phase, depending on calcination temperature, was first identified for the conversion of glucose to 5-HMF. The optimized oxide was subsequently integrated in the final materials. Then, the optimal balance between WO_3 and sulfonic groups was elucidated by testing monofunctional mixtures, enabling rational fine-tuning of the bifunctional catalytic systems. The optimal bifunctional catalysts were evaluated for the one-pot conversion of cellobiose under mild conditions (403 K, 6 h). A tetrahydrofuran (THF)/water solvent system significantly enhances 5-HMF yield by improving its extraction and enhancing cellobiose conversion (Fig. 1). Kinetic studies over longer reaction times will be carried out to maximise 5-HMF yield.

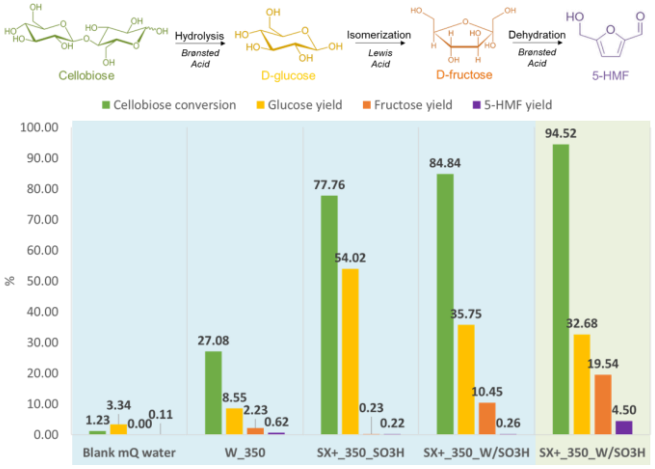


Figure 1: One-pot cellobiose-derived 5-HMF production in water (blue background) and THF/water (green).

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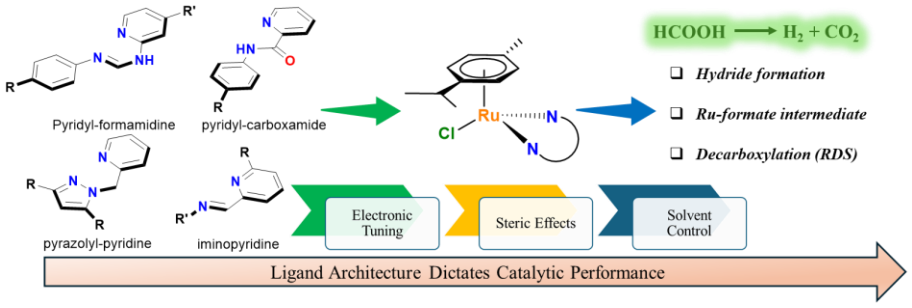
TUNABLE RUTHENIUM CATALYSTS FOR HYDROGEN PRODUCTION FROM FORMIC ACID: GOVERNING REACTIVITY THROUGH LIGAND ARCHITECTURE

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The rational design of ligand scaffolds is crucial for advancing sustainable hydrogen storage technologies. Formic acid (FA), a promising liquid organic hydrogen carrier, enables reversible hydrogen storage via selective dehydrogenation to H_2 and CO_2. We systematically investigate how ligand backbone architecture governs catalytic activity and mechanistic pathways in a family of half-sandwich Ru(II) complexes. Four N,N-bidentate platforms—pyridyl-formamidine,[1] pyrazolyl-pyridine,[2] iminopyridine,[3] and pyridine-carboxamide—were evaluated as tunable scaffolds for formic acid dehydrogenation. Variations in donor strength, steric profile, ion pairing, and solvent compatibility significantly influenced catalytic performance. Electron-donating substituents enhanced turnover frequencies by facilitating hydride formation, whereas steric encumbrance reduced substrate coordination. Solvent-dependent studies revealed mechanistic divergence, and kinetic analyses identified Ru-formate decarboxylation as turnover-limiting. These findings establish ligand architecture as a decisive design parameter for sustainable CO_2–formic acid hydrogen storage systems.



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COLLOIDAL SYNTHESIS OF PHOTOCATALYTIC QUANTUM DOTS HETEROSTRUCTURE

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Colloidal synthesis using Ligand mediated surface engineering is a powerful approach to manifest the physical and chemical properties of quantum dots. [1,2] We present a colloidal synthesis method to attract high-quality carbon quantum dots with surface ligand-induced dual emission through a colloidal synthesis strategy. [3] The colloidal synthesis improved the quality of carbon dots in its size control and uniformity. The colloidal carbon dots showed the improved quantum yield and surface passivation induced dual emission. The results revealed the surface function and interactions.

Benefitting from the good optical and colloidal stability, a new class of van der Waals heterojunction photocatalyst, which is synthesized by hot-injection method, whereby carbon dots (CDs) are grown in situ on ZnSe nanoplatelets (NPLs), i.e., metal chalcogenide quantum wells. [4,5] The resultant organic-inorganic hybrid nanoparticles, CD-NPLs, are able to perform methanol dehydrogenation with the occurrence of α-C-H splitting and C-C coupling. The novel CD-based organic-inorganic semiconductor heterojunction is poised to enable the discovery of a host of new nano-hybrid photocatalysts with full tunability in the band structure, charge transfer, and divergent surface chemistry for guiding photoredox pathways and accelerating reaction rates.

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GREEN SYNTHESIS OF BIO-BASED CO-POLYMERS FOR FOOD PACKAGING APPLICATIONS

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In recent years, biopolymers have gained increasing attention as sustainable alternatives to petrochemical polymers for food packaging within the Circular Bioeconomy. Their advantages include reduced carbon footprint, renewable raw materials, biodegradability or compostability, as well as suitable barrier, mechanical, and processing properties.[1] Among these materials, bio-based aliphatic copolyamides (“green nylons”) show promising properties for sustainable food packaging. This work focuses on the synthesis of biocopolyamides via polycondensation reactions and their evaluation as food packaging materials.[2] Specifically, PA1010/410 copolymers were synthesized from nylon salts derived from decanediamine and sebacic acid, incorporating increasing molar contents (12.5, 25, and 37.5%) of nylon salt derived from sebacic acid and putrescine. The resulting films were processed into lids for minced beef packaging and evaluated under refrigerated storage (5 °C) for 11 days. The developed materials extended the shelf life of minced beef beyond that achieved with conventional petrochemical-based monolayer packaging, demonstrating their potential for sustainable food packaging applications.

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FROM CASTOR OIL TO SODIUM-ION BATTERIES: SUSTAINABLE PA11-BASED HYBRID MEMBRANES FOR ENERGY STORAGE

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The development of sustainable materials for electrochemical energy storage is a key challenge within the framework of Green Chemistry. In this work, hybrid membranes based on Rilsan®, a bio-based polyamide 11 (PA11) derived from castor oil, were developed and evaluated as multifunctional separators for sodium-ion batteries. Unlike fossil-derived polymers, PA11 is produced from a renewable plant resource, enabling up to 80% lower CO_2 emissions than petroleum-based plastics and supporting circular economy principles. Membranes were prepared with different TiO_2 particle loadings (0, 3, 5, and 10 wt%) and subsequently soaked in commercial electrolytes (1 M $NaPF_6$ in EC:PC) to form hybrid systems combining separator and ionic conductor functionalities. Increasing TiO_2 content enhanced ionic conductivity from 4.5 x 10^{-4} S·cm^{-1} for the pristine membrane to 1.6 x 10^{-3} S·cm^{-1} for the membrane containing 10 wt% TiO_2 at room temperature. All systems exhibited electrochemical stability up to at least 4.8 V (vs Na^+/Na). The membranes were evaluated in $Na_3V_2(PO_4)_2F_3$ // Na half-cells. Rate capability tests revealed that the membrane containing 3 wt% TiO_2 delivered the best electrochemical performance, maintaining high capacities even at 2C. Long-term cycling at 1C showed an initial capacity of 103 mAh·g^{-1} with 93% capacity retention after 400 cycles. These results highlight the strong potential of bio-based PA11 hybrid membranes as sustainable battery components, demonstrating how renewable polymers and functional inorganic fillers can enable high-performance energy storage while supporting circular economy strategies and resource valorization.

Acknowledgments:

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ELECTROPOLYMERIZED DONOR–ACCEPTOR POLYMER FILMS FOR POROUS ENERGY MATERIALS

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The development of sustainable materials for energy conversion requires precise control over both electronic structure and mass transport properties. Conjugated microporous polymers (CMPs) offer a promising platform to integrate permanent porosity with extended π-conjugation; however, their implementation as thin films for energy applications remains challenging. Here, we report the design of thiophene–benzothiadiazole donor–acceptor (D–A) monomers and their polymerization via chemical and electrochemical routes to produce porous CMP networks and functional thin films [1]. By tuning monomer topology through terthiophene regiochemistry and rigid three-dimensional cores, we demonstrate that structural design governs porosity retention and electronic properties. While planar monomers lead to pore collapse upon electropolymerization, rigid 3D architectures suppress π–π stacking and yield uniform, highly porous films with surface areas up to 318 $m^2\ g^{-1}$. Electrochemical analysis reveals tunable energy-level alignment within the CMP networks, enabling efficient donor–acceptor interactions and favorable charge transport characteristics. The combination of accessible porosity and controlled frontier orbital energies highlights the potential of these materials for applications in organic photovoltaics, photoelectrochemical systems, and other green energy technologies.

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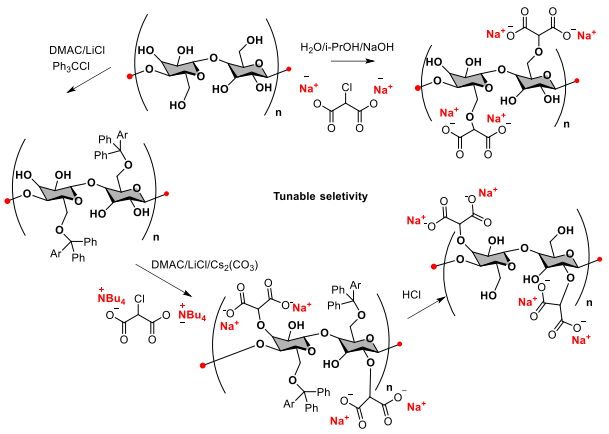
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GREENER AND REGIOSELECTIVE STRATEGIES FOR THE FUNCTIONALIZATION OF CELLULOSE INTO DICARBOXYMETHYL DERIVATIVES

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This work addresses the development of more efficient and controllable methodologies for the chemical modification of cellulose [1], a renewable and widely available starting material, with particular emphasis on achieving good solubility and tuneable material properties. We establish routes to an array of cellulose derivatives with well-defined and differentiated characteristics through precise control over the degree of substitution and regioselectivity, i.e., both where and how much the biopolymer is modified. In parallel, we advance greener processing by substituting traditional Cuoxam or NMMO systems with alternative dissolution strategies, including DMAc/LiCl and concentrated aqueous NaOH solutions. Building on this framework, the present study focuses on the synthesis of dicarboxymethyl cellulose (DCMC) via selective introduction of the substituent at C2 and C3 positions [2], enabled by temporary protection of the primary hydroxyl group with 4-methoxytrityl followed by deprotection. DCMC obtained by our approach aligns with and expands the diverse applications already demonstrated by our group [3], ranging from advanced formulations to functional coatings based on this tailored cellulose derivative.

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HOLISTIC SUSTAINABLE SYNTHESES WITH READILY AVAILABLE SURFACTANTS AND DATA SCIENCE

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A principal-component ***surfactant_map***, using 22 experimental and theoretical descriptors, was developed for 91 commonly accessible surfactants for use in surfactant-enabled organic reactions in water, an important approach for sustainable chemical processes. The effectiveness of the map was demonstrated in rapidly identifying the most suitable surfactants for replacing organic solvents in aqueous nucleophilic fluorination using $KF.2H_2O$, Suzuki-Miyaura cross-coupling and reductive amination of DNA-tagged substrates. In all cases, cheap and commercially available surfactants were found to be superior to designer surfactants, leading to facile work-up and purification. Multiphase continuous flow processes, which included liquid-liquid phase separation, aqueous phase recycling and isolation of the products were developed for amide couplings, S_NAr and photochemical reactions based on fReactors™ and coalescence filter technologies, leading to significantly improved process green metrics and processes suitable for scale-up, and minimal contamination of the products.

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SELECTIVE BIOSORPTION OF YTTRIUM AND EUROPIUM FROM MERCURY-CONTAMINATED WATER USING ENCAPSULATED MACROALGAE

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The European Union faces increasing strategic vulnerability due to its dependence on rare earth elements (REE), often present in industrial wastewater [1]. Conventional treatment and recovery technologies are costly, complex, and poorly selective, limiting their practical implementation. n this study, marine macroalgae biomass encapsulated in alginate is proposed as a sustainable and selective biosorbent for REE recovery from aqueous systems. Microspheres were produced via droplet-based microfluidics and ionic gelation, enabling controlled size and reproducible material properties. SEM confirmed the homogeneous distribution of *Fucus* sp. biomass throughout the internal structure of the microspheres and the influence of the freezing method applied. The selectivity and sorption performance of encapsulated *Fucus* sp. were evaluated in a ternary mixture of Y, Eu, and Hg simulating lamp waste leachate. The effects of initial metal concentration (1–9 µM), pH (3–7), and salinity (0–30 PSU) were assessed using Response Surface Methodology with a Box–Behnken design. Salinity as the most influential parameter and the optimal conditions for maximizing Y and Eu removal while minimizing Hg uptake were determined and experimentally validated: 93.7 % for Eu, 87.2 % for Y, and 14.9 % for Hg. These results highlight the potential of encapsulated macroalgal biomass as a low-cost, environmentally friendly solution for the selective recovery of REE from complex aqueous matrices, supporting resource recovery and water and wastewater treatment.

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SUSTAINABLE OLEFIN METATHESIS USING SPECTROSCOPIC MONITORING AND ORGANIC SOLVENT NANOFILTRATION

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Catalytic ring-closing metathesis (RCM) has gained increasing relevance in pharma, polymer and petrochemical industries1 providing new synthetic routes through versatile C-C formation. Nevertheless, RCM requires the use of large quantities of organic solvent and expensive transition metal-based catalysts showing poor stability in atmospheric conditions, posing sustainable and scalability challenges and thus limiting the industrial applicability of RCM.[2]

This work addresses these challenges by i) the development of adequate in situ monitoring strategies enabling a more efficient real time control of the RCM variables and ii) the use of organic solvent nanofiltration (OSN) for selective separation of the RCM product and recovery of the catalyst3, towards RCM reactions with improved sustainability and scalability. RCM catalyzed by Hoveyda-Grubbs II were carried out using a model substrate, diethyl diallylmalonate(DEDAM) in eco-friendly media conditions. In situ monitoring by RAMAN spectroscopy provided real time information on the reaction kinetics and DEDAM conversion profiles (to a max. of 98.4%) showing good agreement with that obtained by conventional and laborious techniques, e.g. Gas Chromatography (GC). OSN processes outperformed allowing for a catalyst rejection ≥ 95% and a poor rejection of the RCM product (c-DEDAM) £7%, enabling the development of RCM processes with improved industrial applicability.

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ADENOSINE MONOPHOSPHATE AS A VERSATILE BIOMOLECULAR TOOL FOR GREENER SYNTHESIS OF PLASMONIC NANOMATERIALS

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Plasmonic nanomaterials are promising for sensing, catalysis and biomedicine, but their synthesis often relies on unsustainable methods. Adenosine monophosphate (AMP), a biomolecule found in living systems, enables greener synthesis of Au nanostars, Ag nanoplates and Ag@Au nanoplates, together with their controlled coating with silica and mesoporous silica [1–4]. Across these systems, AMP directs growth, improves colloidal stability, and facilitates surface coating and functionalization, contributing also to improved biocompatibility. Overall, AMP emerges as a simple and versatile platform connecting green synthesis with advanced functional plasmonic nanomaterials.

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INTEGRATED BIOMASS MAPPING FOR WILDFIRE PREVENTION AND SUSTAINABLE BIO-OIL CONVERSION

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Forest fires present a critical global hazard, reinforcing the need for proactive forest management to reduce fuel loads and protect ecosystems. In this study, we developed and implemented an integrated framework combining remote sensing with biomass conversion technologies. Field biomass was successfully detected and quantified, enabling the creation of high-resolution fuel maps that accurately represented fuel availability and moisture conditions, thereby enhancing wildfire risk prediction [1,2]. The collected biomass was processed through thermochemical liquefaction to produce bio-oil, which was further characterized into lower-molecular-weight lignin and sugar derivatives, while non-valuable fractions were assessed as potential energy carriers [3]. The liquefaction results were subsequently integrated with the fuel maps to estimate the energetic potential of the harvested biomass. Overall, this interdisciplinary approach demonstrated effective pathways for improving biomass management and utilization while contributing to more accurate forecasting and mitigation of wildfire risks.

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CATALYTIC VALORIZATION OF CARBON DIOXIDE – NEW PATHWAYS TOWARDS SUSTAINABILITY

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From both environmental and economic perspectives efficient catalytic valorization of CO_2 belongs currently to the most important technological challenges. On the one hand, it can help reduce emissions of CO_2, on the other hand, it can provide market-valuable products such as synthesis gas, hydrogen, methanol, ethanol, dimethyl ether, etc. However, it is important to note that due to the high thermodynamic stability of CO_2 molecules, their catalytic activation is difficult and strongly energy demanding. In this work our attention is focused on oxide catalysts for CO_2 hydrogenation to methanol. In our case, two series of cenosphere- and g-Al_2O_3 supported catalysts containing copper, zinc (0.5-10.0 mol.%) or a mixture of these two active components were synthesized via wet impregnation. Our goal was to check the effect of copper and zinc concentration on structural, textural and functional parameters which can control the catalytic activity of the studied systems in CO_2 hydrogenation to methanol (Fig). Additionally, the effect of support was elucidated. The studied samples have been characterized by XRD, RS, SEM/EDS, porosimetry, DRIFT and UV/Vis-DR. Based on our studies, it can be demonstrated that catalytic hydrogenation of CO_2 towards methanol can be considered not only as a good example of a reasonable chemical way of CO_2 emission reduction, but also as a technology providing a valuable market product, simultaneously meeting favorable conditions required from the perspective of process sustainability. The latter aspect was also analyzed in more detail in our work.

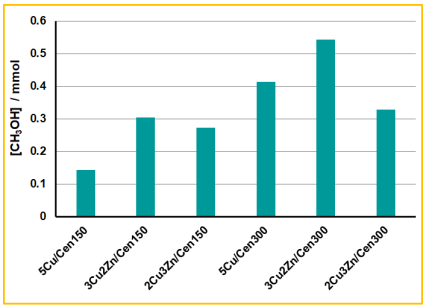


Fig. Efficiency of CO_2 hydrogenation to methanol.

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SIMULTANEOUS WASTE REMEDIATION AND CARBON CAPTURE VIA CO_2 MINERALIZATION OVER INDUSTRIAL BASIC WASTES

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In this study, exhausted lime derived from ceramic industry flue gas treatment was investigated as a feedstock for CO_2 mineralization in a semi-continuous gas–liquid–solid system operating under mild conditions. This approach not only can reduce carbon emissions but also avoid a hazardous waste stream that would otherwise have to be disposed of.

CO2 mineralization technology based on industrial waste is considered a promising strategy for carbon mitigation. This approach aims to take advantage of existing industrial landscape, using readily available industrial wastes to capture CO2. Due to the widespread application of hydrated lime in the abatement of acid flue gases, several industrial sectors produce spent lime (SL) as waste. SL is often disposed of while still far from completely spent due to safety concerns and is classified as hazardous waste. Its application as a direct CO2 sorbent would simultaneously decrease the CO2 emissions and the SL disposal costs [1]. For SLs coming from ceramic industry the carbonation products will be developed for further industrial applications. In particular, this study investigated the spent lime system for the direct gas–liquid–solid absorption-mineralization of CO2. The effects of CO2 concentration, reaction temperature, liquid-to-solid ratio and gas flow rate on CO2 removal performance and the purity of CaCO3 in the mineralization product were comprehensively evaluated. Furthermore, the physicochemical characterization of CaCO3 product was performed. The system demonstrated stable performance across a range of operating conditions and allowed efficient CO_2 capture from diluted streams. Preliminary tests on the carbonated product showed its suitability as a partial substitute for limestone in cementitious binders, with mechanical properties comparable to reference materials. These findings highlight the potential of exhausted lime valorisation as a viable strategy for coupling CO_2 capture with hazardous waste treatment, supporting circular economy approaches in industrial systems.

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GREEN BINDER-SOLVENT SYSTEMS FOR IRON PRUSSIAN BLUE ANODES IN AQUEOUS SODIUM-ION BATTERIES

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Sodium-ion batteries (SIBs) are a compelling, cost-effective, and sustainable alternative to lithium-ion systems. While conventional SIBs utilize flammable and toxic organic electrolytes (e.g., ethylene carbonate-based), aqueous sodium-ion batteries (ASIBs) employ safer and greener salt solutions. Although ASIBs sacrifice a degree of energy density, they offer significant advantages, including reduced costs, streamlined production processes, and outstanding power performance for large-scale energy storage applications. This research presents a comparative analysis of several binder-solvent systems to evaluate their influence on battery performance and sustainability (see **Figure 1**). While polyvinylidene fluoride (PVDF) processed with N-methyl-pyrrolidone (NMP) remains the industrial standard, its use is increasingly restricted due to the known toxicity of NMP. In response, this study evaluates ethyl cellulose as a sustainable binder alternative, tested in conjunction with two solvents: ethanol and Cyrene™. Iron Prussian Blue ($NaFe^{III}[Fe^{II}(CN)_6]$) selected due to its competitive theoretical capacity (85 mAh/g), its structural robustness during cycling, and its lack of critical raw materials, was tested within these systems acting as anode. Notably, electrodes processed using ethyl cellulose and ethanol yielded discharge capacities of ~75 mAh/g, reaching the performance of the traditional PVDF/NMP control (~76 mAh/g). Overall, the main goal of this research is to identify an environmentally benign binder-solvent alternative for battery assembly that balances electrochemical efficiency and ecological impact.

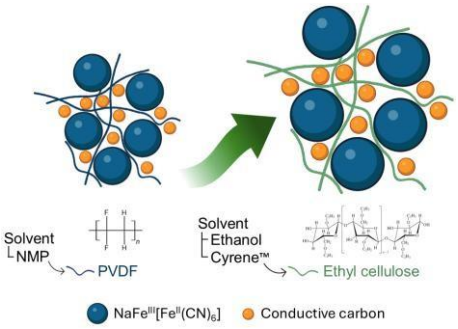


Figure 1. Scheme of the electrode for several binder-solvent mixtures.

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PHOTOTHERMAL SUPPORTED AMINE ADSORBENTS FOR CPVT-DRIVEN DIRECT AIR CAPTURE REGENERATION

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Direct air capture (DAC) is a promising negative-emission technology, yet its large-scale deployment is constrained by the high energy demand of sorbent regeneration. Coupling DAC with concentrating photovoltaic/thermal (CPVT) systems provides an opportunity to utilize renewable solar heat for low-carbon regeneration, while efficient solar-responsive adsorbents remain highly desirable. Herein, we develop photothermal supported amine adsorbents for CPVT-driven DAC regeneration, using amine-functionalized carbon nanotubes (CNTs) as a representative platform. The CNT framework enables broadband solar absorption, rapid thermal transport, and effective amine immobilization, integrating CO_2 adsorption and solar-assisted regeneration within a single material. The optimized 60TEPA-CNT adsorbent achieves CO_2 uptake capacities of 2.21 mmol g^{-1} under dry conditions and 4.11 mmol g^{-1} under humid conditions. Under 1000 W m^{-2} solar irradiation, the adsorbent rapidly reaches 80–90 °C, achieving a photothermal desorption efficiency above 89% while retaining over 90% capacity after 50 cycles. The localized heat generation within the adsorbent layer minimizes intermediate heat-transfer losses and reduces dependence on external heating components. These results demonstrate the potential of photothermal supported amine adsorbents as key materials for renewable-energy-assisted and energy-efficient CPVT-driven DAC systems.

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ENGAGING HIGH SCHOOL STUDENTS THROUGH IMPLICATIONS SYSTEMS THINKING APPROACH IN CHEMISTRY.

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The systems thinking approach is crucial for developing and implementing the 17 Sustainable Development Goals (SDGs) and promoting green and sustainable chemistry [1,2]. It promotes a broader perspective for a holistic understanding of issues, moving beyond a narrow, subject-focused approach. School curricula should adopt a systems thinking approach to address the significant climatic and societal changes we face [3]. This method improves decision-making by addressing sustainability complexities, promoting collaboration, and fostering innovation. It supports long-term planning while considering trade-offs and feedback. Teaching and learning chemistry through this lens allows students to apply scientific principles to real-world problems, highlighting its critical role in global challenges and preparing them for future teamwork across disciplines.

A high school class of 24 eleventh-grade students were enrolled in a comprehensive program to improve their understanding of sustainability and chemistry. An integrated approach to chemistry was developed by applying Systems Thinking and Laboratory work. The six-week intervention had two parts: the first focused on synthesis, while the second concentrated on chemical equilibria. Students completed a survey on sustainability and a pre-test on synthesis and GC. During the intervention, students learned chemical synthesis concepts, analysed four syntheses and related them to SC, GC, and SDGs. They conducted lab experiments to synthesise aspirin and biodegradable plastic using a guided worksheet, followed by a post-test on synthesis, GC, and SC. They completed a pre-test on Chemical Equilibrium and deepened related concepts by analysing equilibrium and relating it to both GC and SC perspectives. In the final week, participants engaged in laboratory activities and completed a survey on sustainable consciousness and action competence for sustainability, along with a post-test to assess their knowledge of equilibrium. Data from research will be presented.

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DRIVING SYSTEMIC CHANGE THROUGH GLOBAL NETWORKS: THE GREEN CHEMISTRY COMMITMENT PROGRAM

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Addressing global environmental and societal challenges requires transforming how chemists are trained. Green chemistry education plays a fundamental role in promoting this systemic change by equipping the future workforce with the knowledge and skills to design safer products and processes for human health and the environment. Integrating these principles across the education continuum helps prepare scientists to contribute to a more sustainable future in diverse cultural, economic, and institutional contexts worldwide.

The Green Chemistry Commitment (GCC) program is a collaborative international initiative designed promote and accelerate the adoption of green chemistry in higher education settings. Launched in 2013 by the non-profit organization Beyond Benign, the GCC aims to connect and support institutions committed to working towards the progressive inclusion of green chemistry in the curriculum.[1] Today, the GCC includes more than 280 universities, colleges, and institutes across over 35 countries, and it has become a global network of educators working to advance responsible chemistry education.

In this presentation, the efforts and impact of the GCC program in catalyzing the adoption of green chemistry education will be discussed. The results from the 2025 GCC Annual Audit will be presented, showing examples of locally adapted strategies that contribute to a collaborative international effort. Comparisons with previous data surveys will demonstrate trends in green chemistry adoption, curricular support and engagement among institutions participating in the GCC program, showing how global and community-driven initiatives contribute to preparing the next generation of chemists for a better future for us and future generations.

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PHOTOCATALYTIC LIGNIN OXIDATIVE VALORIZATION

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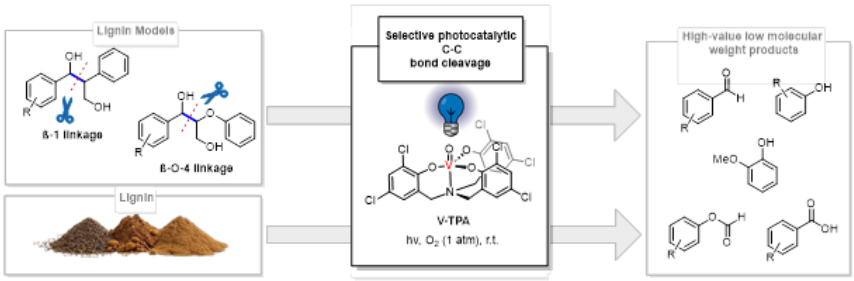
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Lignin, one of Earth's most abundant yet underutilized biopolymers, holds enormous promise as a renewable feedstock for sustainable aromatic chemicals and advanced materials.[1] Its notoriously complex and heterogeneous architecture, however, has long resisted efficient valorization — leaving this remarkable resource largely untapped.

Here, we present an integrated strategy combining selective lignin isolation from poplar wood via a cyclic deep eutectic solvent (DES) extraction procedure [2] with catalytic depolymerization using vanadium-oxo aminotriphenolate (VO-TPA) complexes for the aerobic oxidative cleavage of lignin and its model compounds under blue light.[3,4]

This integrated approach is discussed as a concrete pathway toward a circular bioeconomy, offering sustainable alternatives to fossil-derived aromatics. Optimization of reaction protocols and key mechanistic insights will also be presented.



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REDUCING FLUORINATED GREENHOUSE GAS EMISSIONS THROUGH ADVANCED RECOVERY SYSTEMS AT THE CERN LHC EXPERIMENTS

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At the CERN Large Hadron Collider (LHC), several gaseous particle detectors operate with gas mixtures containing fluorinated compounds such as CF_4, $C_2H_2F_4$ (R134a), SF_6, and C_4F_{10}. Due to their high Global Warming Potential (GWP) and strict European regulations governing their use and trade, significant efforts have been undertaken to reduce greenhouse gas (GHG) emissions associated with detector operation.

Due to the absence of industrially available purification technologies for the specific mixtures used in particle physics, dedicated recovery systems have been designed and deployed at CERN. These systems perform large-scale separation and purification of fluorinated gases from LHC multi-component mixtures by combining different techniques, including membrane separation, adsorption, and distillation [1].

Each system is tailored to the mixture: CF_4 is recovered from CF_4/Ar/CO_2 (10/40/50), R134a from $C_2H_2F_4$/i-C_4H_{10}/SF_6 (95.2/4.5/0.3), and C_4F_{10} from CO_2/O_2/N_2 mixtures, achieving recovery efficiencies of ~70%, 85%, and 90%, respectively. Continuous monitoring by gas chromatography, GC/MS, and infrared analysis ensures recovered gases—typically 90–99.5% pure—are suitable for reuse. As a result of the deployment of these recovery plants, more than 16,400 tCO_2eq were avoided in 2025.

In parallel, ongoing R&D focuses on metal–organic frameworks (MOFs) for R134a adsorption at low concentrations (tens to thousands of ppm) and novel membranes for SF_6 recovery, aiming to further extend advanced gas separation and purification technologies at the LHC.

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ENABLING GREENER ROUTES TO PHARMACEUTICALLY IMPORTANT REACTIONS THROUGH SOLVENT REPLACEMENT AND RECYCLING

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The fine chemical and pharmaceutical industries continue to rely heavily on toxic, petroleum-derived solvents in the manufacture of active pharmaceutical ingredients (APIs). Their production and disposal have significant environmental consequences, with global solvent output estimated at nearly 20 million metric tonnes annually. Many of these solvents are carcinogenic, neurotoxic, or pose reproductive hazards, creating serious risks to both human health and the environment. This highlights the urgent need for practical alternatives that reduce hazard and emissions without compromising performance.

Here, we describe greener routes to two pharmaceutically important reaction classes, fluorination and Henry chemistry, by replacing toxic petroleum-derived solvents and reagents, such as dichloromethane, with water.[1,2] By integrating data science with computational chemistry, we identified solvent systems that improve sustainability while maintaining reaction efficiency. In the Henry reaction system, translation from batch to flow with aqueous-phase recycling reduced process mass intensity (PMI) from 33 to 4, delivering an eightfold reduction in waste. We also demonstrate the potential of biorenewable solvents, such as Cyrene, as replacements for conventional fossil-derived media.

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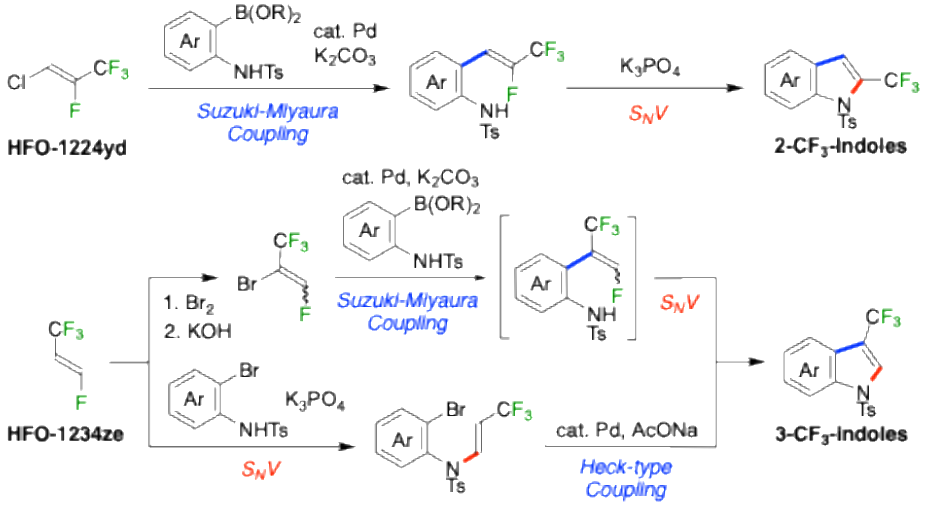
UPCYCLING OF HFOS INTO VALUE-ADDED PRODUCTS: CONSTRUCTION OF 2-CF_3- AND 3-CF_3-INDOLES

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Here, we describe synthetic methods for converting hydrofluoroolefins (HFOs), particularly HFO-1224yd and -1234ze, into valuable fluorinated heterocycles such as trifluoromethylindoles. Since HFOs are increasingly used as environmentally benign fourth-generation refrigerants, their chemical upcycling into potential pharmaceuticals and agrochemicals is an important research goal. One approach employs Suzuki–Miyaura coupling followed by intramolecular S_NV (nucleophilic vinylic substitution) to produce 2- and 3-CF_3-indoles starting from HFO-1224yd(*Z*) and HFO-1234ze(*E*), respectively [1,2]. Another strategy uses HFO-1234ze(*E*) directly via S_NV and subsequent Heck-type cyclization [3]. These methods provide practical routes from industrial fluorocarbon feedstocks to high-value fluorinated molecules, thereby enabling the upcycling of HFOs.



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DEVELOPMENT OF A NEW GREEN METRIC: THE SUSTAINABLE IMPACT FOR EXTRACTION (SIX SCORE)

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To guide the transition toward more sustainable technologies, green chemistry has developed a range of metrics, evolving from mass-based indicators (e.g., E-factor, PMI, atom economy) to more holistic, impact-based approaches and, more recently, toward sector-specific metrics. [1] To meet this need, the Sustainable Impact for eXtraction Score (SIX Score) was developed as a dedicated metric for evaluating the sustainability of extraction processes to promote bioeconomy strategies. [2] Based on the Six Principles of Green Extraction, the SIX Score integrates multiple elemental factors including raw material, chemical inputs, process efficiency, waste generation, equipment requirements, and product characteristics. [3] By consolidating these parameters, the methodology provides a score ranging from 0 to 100 through a structured form in which users report the process inputs and outputs. The metric has been implemented in an open-access software, providing both a tool to evaluate processes and a collaborative database for exploring best practices (Figure 1). As the transition to green chemistry represents a global challenge, the SIX Score aims to support this effort by providing an accessible methodology for sustainability assessment, encouraging the use of alternative sources of chemicals. At the same time, it fosters collaboration and knowledge exchange across the chemical community through the network possibilities offered by the platform.

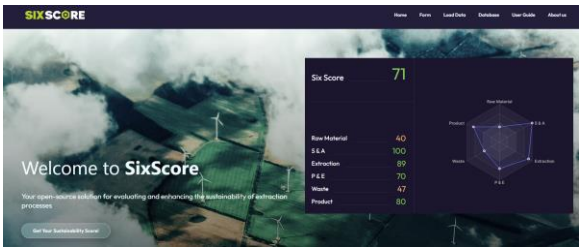


Figure 1. SIX Score website: https://blankto.github.io/SixScore/

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MODERNIZING CHEMISTRY CURRICULA: SPOTLIGHT ON GREEN CHEMISTRY AND SYSTEMS THINKING

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In the US, one of many key differences between tertiary education curricula for students studying chemistry vs. chemical engineering is that the latter includes systems thinking as an essential, foundational cognitive framework. There is an obvious need for professional chemical engineers to apply a systems mindset while scaling up chemical reactions from lab scale to commercial production and this demands that engineering students be trained accordingly. The need for a systems mindset across the spectrum of professional chemists can seem less obvious from a practical standpoint and as a result, chemistry students rarely if ever encounter systems thinking as taught with the intention to inform their understanding of fundamental concepts and skills. Consequently, chemists who become instructors typically lack the expertise to teach through a systems thinking lens (because they themselves were not trained to do so). Therefore, despite the well-proven utility of a systems thinking approach to learning, we have a long way to go toward broad inclusion of this higher-level cognitive approach in the chemistry classroom.

In collaboration with the IUPAC project “Systems Thinking in Chemistry for Sustainability: Toward 2030 and Beyond” (STCS 2030+) we have been assessing perceived barriers for instructors who want to take a systems thinking approach in their chemistry classes so we can develop guidance to support them. At the ACS Green Chemistry Institute1, we have developed open-access resources, including a comprehensive learning module for instructors and an asynchronous introductory course that introduces basic systems thinking concepts. In this talk, I will discuss our perception of barriers to systems thinking inclusion with a focus on how they impact instructors. I will also emphasize the urgent need for professional development opportunities that will enable chemistry instructors to more comfortably leverage systems thinking as a powerful teaching tool.

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AGRO-FOOD WASTES AS ECO-INNOVATIVE SOLUTIONS FOR NATURAL DYEING SOLUTIONS FOR THE 21ST TEXTILE INDUSTRY

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Before the advent of synthetic colors, natural dyes were widely used to dye fibers including wool, linen, cotton and silk. Since the textile industry is one of the most polluting in the world [1-2], with synthetic dyeing being a major contributor, there is an urgent need for sustainable alternatives. Natural dyes, particularly those derived from agro-food wastes/byproducts, offer a promising solution aligned with circular economy principles.

Traditional knowledge is a unique source of inspiration and, although natural dyes are often associated with poor to moderate light/colour-fastness, the brightness and colour hue of some natural colours can still be observed in artworks that have lasted for centuries [3]. This resilience is related to colour formulations, i.e., the dyeing recipes developed in the past. However, many natural dyes require mordants, typically metal salts, to bind to fibers, raising environmental concerns. Eco-friendly biomordants derived from waste materials such as oak galls and pomegranate peels offer a greener alternative, though further research is needed to understand their role in color stability.

This work explores the valorization of wine industry wastes [1], particularly grape pomace, as a source of natural dyes and mordants. Through advanced chemical characterization and analysis of interactions with wool fibers, including ITC to assess chemical affinities, the study investigates sustainable dyeing methods using natural dyes and mordants recovered from winemaking residues.

Overall, the project proposes innovative, biodegradable dyeing solutions inspired by historical practices, contributing to sustainable materials and supporting the goals of the European Green Deal.

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VALORIZATION OF OLIVE BRANCH-BASED CELLULOSE NANOFIBERS IN SA: XG/MOF HYDROGEL COMPOSITES FOR SUSTAINABLE AGRICULTURE

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Water is a fundamental resource for ecosystem sustainability, yet increasing demand driven by climate change, population growth, and food production is pushing water scarcity to critical levels. The agricultural sector, responsible for approximately 70% of global water consumption, faces severe challenges including yield losses, soil salinity, and erosion due to improper irrigation and excessive groundwater use [1]. Developing innovative solutions to enhance water use efficiency in agriculture is therefore essential. In this study, sodium alginate (SA) and xanthan gum (XG) based composite hydrogels were synthesized to improve agricultural water retention and enable controlled water release [2,3]. To overcome the limitations of these biopolymers low mechanical strength and poor stability during swelling/drying cycles cellulose nanofibrils (CNF) derived from olive pruning waste were incorporated as natural reinforcement [4]. Microwave-synthesized Zr-based MOFs (UiO-66 and UiO-66-NH_2) were also integrated to enhance moisture retention and regulate water release [5], combining waste valorization and green synthesis within a sustainable framework. CNFs exhibited low polydispersity (PDI ≤ 0.2), MOFs achieved yields ≥65% and surface areas ≥550 m²/g, and swelling tests confirmed water retention capacities of ≥20 g water/g dry hydrogel.

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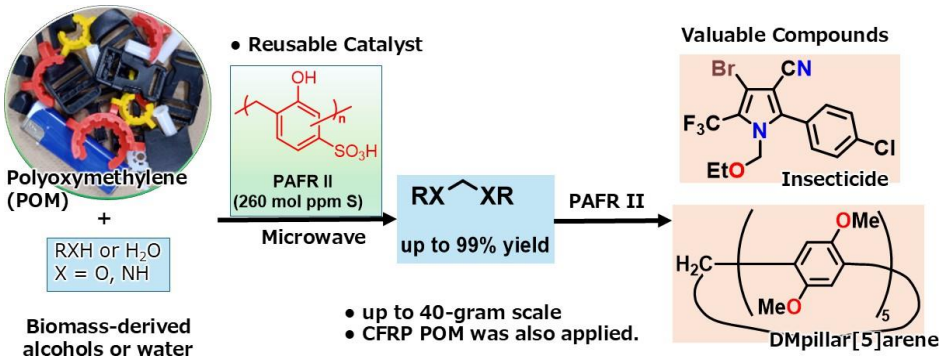
UPCYCLING POM (POLYOXOMETHYLELE) BY POLY(M-PHNENOLSULPHONIC ACID CATALYST) PAFR II AT PPM LEVELS

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Polyoxymethylenes (POMs) are widely used engineering plastics, yet their end-of-life management remains problematic because recycling is difficult and incineration increases CO_2 emissions. We report a green, solvent-free upcycling strategy for waste POM based on reusable heterogeneous catalysis and energy-efficient microwave activation. A second-generation *m*-phenolsulfonic acid–formaldehyde resin (PAFR II), an efficient catalyst for esterification and Ritter reaction,[1] enables efficient POM depolymerization with a low sulfur loading of 260 mol ppm (0.026 mol% S) delivering up to 99% yield of valuable products and outperforming conventional thermal heating.[2] The method converts waste POM into diverse chemicals including solvents, agrochemicals, and pillar[5]arenes using biomass-derived nucleophiles such as alcohols, amines, and water. The catalyst is durable over multiple reuse cycles, and the protocol is applicable to realistic waste streams (e.g., CFRP-derived POM and microplastics) and scalable to 40 g. This work demonstrates a practical pathway toward circular plastic valorization by integrating solvent-free design, catalyst reusability, and energy-efficient activation, and substrate scope also will be described.



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ACCESSIBLE AND GREEN WET IMPREGNATION ROUTES TO EARTH-ABUNDANT SINGLE-ATOM CATALYSTS

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Designing single-atom catalysts (SACs) based on Earth-abundant elements is a promising strategy for sustainable catalysis, yet many synthetic routes rely on multi-step procedures, hazardous reagents, or specialized equipment that hinder accessibility and reproducibility. Here, we report a straightforward bottom-up approach to prepare Ni SACs supported on carbon nitride (CN_x), combining a simple wet impregnation step with a single-stage thermal annealing treatment (no additional promoters/templates nor complex instrumentation). Systematic investigations elucidated the role of each synthetic step in the formation and stabilization of active sites. Spectroscopic and microscopic characterization confirmed the monoatomic dispersion of Ni^{2+} species hosted in square-planar CN_x sites.[1] Due to enhanced visible-light absorption, Ni SACs were evaluated in the photocatalytic synthesis of benzocaine (local anesthetic), delivering high catalytic performance. Life cycle assessment (LCA) and techno-economic analysis (TEA) of our protocol, benchmarked against common SAC synthetic strategies, showed substantial reductions in raw material costs and environmental burdens, especially in water consumption and ionizing radiation. Overall, this work establishes an accessible and green route to earth-abundant SACs integrating catalytic efficiency with the principles of green chemistry.[2]

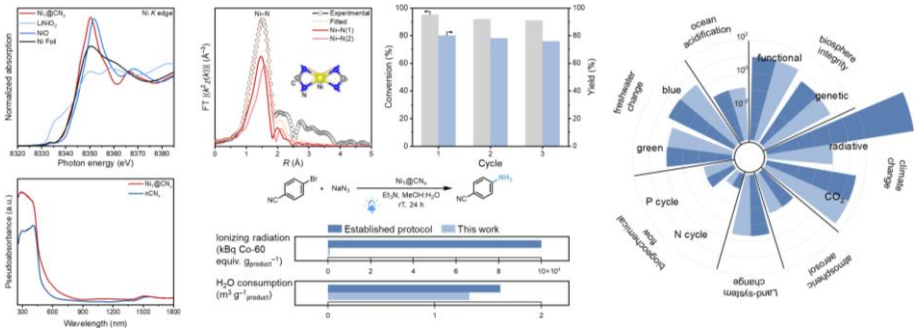


Figure 1. Ni SAC properties, catalytic performance, and LCA and TEA of the proposed SAC synthesis protocol.

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SHINING LIGHT THROUGH DARKNESS: UNVEILING A NOVEL CLASS OF RESORCINARENE-BASED DEEP EUTECTIC SOLVENTS *VIA* PXRD-GUIDED MECHANOCHEMISTRY

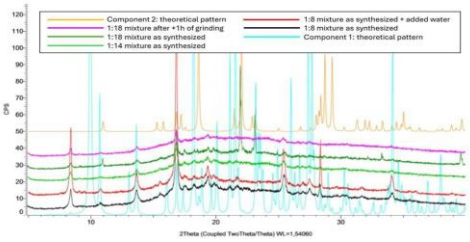
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We report herein the room-temperature mechanochemical synthesis of a novel class of supramolecular deep eutectic solvents (SUPRADESs) devoid of cyclodextrins. Given the intrinsic complexity and intense dark coloration of these highly viscous media, visual assessment of the solid-to-liquid transition is highly unreliable. To address this, powder X-ray diffraction (PXRD) was employed as an *in-itinere* guiding tool within the synthetic workflow. Monitoring the progressive suppression of Bragg peaks enabled structural validation of the mixing process, facilitating the optimization of reproducible synthetic protocols. Crucially, PXRD extends beyond mere phase confirmation: it serves as a powerful diagnostic probe to assess solubility and hydration limits. The unequivocal reappearance of diffraction peaks provides a clear analytical threshold for phase separation that visual inspection cannot detect. Overall, the collected results highlight the great potential of these unconventional macrocycle-containing formulations, establishing PXRD as an indispensable tool for their standardized preparation.





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DO WE REALLY NEED THREE DAYS FOR SILICA NANOSPHERES? TOWARD A GREENER AND TIME-EFFICIENT SYNTHESIS

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Catalytic materials should align with green chemistry principles not only in terms of catalytic performance, but also in terms of synthesis. Hollow silica nanospheres (HNS) are attractive materials for heterogeneous catalysis because of their high specific surface area, porous shell, and accessible internal cavity, but their preparation often relies on low temperatures, long synthesis times, and use of conventional aromatic swelling agents.[1,2] Here, we report a greener single-micelle-templated sol-gel synthesis of HNS performed at room temperature, shortening reaction times, and exploring alternative and greener swelling agents. For this latter task, a low-field benchtop NMR (43 MHz) was used as a rapid screening tool to probe surfactant/swelling-agent interactions relevant to micelle formation. This approach provides a simple and accessible way to guide the selection of swelling agents before synthesis thus reducing trial-and-error. The optimized conditions preserved the typical features of HNS while significantly improving the sustainability and practicality of the process.

This optimized route was then extended to the preparation Sn-doped HNS, yielding acidic materials in only 3 hours, at room temperature and without the need for a hydrothermal treatment. The catalysts showed excellent performances in the valorisation of glycerol to solketal. Finally, the active sites have been characterized using ^{119}Sn SS-NMR and ^{31}P MAS NMR using trimethyl phosphine as a probe molecule.[3] Overall, this work combines process simplification, catalyst design, and accessible characterization tools to advance the sustainable preparation of Sn-doped hollow silica nanospheres as efficient heterogeneous catalysts.

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SELECTIVE LITHIUM EXTRACTION FROM SPENT CATHODE VIA REAGENT-FREE MECHANOCHEMICAL REACTION

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With the rapid growth of electric vehicles and the global push toward carbon neutrality, the demand for lithium-ion batteries has increased significantly, leading to the generation of a massive amount of spent lithium-ion batteries and the depletion of valuable metals such as Li, Ni, Co, and Mn [1]. Conventional recycling methods, including hydrometallurgy and pyrometallurgy, often cause significant Li loss as slag or gas and generate environmental pollution such as wastewater and toxic emissions [2]. To mitigate these challenges, researchers have explored mechanochemical approaches for selective Li extraction. However, most mechanochemical strategies still require auxiliary reagents such as reductants or oxidants, which complicate the process and necessitate additional separation steps, ultimately generating wastewater. Here, we introduce a reagent-free mechanochemical strategy for selective Li extraction from NCM622 cathodes. During the mechanochemical reaction, Ni, Co, and Mn undergo oxidation, which promotes Li release from the cathode lattice together with lattice oxygen to maintain electron neutrality. The released Li reacts with atmospheric CO_2 and gradually forms Li_2CO_3, enabling selective Li extraction in a neutral solution with 100% efficiency. This strategy provides a sustainable and energy-efficient pathway for Li recovery without external heat input, additional chemical reagents, or wastewater generation.

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Acknowledgments:

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SCALE-UP OF A TANDEM PROCESS FOR CO_2-BASED E-FUEL SYNTHESIS - FROM BATCH TO CONTINUOUS OPERATION

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The European Green Deal targets climate neutrality by cutting greenhouse gas emissions to net zero [1]. Since transport is a major emitter [2], renewable alternatives such as e-fuels are essential, particularly for heavy transport and shipping. Produced from renewable electricity and resources, e-fuels can be used in conventional combustion engines and are considered CO_2-neutral [3]. The EU project E-TANDEM aims to realise an efficient and direct production of a new, oxygenated, diesel-like e-fuel for marine and heavy-duty transport. This involves the use of CO_2 as the only carbon source and renewable electricity as the only energy. A hybrid catalytic process converts electrocatalytically produced syngas into long-chain alcohols through a one-pot combination of Fischer-Tropsch synthesis and hydroformylation [4]. Having demonstrated that the tandem reaction of syngas to higher alcohols is feasible in batch mode in the laboratory, the new e-fuel concept was also tested in a continuous operation in a miniplant as a step toward industrial application [5]. An energy-efficient membrane enabled the homogeneous catalyst recycling. For process scale-up, the cobalt-catalyzed reductive hydroformylation was first established in continuous operation with membrane-based catalyst separation and demonstrated stable performance for more than 60 hours. Subsequently, the integrated tandem process was implemented in the miniplant with continuous gas feed.

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LANTHANIDES EXTRACTION USING HYDROPHOBIC EUTECTIC SOLVENTS: INFLUENCE OF HYDROGEN-BOND DONORS

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The production and recycling of lanthanides (Ln) typically rely on hydrometallurgy, with solvent extraction (SX) being the industrially favoured approach for their separation from complex aqueous phases, involving the selective transfer of ions in a biphasic system facilitated by the amphiphilic molecules (extractants) to ensure metal coordination and solubility in the apolar phase [1]. However, the similar chemistry of Ln cations makes their separation challenging, resulting in poor selectivity and complex processes. Hydrophobic and non-ionic eutectic solvents (HES) were proposed as a solution for the SX of Ln due to the incorporation of extractants as HES component, thereby overcoming typically solubility issues, removing the need for organic diluents, and allowing for process intensification. HES result from the interactions between two compounds, typically a hydrogen bond donor (HBD) and acceptor (HBA), yielding a self-organised liquid phase [2]. However, it is not clear how the HES structure reorganization during Ln SX influences the macroscopic properties relevant to their applications such as Ln distribution, selectivity, and viscosity. This work aims to compare the distribution of different HES consisting of the extractant trioctylphosphine oxide (TOPO) and HBDs of varying polarity. Ln distribution in HES is shown to be highly dependent on the hydrophilicity of the HBD and equilibrium water content in the HES phase, demonstrating how through simple variations in polarity Ln distribution could be improved by one order of magnitude whilst reducing viscosity.

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SMART MATERIALS FOR DIRTY WATERS: REVERSIBLE AEROGELS UNLOCK CLOSED-LOOP HEAVY METAL REMEDIATION FOR CATALYTIC APPLICATIONS

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Bio-based catalytic materials are emerging as promising platforms for the development of sustainable chemical processes [1]. In this study, we present a dynamic covalent aerogel derived from chitosan and aldehyde-functionalized lignin, which has been developed as a renewable heterogeneous catalyst with the additional capability to remove toxic metal ions from water [2]. The three-dimensional framework is established through reversible Schiff-base linkages between chitosan and formylated lignin, the latter of which is obtained via a mild Reimer–Tiemann functionalization. Density Functional Theory (DFT) calculations indicate that metal capture is predominantly governed by a tridentate coordination mode. Subsequent to metal uptake, the aerogels can be directly repurposed as recyclable heterogeneous catalysts for cross-coupling reactions. It is noteworthy that these catalysts demonstrate exceptional catalytic performance under mild conditions and in green solvents, thereby enabling the coupling of up to 90% yield. Their straightforward and cost-effective preparation, combined with their pronounced stability, highlights their potential for scale-up and industrial implementation. Furthermore, the reversible nature of the covalent network enables the recovery of the original building blocks and the regeneration of the material, thereby establishing a circular strategy that integrates water remediation with bio-based catalysis.

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INTEGRATING SUSTAINABLE MULTISTEP SYNTHESIS AND MECHANOCHEMISTRY INTO UNDERGRADUATE GREEN CHEMISTRY EDUCATION

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Embedding Green Chemistry principles into undergraduate laboratory teaching is essential for preparing future chemists to engage with sustainability-driven scientific and industrial challenges. In this work, we present a newly designed laboratory experiment integrated into the Green Chemistry course of the Chemistry BSc at the University of Coimbra. The experiment introduces students to the sustainable transformation of biomass-derived furan building blocks into functionalized pyridines—key heterocycles widely found in pharmaceuticals, agrochemicals, and other bioactive compounds. The multistep sequence involves the *in situ* generation of nitrosoalkenes, a hetero-Diels–Alder cycloaddition to form furoxazines, mechanochemical rearrangement into oxazines, and final aromatization to the pyridine product.[1] The experiment combines advanced synthetic concepts with sustainability-focused tools, including solvent-free mechanochemistry (ball-milling), digital toxicity assessment (SwissADME, ProTox), and quantitative green-metric calculations (Atom Economy, E-factor). Assessment data of the improvement in students' understanding of renewable feedstocks, heterocycle synthesis, and environmental impact analysis will be presented.

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GREEN CHEMISTRY AS A CENTRAL AREA FOR SUSTAINABILITY-RELATED CROSS-DISCIPLINARY AND MULTIDISCIPLINARY NETWORKS

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Multidisciplinarity is broadly acknowledged as fundamental in the pursuit of sustainability, and the operational aspects of "how to go about it" are objects of active research. As the chemistry-pertaining approach to the pursuit of sustainability, green chemistry can constitute an ideal centre for both cross-disciplinary networks of interfaces with the various chemistry areas and for multidisciplinary networks of interfaces with all the other disciplines. This role needs to be adequately highlighted within green chemistry education, with emphasis on the operational components and observed or potential outcomes.

The proposed presentation outlines the nature of individual interfaces between green chemistry and the other chemistry areas, analysing routes and benefits, followed by outlines of the ensemble of interactions between green chemistry and other disciplines, jointly contributing to the design for sustainability in a number of fields as well as to the addressing of specific issues. It also underlines the potential contributions that green chemistry, as one of the first – if not the first – green approach to be developed for a specific discipline, can contribute to the development of systematised green approaches in other disciplines. The consideration of representative examples also emphasises the nature of crossdisciplinarity and multidisciplinarity in terms of ability to constructively "talk to each other" across specialization areas and disciplines – something that does not imply becoming experts in the others' fields, but developing the awareness of what interfaces and collaborations can build [1].

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GREEN BIOCOMPOSITE NANOPARTICLES AS CATALYSTS FOR POLLUTANTS DEGRADATION IN WATER

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In the field of nanoscience, metal nanoparticles play an important role receiving a tremendous attention from the scientific community in the last decades for their interesting catalytic, optical and electronic properties.[1] Amongst the different applications such as in biomedicine, materials science, electronics fields, the catalytic properties of metal such as gold and silver nanoparticles make them interesting also in the environmental field for the degradation of organic pollutants which represent a great concern of the modern society.

Recently, several works have been focused on the development of green gold nanoparticles by using natural extracts that allow a green synthetic approach in terms of reducing agents, stabilizers and solvent. In addition, the use of natural extracts derived from agricultural or industrial wastes respect also the principles of the circular economy.[2]

In the present work *Aloe vera* wastes were used to prepare green gold nanoparticles. *Aloe vera* fresh leaf contains fibers, proteins, organic acids, vitamins, minerals, monosaccharaides, and polysaccharides, which partially remain in the leaf wastes providing the reducing sugars for gold reduction and others organic components for nanoparticles stabilization. Some experimental factors that affect the nanoparticles properties were considered. Gold nanoparticles were characterized by using TEM, FTIR, DLS analyses and used in catalytic studies for dyes degradation in water.

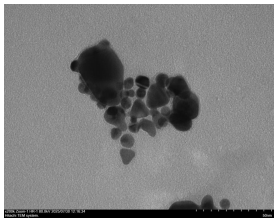


Figure 1. TEM of gold nanoparticles synthesized from Aloe vera wastes.

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ATOMIC-SCALE MANIPULATION OF ZEOLITES FOR SUSTAINABLE APPLICATIONS

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Zeolites are among the most powerful heterogeneous catalysts, renowned for their activity, shape selectivity, and thermal stability. As microporous solid acids, aluminosilicate zeolites transformed petrochemical industry by replacing corrosive mineral acids and enabling the large-scale production of high-quality fuels and bulky chemicals. Beyond these established applications, tuneable composition and well-defined microporous architecture make zeolites attractive for the development of sustainable catalytic processes compatible with a low-carbon future. Unlocking this potential, however, requires synthetic approaches capable of expanding chemical and structural space available for zeolite design. Conventional hydrothermal synthesis produces zeolites through the self-assembly of ionic species [1]. Because this process is difficult to control or predict, the discovery of new zeolite structures and compositions still relies on empirical trial-and-error approaches. To overcome this limitation, we have developed a strategy for the atomically precise modification of germanosilicate zeolites composed of silica-rich domains interconnected by chemically labile Ge-containing moieties. These materials provide a unique platform for the selective water-induced activation of Ge-O bonds, enabling either controlled structural reorganization or targeted chemical modification [2]. The distinctive properties of the resulting previously unattainable zeolites have been demonstrated in the CO_2 adsorption and in the valorisation of biomass-derived compounds [3,4]. This contribution highlights atomically precise zeolite manipulation as a route to advanced materials for sustainable carbon management.

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FROM RENEWABLE FDCA-DERIVED CYCLIC CARBONATES TO NON-ISOCYANATE POLYURETHANE AND APPLICATIONS

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Non-isocyanate-(hydroxyl)polyurethanes (NIPHUs) are a promising class of polymers achieved by substituting diisocyanates (classified as carcinogenic, mutagenic and toxic to reproduction) with safer cyclic carbonates. Despite their improved sustainability, most NIPHUs are still produced from fossil-based cyclic carbonates. To address this limitation, in this work we employed a renewable FDCA-derived bis-cyclic carbonate (previously synthesized in our group)[1] to produce a novel NIPHU that exhibits promising properties for adhesive or coating applications while additionally featuring a reprocessable structure (Fig. 1). In our study, the reactivity of the starting cyclic carbonate was systematically investigated by screening key reaction parameters including different diamine structures, solvent, temperature, time, and catalysts. This optimization led to reaction conditions that improved the selectivity toward the target NIPHU (61%), while limiting the formation of polyamide (39%) and urea (0%) by-products and achieving a 92% conversion of the starting cyclic carbonate under mild, solvent-free conditions (100 °C). Follow-up studies on possible applications as a coating were performed testing the NIPHU crosslinking degree using an in-house-developed renewable crosslinker (FDCA-bis-epoxide), resulting in a gel content ranging between 52 and 76%. After tuning polymer-to-crosslinker ratios by monitoring solvent swelling, water uptake, and thermal properties by thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC), the recyclability and reprocessability of the final material were assessed, yielding promising results.

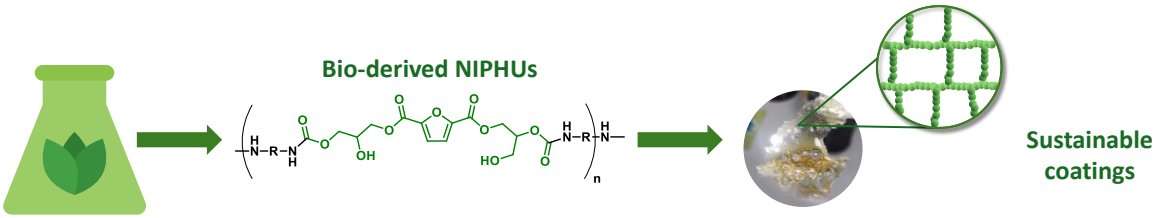


Fig.1 From bio-derived cyclic carbonates to NIPHUs and sustainable coatings applications.

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FROM RESIDUES TO RESOURCES: HIGH-VALUE FURAN BUILDING BLOCKS FROM PENTOSE SUGARS

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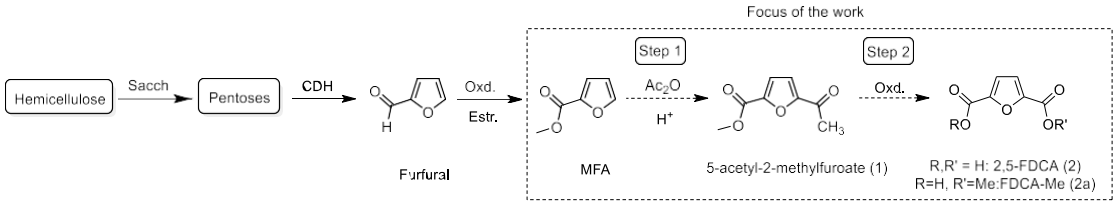
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5-Hydroxymethylfurfural (5-HMF) and derivatives, derived from edible C6 sugars, are key intermediates in most synthetic routes explored to date for producing 2,5-furandicarboxylic acid (2,5-FDCA), one of the most promising biobased building blocks. As an alternative, non-digestible C5 sugars such as xylose and arabinose—widely present in agricultural residues—offer potential advantages since they do not compete with food resources. Here, we outline a two-step strategy to synthesize 2,5-FDCA starting from 2-furoic acid, which is derived from C5 sugar. Step one involves Friedel–Crafts (FC) acylation of the methyl ester of 2-furoic acid (MFA) with acetic anhydride in the presence of an acid catalyst, yielding the intermediate 5-acetyl-2-methylfuroate (1). In the second step, under Amoco conditions, this intermediate (1) is oxidized in air to give the 2,5-FDCA (2) and the monomethyl ester of 2,5-FDCA (2a). During the FC acylation, $ZnCl_2$ provided 100% selectivity to 5-acetyl-2-methylfuroate (1) at 36% conversion, while methanesulfonic acid (MSA) gave the highest substrate conversion at 59% with 80% selectivity to 5-acetyl-2-methylfuroate (1). In the oxidation phase, Amoco catalysts with varying Co/Mn/Br ratios (including catalysts lacking one of these components) were used to examine the oxidation of the intermediate (1). Yields of over 95% were achieved for the 2,5-FDCA (2) and the mono-methyl ester of 2,5-FDCA (2a).



Scheme 1. Two-step strategy to synthesize 2,5-FDCA (2) starting from pentose sugars. In step 1, MFA is directly acetylated at 5th position using FC acylation reaction using an acid catalyst. Step 2 is subsequent oxidation of 5-acetyl-2-methylfuroate (1) to give 2,5-FDCA (2) and the mono-methyl ester of 2,5-FDCA (2a). Abbreviations: Sacch = saccharification; CDH = cyclodehydration; Oxd. = oxidation; Estr. = esterification; Ac_2O = acetic anhydride.

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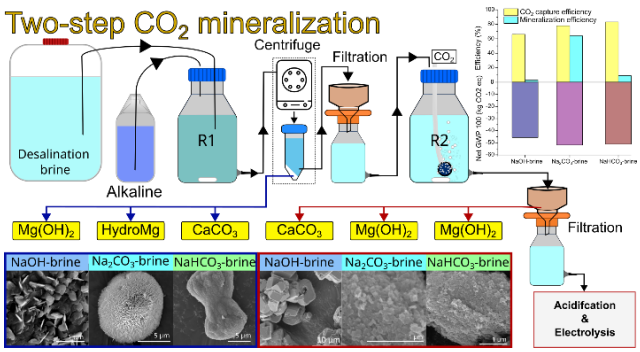
ELECTROLYTIC CO_2 MINERALIZATION WITH DESALINATION BRINE: ADVANCING SUSTAINABLE CARBON UTILIZATION

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CO_2 mineralization represents a promising pathway for long-term and durable carbon storage while simultaneously creating sustainable construction material [1]. This work explores an integrated approach coupling brine electrolysis with CO_2 mineralization to enhance capture efficiency and valorize desalination brine. By extending carbonate equilibria through controlled alkali generation, both simulation and experimental studies revealed the formation of high-purity mineral products, including $Mg(OH)_2$ (94.1 ± 1.3 wt% Mg), $CaCO_3$ (97.1 ± 0.9 wt% Ca), hydromagnesite, and aragonite. Systematic evaluation of NaOH, Na_2CO_3, and $NaHCO_3$–brine mixtures identified the Na_2CO_3–brine configuration as optimal, achieving CO_2 capture efficiency of 78% and mineralization efficiency of 64%, while simultaneously contributing to brine softening. These findings highlight both the potential and current limitations of brine-assisted CO_2 mineralization, offering insights for process optimization toward scalable, environmentally responsible carbon utilization technologies.



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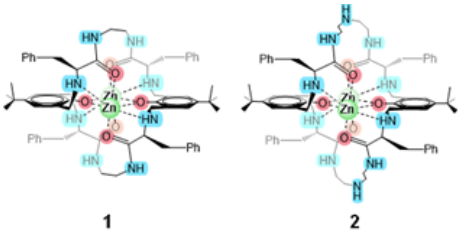
HYBRID MOF–MACROCYCLE CATALYSTS FOR CO_2 VALORIZATION

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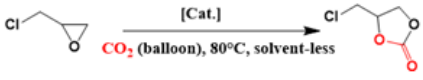
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Macrocycles have received considerable attention owing to their unique structural and functional properties in a wide range of applications. Their preorganized cavities and well-defined binding environments make them especially appealing for the development of biomimetic catalysts with enzyme-like behaviour [1]. Metal–organic frameworks (MOFs) are porous crystalline coordination polymers which modular nature enables precise structural and functional tuning through variation of metal nodes, organic linkers, and post-synthetic modification strategies. In this regard, the zirconium-based biphenyldicarboxylate UiO-67 remains particularly attractive because of its outstanding chemical stability, robustness, and synthetic versatility [2]. Although macrocycle-containing polymers and macrocycles immobilized on solid supports have been explored to improve catalytic efficiency and recyclability in CO_2 valorization, the post-synthetic incorporation of catalytically active macrocycles into MOFs remains underdeveloped, particularly in multicomponent systems designed for heterogeneous catalysis. Here, we report the synthesis of a series of pseusopeptide macrocycles and their post-synthetic incorporation into UiO-67 to generate hybrid materials for the catalytic conversion of CO_2 into cyclic carbonates under mild conditions.



1

2



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TUNING CO_2 HYDROGENATION SELECTIVITY ON RU VIA HIERARCHICAL ALUMINA SUPPORT DESIGN

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The catalytic performance of multicomponent catalysts depends strongly on their chemical architecture, defined as the spatial arrangement of catalyst components, which governs interactions between the active phase and the support and thus influences activity and selectivity. In this work, Ru catalysts were prepared using three types of hierarchically organized Mg-co-doped alumina nanosheets as supports. These materials combine high thermal stability, favorable textural properties, and a high concentration of pentacoordinate Al^{3+} species capable of stabilizing Ru nanoparticles [1].
The catalysts were comprehensively characterized to determine their composition (EDS), texture and porosity (N_2 physisorption), morphology (TEM, SEM, STEM-HAADF), Ru dispersion (H_2 chemisorption), structure (XRD, Raman, ^{27}Al MAS NMR), and surface chemical properties (CO_2-TPD, H_2-TPR, XPS, *in situ* IR). Their catalytic performance in CO_2 hydrogenation was evaluated in a fixed-bed flow reactor using a CO_2/H_2/He mixture (4:16:80 vol.%) at 370°C. The catalyst with Mg deposited on the support surface showed the highest CO_2 conversion (~80%) and the greatest stability and CH_4 selectivity (97%). In contrast, incorporation of Mg^{2+} into the support structure decreased CH_4 selectivity to ~50% with increased CO formation. The specific support structure ensured excellent stability of Ru nanoparticles under reaction conditions providing high stability in all studied systems.

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3D PRINTED ZEOLITE COMPOSITES AS HIGHLY-EFFECTIVE MATERIALS FOR CO_2 CAPTURE AND METHANATION

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Rising greenhouse gas emissions, particularly of CO_2, challenge sustainable development due to their role in climate change. CCU technologies address this by converting CO_2 into valuable products. CO_2 methanation is especially promising, as it reduces emissions while producing methane compatible with existing natural gas infrastructure [1, 2].

New adsorbent/catalyst systems for CO_2 capture and methanation were developed based on zeolite composites. The latter were obtained from coal fly ash and rice husks and contain Na-X, Na-LTA and Na-Sodalite zeolites in different ratios depending on the synthesis conditions. The composite with the highest NaX content and the largest population of accessible Na^+ exhibits the highest CO_2 capacity. CO_2 adsorption at room temperature shows that molecular adsorption dominates, ensuring CO_2's desorption up to 100°C. Incipient impregnation of zeolite composites with Ni or Ni-Mn resulted in the formation of Fe^0 and Ni_3Fe intracrystalline nano phase in both types of catalysts in which Fe originates from the used fly ash. Among them, Ni-Mn-containing catalysts show higher activity and selectivity for CO_2 methanation than the Ni-containing ones due to the beneficial role of Mn on the Ni dispersion. 3D-printed Ni-Mn catalysts exhibited stable activity of 80 % and 98 % selectivity to methane at 350°C for 30 h TOS. From a sustainability perspective, the use of rice husk and fly ash-derived zeolite composites aligns with the circular economy principles, while the combination of bimetallic catalysts and 3D printing offers a pathway to tailor catalyst architectures for enhanced performance.

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SINGLE-ATOM MXENES AS VERSATILE CATALYSTS FOR CINNAMALDEHYDE TRANSFORMATIONS

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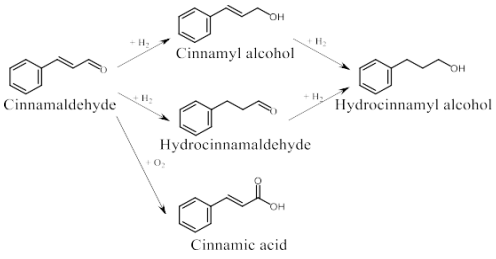
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Cinnamyl alcohol is a key organic intermediate, widely employed in the pharmaceutical and perfumery industries [1]. Its production is associated with a limited scalability, low productivity, and an adverse environmental effect. However, MXenes [2] can provide a more efficient pathway for the carbonyl group reduction using H2 under low pressure and moderate temperatures.

This study introduces a new synthetic strategy by incorporating single-atom transition metals (Fe, Co) in MXenes together with less-studied elements as In, followed by the evaluation of their catalytic performance in the hydrogenation / oxidation reactions. All investigated MXenes presented a rather complicated composition, a small surface area (less than 2.5 $m^2 \cdot g^{-1}$) combined with a well-distributed structure characterized by XRD, Raman, XPS and DRIFT techniques. For cinnamaldehyde hydrogenation, high activities were achieved over Co(SA)–$Ti_3C_2Cl_x$ (TON = 807.7; TOF = 161.5 h^{-1}), In–$Ti_3C_2Cl_2$ (TON = 391.6; TOF = 78.3 h^{-1}), and In_2O_3 (TON = 988.7; TOF = 197.7 h^{-1}). Notably, a higher selectivity toward cinnamyl alcohol was also measured, *e.g.* 75.7% for Co(SA)–$Ti_3C_2Cl_x$, 85.0% for In–$Ti_3C_2Cl_2$, 67.8% for Fe(SA)–$Ti_3C_2Cl_x$, 60.5% for (In,Ti)C, compared to only 9.8% for In_2O_3. These results also highlighted the role of the active elements upon the catalytic selectivity. For the oxidation, the selectivity to the cinnamic aldehyde was total with a maximum of the conversion of 34.5% for Fe(SA)-Ti3C2Clx, corresponding to a TON of 21.8.



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SUSTAINABILITY AND ECONOMIC BOUNDARIES OF MICELLAR CATALYSIS IN FINE CHEMICAL SYNTHESIS

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Micellar catalysis in aqueous media has gained attention as an alternative reaction environment to organic solvents in fine chemical manufacturing, motivated by concerns related to economic viability, environmental sustainability and safety. Despite being promoted as greener alternatives, comparative analyses spanning diverse chemistries, reaction environments, and surfactant systems remain limited, constraining a comprehensive assessment of the scope and limitations of micellar catalysis. To address this gap, we present an integrated techno-economic analysis and environmental impact assessment benchmarking six representative industrial processes performed under optimized micellar and conventional solvent-based conditions. The developed framework integrates key economic indicators such as capital (CapEx) and operational (OpEx) expenditures with environmental impacts quantified across eighteen different categories and interpreted within the nine planetary boundaries.[1] Technological and material-based hotspots were identified in micellar processes, where OpEx increased from 29,300 to 65,300 € $kg_{product}^{-1}$ $year^{-1}$ compared to organic solvent-based systems, mainly driven by raw material costs (76 % of total OpEx) associated with surfactant manufacturing, providing a quantitative foundation for sustainable micellar processes.

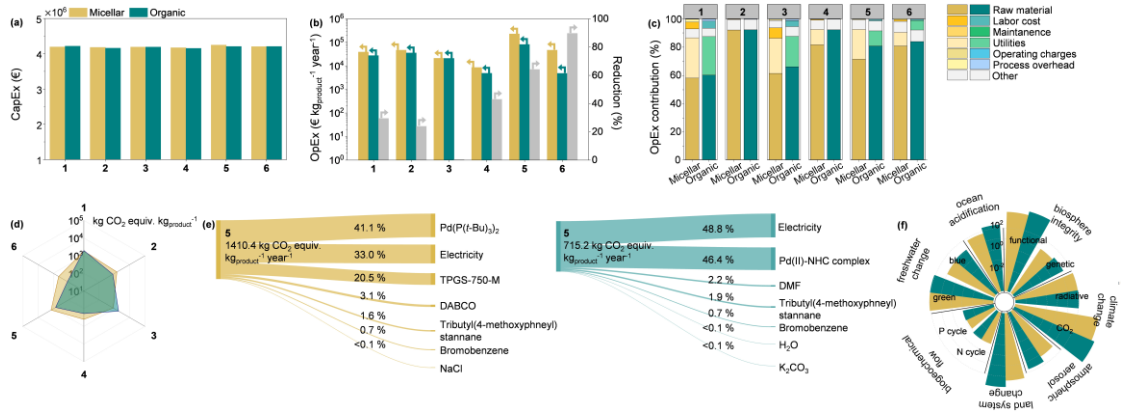


Figure 1. Comparison of micellar and organic solvent–based systems in terms of CapEx (a), OpEx (b), OpEx contributions (c), carbon emissions (d), component-wise breakdown of carbon emission (e), and impacts across the nine planetary boundaries (f).

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LOW-TEMPERATURE ACETYLENE HYDROGENATION OVER PALLADIUM-MOF CATALYST

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Developing efficient and sustainable catalysts for acetylene hydrogenation is essential for reducing energy consumption and improving process selectivity in the petrochemical industry. Pd-based catalysts are commonly used in this process [1]; however, their selectivity remains insufficient, often leading to over-hydrogenation and the formation of less valuable ethane which drive the need for further improvements. In this study, we explore MOF MIL-53 as a support material for Pd nanoparticles (NPs). MIL-53 was chosen by its flexibility, having “breathing” structure, meaning its pore size can dynamically change in response to external conditions. Additionally, the presence of secondary metals such as Ga, Ti and Cr can further enhance catalytic performance.

The synthesize of MIL-53 was carried out via a conventional solvothermal method, as well as a green approach that eliminates the use of HF and reduces synthesis time [2]. Pd functionalization was achieved using wetness impregnation with various Pd precursors and photodeposition.

Catalytic activity was evaluated in a fixed-bed reactor at 1 bar and temperatures ranging from 50 to 250 °C. Moreover, in-operando synchrotron XAS experiment was conducted, unrevealing the local electronic and structural properties of both active Pd sites and MOF metal centers. PCA and MCR analysis were used to identify and quantify the evolution of species under reaction conditions.

Among the materials studied, photodeposited Pd on MIL-53(Cr) exhibited the best catalytic performance, achieving 99.2% selectivity and 97.4% conversion at 90 °C, with high stability over 18 h of reaction. Further work is underway to partially substitute Cr with Ti, with the aim of improving photodeposition efficiency, and promoting Pd active sites incorporation within the MOF pores.

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Synthesis and characterization were carried out at the ITQ of the UPV-CSIC, and XAS measurements were performed at the CLÆSS beamline of the ALBA Synchrotron (proposal #20260380030).



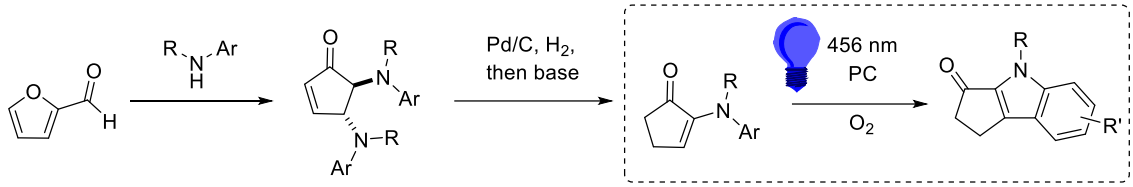
PHOTOCATALYTIC SYNTHESIS OF INDOLES

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Indole derivatives are important motifs in natural products, pharmaceuticals, and agrochemicals,[1,2] which has driven interest in the development of new and more sustainable synthetic methodologies. Many classical approaches rely on harsh reaction conditions, toxic or expensive reagents, and display limited functional group tolerance. [3] In this context, visible-light photocatalysis enables mild and selective transformations aligned with green chemistry principles.[4] We aimed to develop a photocatalytic strategy for the synthesis of indole derivatives starting from renewable feedstocks. Specifically, furfural, an industrial platform chemical readily obtained from biomass waste, was explored as a precursor. The synthetic sequence involves the conversion of furfural into trans-diaminocyclopentenones via Nazarov-type electrocyclization, followed by catalytic hydrogenation and β-amine elimination to afford α-enaminones as key precursors to the photocatalytic transformation (Scheme 1). These enaminones undergo an oxidative photocyclization of under blue light irradiation using the organic photocatalyst 3DPAFIPN in the presence of atmospheric oxygen. Under optimized conditions, a broad range of indole derivatives was obtained in moderate isolated yields (38–53%).



Scheme 1. Synthetic pathway for enaminones and their photocatalytic oxidation.

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3D PRINTING OF ZIF-8 FOR ETHANE/ETHYLENE SEPARATION

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The separation of ethane/ethylene mixtures remains a highly energy-intensive process in the petrochemical industry. Ethylene, a key feedstock for polymer production, is mainly obtained via steam cracking and requires purification to reach polymer-grade purity. Adsorption-based processes have emerged as promising alternatives, particularly using ethane-selective adsorbents that enable direct recovery of high-purity ethylene and may reduce energy consumption [1]. Metal–organic frameworks (MOFs) have gained attention for gas separation due to their tunable pore structure and chemical functionality [1]. ZIF-8 stands out for its high thermal stability, hydrophobicity, large surface area, and affinity toward ethane [2]. ZIF-8 is typically obtained in powder form, which limits industrial application due to pressure drop and handling issues. Therefore, subsequent material shapping is needed. In this work, ZIF-8 monoliths were fabricated via Direct Ink Writing (DIW) using ZIF-8/bentonite inks. The structures were characterized in terms of textural, morphological, and thermal properties. Adsorption equilibrium isotherms of C_2H_6 and C_2H_4 were measured at 283, 303, and 323 K to evaluate the performance of the 3D printed structure and compare it with pristine ZIF-8. The results demonstrate that ZIF-8 can be structured by 3D printing with a moderate impact in its original properties.

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SUSTAINABLE CATALYTIC PRODUCTION OF BIO-BASED 1,5-PENTANEDIOL AND ITS USE IN FURANIC POLYMERS

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Development of renewable diols is essential for advancing sustainable polymer systems. Among them, 1,5-pentanediol (1,5-PDO) stands out as a versatile C5 building block, though its commercial use has been limited by the lack of efficient and affordable production routes [1]. This work presents an integrated approach for producing bio-based 1,5-PDO from tetrahydrofurfuryl alcohol (THFA), a lignocellulosic intermediate manufactured at scale. Hydrogenolysis using a non-noble Ni–Co–La mixed oxide catalyst [2] enables high productivity in a cost-effective and sustainable manner. A kinetic study revealed zero-order dependence on THFA below 50% conversion and an apparent activation energy of 77 kJ·mol^{-1}, supporting accurate process modelling. Three production capacities (2,000–7,000 t·y^{-1}) were evaluated, combining semi-batch hydrogenolysis with vacuum distillation and strong energy integration. The minimum selling price decreases from 3,712 to 2,700 USD·t^{-1} with increasing capacity, remaining well below the current 1,5-PDO market price. These results demonstrate competitive economics at moderate scales using biomass-derived feedstocks. To validate monomer quality, bio-based 1,5-PDO was obtained at 99.4 wt% purity and polymerized with 2,5-furandicarboxylic acid (FDCA) to produce poly(pentamethylene 2,5-furandicarboxylate) (PPeF). The resulting Bio-PPeF showed higher molecular weight and improved mechanical and barrier properties compared to its petrochemical analogue, reflecting the purity and reactivity of the renewable monomer. These attributes underline the potential of bio-based 1,5-PDO for high-performance, fossil-free packaging materials. Overall, this work provides a full proof-of-concept—from catalyst behaviour to polymer application—confirming the techno-economic feasibility of sustainable 1,5-PDO production from THFA.

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NATURE-DERIVED MATERIALS FOR SOIL MOISTURE SENSING: A GREEN CHEMISTRY APPROACH TO AGRICULTURE 4.0

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Humidity monitoring is essential in agriculture, food processing, and healthcare, among driving the demand for sustainable sensing materials compatible with the Internet of Things (IoT) [1].

This work presents a hydrochromic humidity sensor based on cellulose acetate (CA) incorporating the ionic liquid bis(1-butyl-3-methylimidazolium) tetrachlorocobaltate(II) ($[Bmim]_2[CoCl_4]$). The composite exhibits a visible colourimetric response, transitioning from blue to transparent upon exposure to water within the 50–90% relative humidity range. The CA/$[Bmim]_2[CoCl_4]$ material demonstrates strong potential for soil moisture monitoring in Agriculture 4.0, offering a sustainable, nature-derived approach to addressing water scarcity and climate change.

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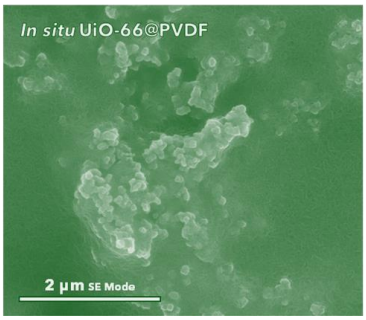
DEVELOPMENT OF MOF-DERIVED MATERIALS TOWARDS SUSTAINABLE PROCESSES

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Metal–organic frameworks (MOFs) have been proven to be excellent contenders for bridging the gap between zeolites and mesoporous silica. MOFs are formed by metal ions/clusters and organic linkers and have captured widespread interest, achieving an explosive development over the last decades. The crystalline nature, structural diversity, and tuneability, as well as ultrahigh surface area make MOFs find their potential applications in diverse areas, such as gas sorption and separation, chemical sensing, proton conductivity, biomedicine, and catalysis. However, in numerous MOFs the structural stability and performance limit their practical applications, relatively to other porous materials. Thus, distinct strategies have been used to prepare MOF based materials and overcome these drawbacks. [1, 2] The modification and derivation of MOF materials, and their utilization as platform, template or subtract opens an avenue to the preparation of diversified porous MOF-based materials with unique advantages in comparison to traditional pristine materials. Following our interest in the development and application of functional MOFs towards sustainable energy-related processes, including mitigation and valorisation of CO_2, an overview of interesting MOF-based materials prepared and investigated in our research group is reported.



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ZIF-8 SYNTHESIS IN BIO-BASED ORGANIC CARBONATES AND END-OF-LIFE APPLICATIONS IN WATER TREATMENT

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Zeolitic imidazolate frameworks (ZIFs) are a subclass of the well-known metal-organic frameworks (MOFs), among which ZIF-8 stands out. It consists of tetrahedral units where each Zn ion coordinates four 2-methylimidazolate linkers, forming a three-dimensional sodalite-type topology. The solvothermal method using dimethylformamide (DMF) as solvent is commonly employed for the traditional synthesis of ZIF-8 [1]. However, since DMF is a toxic, fossil-based solvent that poses risks to human health and to the environment, the development of new synthetic processes based on alternative solvents has become a primary goal in this field [2].

To contribute to this topic, this work explores the innovative use of dimethyl carbonate (DMC) and DMC-methanol mixture as alternative solvents for the synthesis of ZIF-8, adopting a life cycle perspective and using LCA as a tool for sustainability evaluation. Furthermore, following Green Chemistry principles, the potential of recycling the used solvents for further ZIF-8 synthesis is being evaluated. ZIF-8 is also investigated for the treatment of water and wastewater contaminated by dyes. In particular, ZIF-8 shows high efficiency toward methylene blue removal through both adsorption and photocatalysis. A valorisation strategy aimed at reusing spent ZIF-8 is also investigated by producing several photoactive adsorbent materials, yielding very promising results.

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A NOVEL IN-SITU DERIVATIZATION AND ISOLATION STRATEGY FOR NATURAL PRODUCTS

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From 1981–2019, 24% of all 1881 approved drugs were natural products (NPs) or derivatives (*i.e.* 441). The traditional framework for accessing NPs remains challenging due to labor-intensive procedures, low isolation yields, and the usual requirement for additional synthetic derivatization.[1] Furlan's group introduced the innovative concept of Chemically Engineered Extracts (CEEs), which involves chemically diversifying crude NPs extracts by targeting common reactive molecular fragments, followed by isolation and purification of the resulting NP hybrids.[2]

Herein, we describe a novel PhotoCEE platform that combines polymer-supported photochemical transformations to *in situ*, target olefins present within NPs extracts, followed by easy isolation (Figure 1). This strategy enables the simultaneous derivatization of multiple NPs, thereby allowing the rapid and cost-efficient generation of large molecular libraries of structurally complex NP hybrids. As a proof of concept, we used the natural extract of Sphaerococcus *coronopifolius* and *Mentha spicata*.

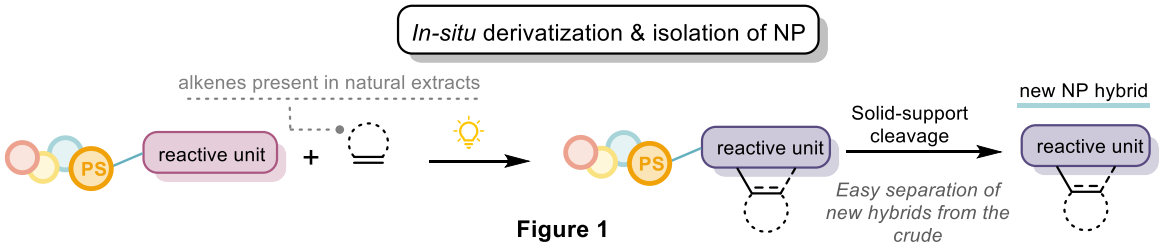


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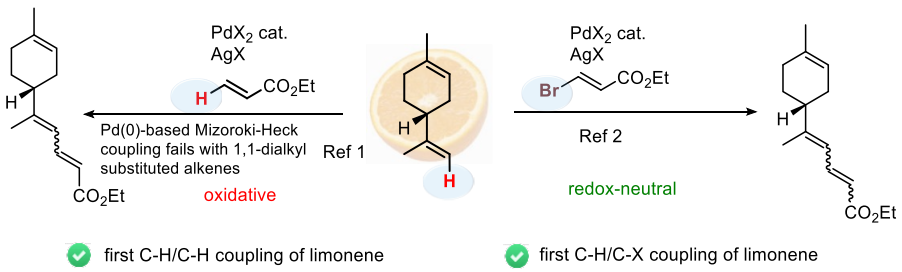
C–H ACTIVATION: FIRST CH/CX PD-CATALYSED COUPLING FROM TERPENES

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Terpenes are a large and structurally rich class of natural hydrocarbons. Their structures make them ideal building blocks, alternative to petroleum feedstocks, for C–C bond formation via catalytic C–H activation. In the frame of our long-term project directed toward the extension of the chemical space of bio-based molecules through selective C–H activation, we recently reported a Pd-catalyzed C(sp^2)–H/C(sp^2)–H cross-dehydrogenative coupling between limonene (as well as other terpenes), and acrylates (as well as other partner alkenes), which allowed selective access to 1,1-dialkylsubstituted 1,3-dienes.[1] However, the 1,1-disubstituted alkene motif incorporated in limonene, and most of the terpenes, does not allow couplings via the classical Pd(0)-catalysed Mizoroki-Heck (MH) reactivity. We have now found that by reversing the redox pattern of the MH coupling, *i.e.* by using a Pd(II)-catalysis instead of the classical MH Pd(0)-based one, in conjunction with an acrylate oxidized at the β position allows access to the desired sorbate derivatives. The presentation will provide further details on this newly developed and unprecedented coupling, including analysis of the mechanism via DFT calculations.[2]



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ECOFRIENDLY ISOLATION AND CHARACTERIZATION OF CELLULOSE FROM ALGERIAN ARUNDO DONAX L. VIA A TOTALLY CHLORINE-FREE MULTISTEP PROCESS

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This study reports the ecofriendly isolation and comprehensive characterization of cellulose from Algerian Arundo donax L. (giant reed), an abundant and fast-growing aquatic lignocellulosic biomass. Cellulose was extracted through a multistep procedure comprising Soxhlet extraction, alkaline treatment, and a totally chlorine-free (TCF) two-step bleaching process based on hydrogen peroxide and acetic acid, thereby avoiding the use of toxic chlorine-based reagents. The chemical composition of the raw giant reed and the isolated giant reed cellulose (GRC) was assessed according to TAPPI standards. A cellulose yield of 34.5% was achieved, with a high α-cellulose content of 91.80%, confirming the high purity and efficiency of the isolation process. The structural, morphological, crystalline, and thermal properties of the isolated GRC were thoroughly investigated using Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), X-ray diffraction (XRD), thermogravimetric analysis (TGA), and differential scanning calorimetry (DSC). FTIR analysis confirmed the complete removal of lignin, hemicellulose, and other non-cellulosic components, as evidenced by the disappearance of characteristic bands at 2860, 1731, 1515, and 1242 cm^{-1}. XRD measurements revealed that the isolated GRC belongs to the cellulose I allomorph, with a crystallinity index of 67.85%. SEM micrographs showed that the chemical treatment transformed the rough fiber surface of raw giant reed into a fibrillated and smoother morphology. TGA and DSC analyses demonstrated enhanced thermal stability of GRC compared to the raw giant reed, with an onset degradation temperature of 276.3 °C. This work establishes a green and effective pathway for valorizing Algerian giant reed waste into high-purity cellulose, with potential applications in biocomposites, pharmaceuticals, and green material engineering.



SYNTHESIS OF TAILORED BIOCOMPATIBLE BLOCK POLYESTERS BY MEANS OF [OSSO]-TYPE CATALYSTS

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The development and application of degradable and non-toxic polymers have gained significant attention due to environmental and health concerns associated with conventional synthetic plastics. Traditional polymers, while offering excellent mechanical and chemical stability, persist in the environment, leading to severe ecological accumulation.[1] Degradable polymers break down through chemical, enzymatic or biological processes into harmless by-products, reducing the long-term environmental footprint of polymeric materials and supporting sustainability. This impact can be further improved by incorporating sustainable and bio-sourced monomers.[2] Here, to expand the use of bio-based epoxides as ROCOP (ring-opening copolymerization) monomers for polyester (PE) synthesis, we synthesized two terpene-based terminal epoxides, cinnamyl-glycidyl-ether (CGE), geranyl-glycidyl-ether (GGE), and a saturated fatty acid terminal epoxide from undecanoic acid, epoxymethyl-undecenoate (EMU). We examined their copolymerization with phthalic anhydride (PA) in the presence of [OSSO]-type catalysts.[3,4] Depending on the monomer feeding ratio, di-block AB and tri-block ABA/BAB copolymerization with CHO and vCHO revealed a combination of soft and hard blocks, enabling a customizable final material. The degradability of selected copolymers was assessed under hydrolytic conditions. Lastly, cytotoxicity tests on human hepatocarcinoma cells verified the non-toxicity of the polyesters, with good cell viability suggesting their suitability for environmentally sustainable applications.

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DIAZO-FORMING ENZYMES – CATALYTIC MECHANISM AND BIOCATALYTIC APPLICATIONS

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From the investigation of a cryptic microbial biosynthetic pathway, we uncovered a diazo-forming enzyme, Aha11, and helped define a three-enzyme system that catalyzes nitrite-dependent N–N bond formation. Two of these enzymes—a flavin-dependent monooxygenase and a lyase—convert L-aspartate into nitrite or nitrous acid via a nitrosuccinate intermediate. Together, they form the L-aspartate/nitrosuccinate (ANS) pathway. The third enzyme, an ATP-dependent catalyst such as Aha11, uses the resulting nitrite as a nitrogen donor to synthesize N–N bond-containing products, including diazo compounds. We further demonstrate that these N–N bond-forming enzymes can be engineered to accept a range of substrates. By constructing chemoenzymatic cascades, we highlight the catalytic potential of this system for the synthesis of diverse nitrogen–nitrogen bond-containing molecules.

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CLOSING THE LOOP WITH INSECTS: KEY TRANSFORMATIONS AND SUSTAINABLE SOLVENT APPLICATIONS

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Insects hold great promise for a sustainable future, offering a way to eliminate organic waste under benign conditions while providing a nutritious protein source for humans and animals. Our research investigates the key chemical and biochemical transformations required to develop an insect-based circular economy, including analyzing the microbiome of the biodegradation process and valorizing the resulting insect biomass and residues, for the generation of products for food, biomedical and environmental applications.

A key focus is the upgrading of insect frass, a byproduct generated in large quantities during biodegradation. Valorizing this frass is crucial for the economic and environmental sustainability of the entire bioeconomy. We have demonstrated that frass from mealworms (*Tenebrio molitor*) fed on plastic or food waste can be used to produce high-quality chitin and chitosan. These essential biopolymers can be isolated with high purity and molecular weight, comparable to commercial products. Furthermore, this extraction can be achieved in a one-pot process using either acid/base treatments or protic ionic liquids, avoiding the need for highly corrosive acids for demineralization.

These findings provide strong evidence that an insect-based bioeconomy for waste recycling is not only sustainable but also commercially viable.

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MICROALGAE – A BLUE PERSPECTIVE OF GREEN CHEMISTRY

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In times when sustainability and resilience are increasingly paramount [1], renewable biological resources are gaining relevance. Marine microalgae are a natural source of numerous molecules with enormous potential. The variety of their chemical composition allows for applications as diverse as in cosmetics, food, pharmaceuticals, or bio-oil production. This presentation is focused on two microalgae species with very distinct characteristics, *Nitzschia* sp. and *Gymnodinium* sp., aiming to reveal their chemical composition and biological potential. *Gymnodinium* sp. produces biotoxins, but these biomolecules may serve as leads for drugs with anaesthetic potential, resulting from their ability to act through the reversible blockade of the voltage-gated sodium channels on excitable membranes [2]. In turn, *Nitzschia* sp. is rich in fatty acids and produces valuable molecules as secondary metabolites, such as fucoxanthin and lutein, whose antioxidant, anti-inflammatory and photoprotective properties are known. These economically relevant compounds could be extracted efficiently from the microalgae, and subsequently analysed by HPLC, with different detectors, and by GC-MS. The sustainable exploitation of these resources may represent a step forward in the path to a sustainable blue bioeconomy.

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ADVANCING CIRCULAR RESOURCES MANAGEMENT: EXPERIMENTAL EVALUATION OF NUTRIENT RECOVERY TECHNOLOGIES FROM WASTEWATER

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Wastewater management poses a significant challenge in many developing regions, especially in peri-urban areas where standard centralized treatment systems are impractical. In this context, the recovery of nutrients from wastewater is a key strategy for advancing circular economy principles [1]. Through a rigorous decision-making analysis [2] three promising nutrient recovery technologies (NRTs) were identified as the most cost-effective for low-concentration of nutrients in domestic wastewater. This study presents a comparative evaluation of these NRTs at laboratory scale applied to waste streams with different physicochemical characteristics, including anaerobic treatment effluents from Bucaramanga (Colombia) and sludge-derived matrices from Sabadell (Spain). Results demonstrated that Adsorption allowed the simultaneous recovery of Nitrogen (N) and Phosphorus (P), offering a balanced approach for dual nutrient removal and valorisation. Ammonia stripping was a highly efficient technology, achieving N recovery efficiencies above 90%[w/w] under controlled pH and temperature conditions. In contrast, struvite precipitation achieved high phosphorus recovery efficiencies (75–94%[w/w]) in matrices with elevated PO_4–P concentrations (>40 mg/L), being dependent on phosphorus availability. These results highlight the context-dependent performance of NRTs and the importance of coupling decision-support tools with experimental validation to enhance implementation feasibility.

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EFFECT OF THE SYNTHESIS PARAMETERS ON THE SUSTAINABLE PRODUCTION OF PET-BASED AEROGELS

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Polyethylene terephthalate (PET) packaging can be mechanically processed to be recycled (rPET) several times, but after a certain number of cycles its polymer chains start to degrade leading to poorer mechanical properties. The resultant wastes are predominantly managed through conventional landfilling or incineration, which contribute to substantial environmental impacts. The development of multifunctional insulation materials, that can be obtained using plastic wastes as raw materials, is an environmentally and economic sustainable strategy, contributing to energy savings and circular economy. Polymer-based aerogels can be a cutting-edge solution in this regard, offering very low density and thermal conductivity porous materials [1, 2].

The present work describes the room temperature preparation of rPET aerogels through a dissolution/precipitation method [3]. The developed system was optimised, and the resulting materials were extensively investigated, regarding their physical, thermal and mechanical features. The obtained bulk density values were very low, down to 100 kg m^{-3}, and good thermal properties were achieved, as low as 37 mW m^{-1} K^{-1} (Hot Disk®).

A design of experiment was performed to assess the influence of different synthesis parameters on the material properties, offering reliable guidelines for more sustainable synthesis procedures.

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SUSTAINABLE VALORISATION OF CHESTNUT SHELLS THROUGH GREEN EXTRACTION

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Agro-industrial food waste is an increasing environmental challenge, particularly in chestnut processing, where industrial freezing involves brulage treatments that generate large quantities of shell residues. In Trás-os-Montes (Portugal), a major European chestnut-producing region, these residues represent an underexploited biomass [1]. This work evaluates brulage-treated chestnut shell valorisation using supercritical CO_2 extraction versus conventional extractions with polar and non-polar solvents [2,3]. Extracts were evaluated for yield, total phenolic and flavonoid contents, antioxidant capacity, and chemical profile by GC-MS. The first set of results indicated low yields (<1%), comparable recoveries for both techniques, and similar chromatographic profiles. Oleic acid was identified as the predominant compound, followed by L-ascorbic acid, linoleic acid, γ-sitosterol, and long-chain alkanes. These findings highlight chestnut shells as a low-cost, sustainable biomass with potential for high-value-added applications aligned with circular bioeconomy principles.

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GREEN IUPAC 2026
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GREEN C-H ACTIVATION REACTIONS FOR THE SYNTHESIS OF POTENTIAL BIOACTIVE THIENOPYRIDINONE DERIVATIVES

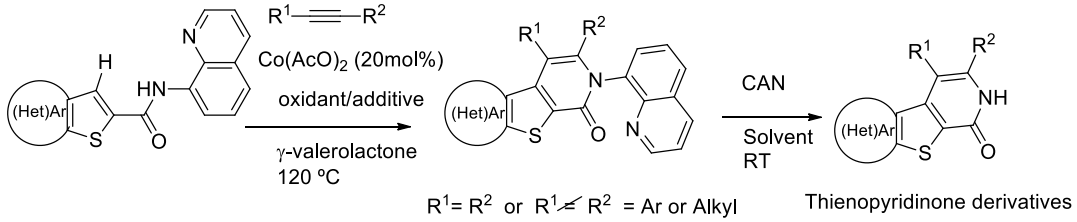
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Heterocycles are widely found in natural products and medicinally relevant compounds. Sustainable C–H functionalization catalyzed by earth-abundant transition metals such as cobalt has become an important strategy for their synthesis and modification [1]. In our previous work, we developed a rhodium-catalyzed C–H activation reaction using a carboxylic acid as a directing group (DG) for the preparation of heterocycles, enabling the synthesis of biologically active compounds [2,3].

Herein, we report a sustainable cobalt-catalyzed C–H/N–H activation and annulation strategy for the synthesis of thienopyridinone derivatives from (Hetero)aromatic fused thiophene amides bearing 8-aminoquinoline as a bidentate directing group and internal alkynes. The transformation proceeds using $Co(OAc)_2$ and inexpensive oxidants in bio-based γ-valerolactone at 120 °C. The quinoline directing group can be removed under mild conditions using cerium ammonium nitrate (CAN) at room temperature, providing direct access to unprotected thienopyridinone derivatives (Scheme 1). The synthesized compounds will be further evaluated in biological assays.



Scheme 1-Synthesis of thienopyridinone derivatives by C-H/N-H activation, annulations and removal of quinoline.

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GREEN BIOCATALYTIC PROTEIN MODIFICATION FOR DIAGNOSTIC AND THERAPEUTIC APPLICATIONS

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While small molecules (MW < 1000) have historically been the main source of therapeutic agents, protein based "biologics" are becoming more prevalent. Examples include antibodies, enzymes and other proteins. The function of protein-based agents can often be augmented via the attachment of cytotoxic moieties or imaging agents. To date, chemical modification of lysine and cysteine residues has been the primary method for preparing protein conjugates. However, such methods have important limitations in terms of specificity and stability. In the last 10 years, numerous enzymatic methods have been developed that allow highly selective protein modification.[1] Using farnesyltransferase, we have shown that substrate analogues containing functionality including, aldehydes, alkynes, azides and strained alkenes can be enzymatically incorporated with high efficiency into proteins. Subsequent biorthogonal ligation reactions afford proteins with unique reactive chemical handles that can be exploited for subsequent protein derivatization.[2] Here, three types of protein conjugates, prepared via enzymatic modification will be described. First, conjugates based on nanobodies against CD11b and CD45 were modified with a deferoxamine chelator to allow PET imaging of inflammation in mice. Next, DARPin proteins functionalized with cytotoxic agents that target EpCAM, an epitope present in high levels on the surface of cancer cells, were used to selectively kill them. Finally, the assembly of farnesylated chemically self-assembling nanorings (CSANs) bearing various cargos that can be used for diverse applications ranging from cell killing to cellular barcoding will be reported. These examples highlight the power of green biocatalytic protein modification.

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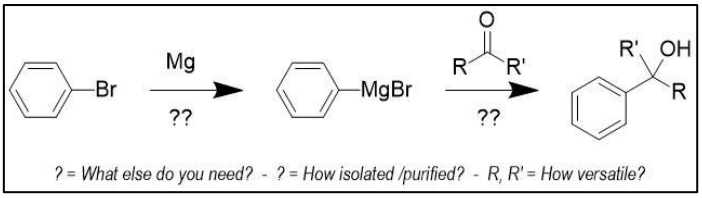
SUSTAINABILITY AND SYSTEMS THINKING IN THE LABORATORY CLASS

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Systems thinking in chemistry is intricately linked to planetary boundaries, the UN Sustainable Development Goals, and Green Chemistry and Chemical Engineering, with their 12 principles.[1] Laboratory classrooms are highly functional and expensive to run environments, and recently been identified as best suited to teach practical skills above all.[2]

How can these subjects be combined in an engaging manner? This presentation seeks to answer this question by highlighting best practice from current modules. The Grignard reaction[3] lends itself to designing sustainable protocols for synthesis and isolation based on recent developments[4] and this lab practical compares the conventional to the mechanochemical version.



Engineering aspects are evaluated in a 3-componend condensation that can be performed under reflux, sonochemically, microwave irradiation and mechanochemically, while providing pharmaceutical context to students. On a larger scale, the production of nylon and its precursors has been linked to teaching SOCME and green chemistry metrics.[5]

The intention is to discuss these and additional undergraduate activities that link sustainability and systems thinking, while teaching laboratory skills, and to provide ideas for the audiences' own designs.

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NON-THERMAL PLASMA-ASSISTED CATALYTIC CO_2 VALORISATION TO METHANOL

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The sustainable conversion of CO_2 into value-added chemicals is a key challenge in achieving low-carbon energy and chemical systems. Methanol is particularly attractive as a platform chemical, sustainable fuel, and liquid hydrogen carrier. However, conventional thermocatalytic CO_2 hydrogenation requires high temperatures (200–300 °C) and pressures (3–30 MPa) and suffers from limited conversion due to the thermodynamic stability of CO_2 [1]. Non-thermal plasma (NTP) offers a promising alternative, as energetic electrons (1–10 eV) enable CO_2 activation at near-ambient conditions, enabling new reaction pathways inaccessible to thermal catalysis [2].

This work investigates how engineering Cu, Zn, and Cu–Zn interfacial sites within the zirconium-based metal–organic framework UiO-66 can enhance NTP-driven CO_2 activation and methanol selectivity. UiO-66 offers high thermal stability, a highly ordered porous structure, and well-defined Zr-oxide nodes that provide controllable anchoring sites for metal species, enabling systematic tuning of metal–support interactions known to be critical in plasma catalysis [3].

The catalysts were synthesised via solvothermal MOF preparation followed by incipient wetness impregnation. Catalyst performance was evaluated in a dielectric barrier discharge (DBD) fixed-bed reactor under near-ambient conditions while varying gas composition, plasma power, and catalyst mass. Online GC analysis quantified conversion and product distribution.

Preliminary results indicate that bimetallic Cu–Zn@UiO-66 exhibits the most favourable balance of CO_2 conversion and methanol selectivity, suggesting synergistic activation pathways promoted by dual-metal interfacial sites. Structure–performance correlations reveal that metal dispersion and coordination within the MOF strongly influence plasma-driven reaction chemistry.

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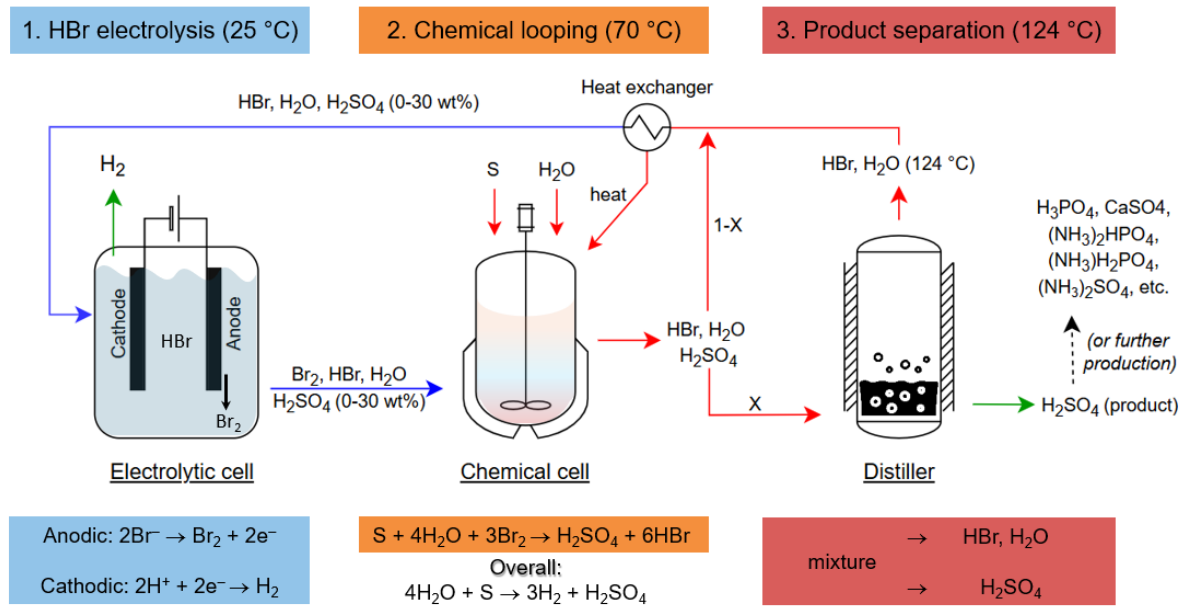
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BROMIDE-MEDIATED ELECTROLYSIS ENABLES GREEN HYDROGEN AND OXOACID PRODUCTION

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Hydrogen production by water electrolysis is constrained by high costs and limited product value. We report a bromide-mediated electrolysis–chemical-looping process that couples H_2 generation with H_2SO_4 production, $4H_2O + S \rightarrow 3H_2 + H_2SO_4$. HBr electrolysis produces H_2 at the cathode and liquid Br_2 at the anode that phase-separates spontaneously, enabling membraneless operation at 1 A cm^{-2} and 1.3 V. Br_2 then reacts with sulfur and water at 70 °C to regenerate HBr and form H_2SO_4 in 95% yield, with product recovery by distillation at 124 °C. Partial recirculation can yield integrated energy input of 44 kWh kg^{-1} H_2. Replacing O_2 evolution with H_2SO_4 adds ~$1.8 per kg H_2 in net product value and can yield a net-negative climate footprint by displacing market H_2SO_4.





PHASE EQUILIBRIUM STUDIES FOR SUSTAINABLE EFFICIENT SUB-ZERO THERMAL ENERGY STORAGE

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Sustainable energy needs are boosting interest in thermal energy storage (TES) to improve efficiency and balance supply and demand [1]. For low-temperature uses (refrigeration, cold-chain logistics, and medical applications), phase change materials (PCMs) are attractive due to their high latent heat and reversible energy charge/discharge phase transitions [1,2]. However, finding efficient, reliable, and environmentally safe PCMs remains challenging.

Over recent years, we have studied solid–liquid equilibria of organic PCMs, providing experimental data and thermodynamic insight for low-temperature TES design. We first examined di-n-alkyl adipate binaries (diethyl/dibutyl adipates), identifying eutectic behaviour near −33 °C. We then explored n-alkane systems (n-octane/n-decane and n-decane/n-dodecane), both with sub-zero eutectics, and later n-nonane/n-decane and n-nonane/n-undecane, focusing on odd–even carbon-chain effects [2]. More recently, adipate mixtures (dimethyl/dipropyl, diethyl/dipropyl, and dimethyl/dibutyl) evidenced eutectic diagrams between −33 °C and −20 °C, highlighting low-temperature TES potential. Overall, this four-year work expands the PCM candidate pool and understanding of low-temperature phase behaviour, supporting TES development and thermodynamic insights.

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Acknowledgments:

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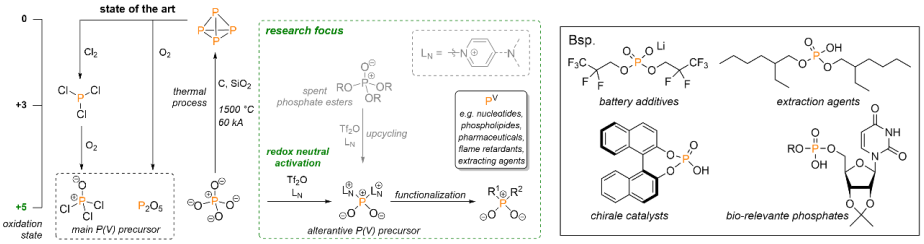
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CLOSING THE LOOP IN PHOSPHORUS CHEMISTRY: REDOX-NEUTRAL PATHWAYS FROM PHOSPHATE FEEDSTOCKS

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Phosphorus compounds are essential in biological systems and industrial applications, yet their conventional synthesis is inefficient and environmentally demanding. The dominant route relies on redox-intensive conversion of phosphate (P(V)) via elemental white phosphorus and subsequent (oxy)chlorination to PCl_3, PCl_5, and $POCl_3$, resulting in high energy consumption and substantial waste. This approach is inherently unsustainable, underscoring the need for greener alternatives. We present a redox-neutral methodology for activating primary and secondary phosphate sources using Tf_2O and pyridine (LN), enabling direct P–O bond cleavage in common P(V) feedstocks to yield the versatile phosphorylation agent $[(LN)_2PO_2][OTf]$. This strategy employs cost-effective phosphoric acid and related phosphates, significantly reducing energy demand and environmental impact compared to established processes.



Our approach not only improves the sustainability of phosphorus compound synthesis but also provides a pathway to access bulk chemicals. The resulting $[(L_N)_2PO_2][OTf]$ phosphorylation agent can be used to synthesize a variety of phosphorus-containing molecules.This advancement aligns with the principles of greener chemistry by minimizing hazardous reagents and by-products, optimizing atom economy, and reducing overall process energy demands.

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BORONIC ACID-FUNCTIONALIZED MULTILAYERED BIOMEMBRANES FOR PH-DRIVEN BINDING AND RELEASE OF CATECHOL-RICH ANTHOCYANINS

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The design of (bio)materials incorporating dynamic boronate–catechol chemistry has emerged as a versatile strategy in molecular recognition, sensing, and drug delivery, owing to its responsiveness to specific analytes and changes in physicochemical parameters such as pH. Plant-derived polyphenols are highly relevant bioactive compounds that could benefit from this chemistry in the development of smart functional systems [1]. However, studies exploring their interactions with boronic acid derivatives—particularly those involving pH-responsive anthocyanins (ANCs) remain scarce.

In this work, sustainable and free-standing multilayered biomembranes were fabricated via electrostatically driven interactions between oppositely charged polysaccharides, using a Layer-by-Layer (LbL) supramolecular assembly approach [2]. To this end, a boronic acid–chalcone receptor (BACt conjugated to carboxymethylcellulose/alginate (CMC/ALG) via carbodiimide coupling. The resulting functionalized polysaccharide (CMC/ALG–BACt) was then combined with positively charged quaternized chitosan (CHT-QT) to construct multilayered biomembranes. Catechol-rich ANCs were incorporated within the membranes, and their content was quantified by HPLC. Their release profiles were further evaluated under pH-regulated conditions.

This study provides valuable insights into the binding affinity of structurally diverse catechol moieties within the anthocyanin framework, contributing to a deeper understanding of dynamic boronate–catechol complexation. These findings open new avenues for the development of advanced active and sensing materials, particularly in food packaging applications.

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SUSTAINABLE CU-CATALYSTS FOR ESTER HYDROGENOLYSIS: FROM CONVENTIONAL TO MECHANOCHEMICAL APPROACH

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Traditional ester hydrogenolysis relies heavily on Adkins catalysts, which consist of $CuO.Cr_2O_3$. Due to the presence of Cr_2O_3, which actually acts as a structural promoter, the catalyst does not meet sustainability requirements.

This study contributes to the development of sustainable alternatives by designing Cr-free Cu/SiO_2 catalysts. We investigate the impact of catalyst preparation techniques - comparing conventional methods such as impregnation and deposition-precipitation with a solvent-free mechanochemical ball-milling approach. To elucidate how synthesis affects CuO dispersion and the nature of the resulting active sites, we employed a multi-technique characterization suite including XRD, TPR, and in situ FTIR spectroscopy with adsorption using CO and NO as probe molecules. Our results demonstrate that the preparation method greatly determines morphology, with Cu particles ranging from sub-3 nm to 15 nm. The detailed analysis of these particles was provided by FTIR with NO and CO adsorption on the active sites. This helped identify different Cu states formed on the catalyst surface and variations in metal-support interactions. Notably, the mechanochemical route successfully produced well-dispersed CuO nanoparticles while eliminating solvent waste. The energy intensity of all processes was assessed and compared.

The catalytic performance was evaluated in the hydrogenolysis of methyl butyrate to butanol and methanol. Beyond standard conversion and selectivity metrics, we provide a rigorous analysis of catalyst productivity and turnover frequency (TOF). These findings highlight the potential of mechanochemistry and explore the limitations and benefits of traditional methods for sustainable catalyst synthesis to obtain high-performance active sites for C-O bond hydrogenolysis.

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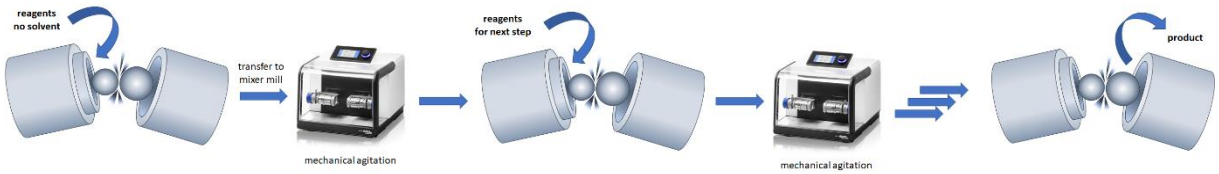
EXPLORING THE POTENTIAL OF SOLVENT FREE SYNTHESIS VIA MECHANOCHEMISTRY

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In recent years, mechanochemistry has revived as an important method in modern synthetic chemistry.[1] Especially en route to more sustainable and environmentally benign chemical processes, mechanochemical transformations are privileged,[2] since this approach offers important advantages: the ability to conduct conventional synthetic reactions without the need for solvents coupled with rapid reaction kinetics. These unique features make mechanochemistry highly attractive for both industrial applications and fundamental research across diverse fields, including material science, inorganic chemistry, and organic chemistry.

Along this line, we report on a set of such transformations including Tsuji-Trost allylations,[3-5] and it will be demonstrated that these transformations can be incorporated in multistep reaction sequences without isolation of intermediate products. Most importantly, it will be shown that the methods are applicable to compounds of relevance as active pharmaceutical ingredients.



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BALL MILLING AS A GREEN AND EFFICIENT METHOD FOR NUCLEOPHILE–HETEROALLENE COUPLING

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Heteroallenes, in particular isocyanates and isothiocyanates, constitute a significant class of chemical compounds widely used in various branches of industry, including photocatalysis, medicine, and materials science.[1] Despite their broad applicability, their practical use is limited by significant toxicity. One strategy to mitigate this issue involves combining heteroallenes with other building blocks, such as amines or thiols. These introduced motifs may reduce adverse effects of heteroallenes on human health due to their beneficial properties, including antibacterial[2] and antiviral activity,[3] while also improving the biodegradability of the resulting products.[4] Traditionally, such transformations require the use of toxic solvents,[5] inert atmospheres,[6] or transition-metal catalysts.[7] However, recent studies have demonstrated that mechanochemistry offers a promising opportunity to develop efficient and environmentally friendly protocols for NCO/NCS functionalization.[11, 12]

Herein, we present a novel mechanochemical strategy for the functionalization of isocyanates and isothiocyanates with two classes of nucleophiles: thiols and amines. Depending on the reagents employed, the reaction can lead to a variety of products, including thiazolines, aminothiazolines, thiocarbamates, and imine hydrochlorides. The most important advantages of the developed methodology include the complete elimination of transition metals, solvents, and any other additives, a short reaction time (1 h), full chemoselectivity, and simplified product isolation.

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SEMI-HYDROGENATION OF INTERNAL ALKYNES BY UNCONVENTIONAL METHODS AND APPLICATION TO PHEROMONE SYNTHESIS

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While the semi-hydrogenation of alkynes to obtain the corresponding *Z*-alkene is a well-known process in industry with the use of the Lindlar catalyst, the synthesis of *E* alkenes from internal alkynes remains a challenge in organic synthesis, and much more expensive routes are commonly used for their synthesis.

Here we show that ppm of $PdCl_2$ [1] catalyze the direct transformation of long–linear chain internal alkyl alkynes into the corresponding *E* alkenes, with moderate yields, after *cis* semi–hydrogenation and in–situ *Z/E* isomerization reactions, with just minor skeletal isomerization (<10%) and none over–hydrogenation reaction. An economic analysis supports the feasibility and higher sustainability of our one–pot process respect to the current Lindlar´s catalyst–Na/NH_3 two–step process. The procedure for the obtaining of the Z-alkene can be scaled to 10 L under industrially-relevant reaction conditions, maintaining a good yield (94%). [2]

Also, a new electrochemical method has been found to obtain *E* alkenes directly from the alkyne, with good yields (> 70%). In this case, the water in the reaction media is the responsible for the semi-hydrogenation, without the need for another reducing agent.

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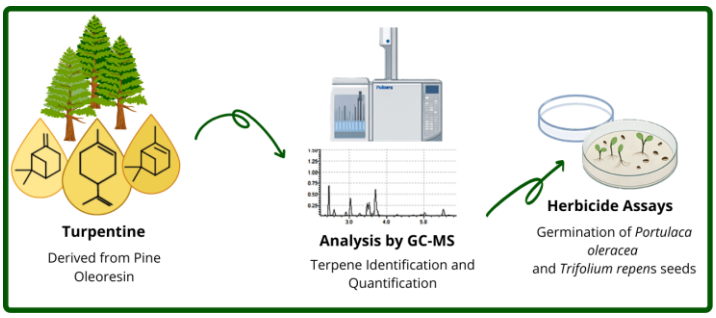
VALORIZATION OF PINE-DERIVED BY-PRODUCTS: IS TURPENTINE A SUSTAINABLE HERBICIDE?

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This study aims to access the herbicidal potential of terpenes present in turpentine. Specifically, herbicidal tests were carried out, to evaluate the germination and initial development of weed species Trifolium repens and Portulaca oleracea in the presence of a turpentine sample obtained from Pinus elliottii oleoresin. Oleoresine, is a natural mixture mainly composed of resin acids, terpenes, and neutral compounds, which are responsible for its bioactivity. By the industrial process of oleoresin distillation two main fractions are obtained: a resinic fraction (colophony also known as gum rosin) and a volatile fraction (turpentine). Turpentine consists mainly of terpenes, which are organic compounds formed from units of isoprene and have a wide range of applications in various industries (*e. g.*, cosmetic, pharmaceutical, agricultural).



The first phase of this work involved the chemical characterization of the turpentine sample. The terpenes in the turpentine sample were identified and quantified using various techniques. Subsequently, solutions with different terpene concentrations and a negative control were prepared and applied in herbicidal activity assays. During seed germination and seedling development of *Trifolium repens* and *Portulaca oleracea* various bioindicators were determined, showing consistent and reproducible effects, indicating that turpentine presents natural herbicide potential.

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PROCESS ANALYSIS AND MODELLING OF SUSTAINABLE IN-SITU OXYGEN EXTRACTION FROM LUNAR REGOLITH

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The sustained human presence on the Moon will require advanced In-Situ Resource Utilization (ISRU) technologies capable of reducing logistical dependence on Earth by producing essential consumables, such as oxygen, directly from local resources. From a green chemistry and sustainable engineering perspective, ISRU represents a compelling example of resource-efficient chemical processing, in which local materials must be transformed efficiently while minimizing waste and external inputs. Lunar regolith, the fine unconsolidated layer covering the Moon's surface, is primarily composed of oxide and silicate minerals including SiO_2, Al_2O_3, TiO_2, FeO, CaO, and MgO, which collectively contain approximately 40–45 wt.% oxygen [1]. The ability to extract oxygen from this abundant material provides a pathway toward sustainable life-support and energy systems, significantly reducing the environmental and energetic costs associated with transporting consumables from Earth. This study focuses on the modelling and thermodynamic analysis of an ISRU process, implemented in Aspen Plus® simulation software, for producing oxygen (O_2) from lunar regolith. In the first stage, carbothermal reduction of regolith, using reducing agents such as methane (CH_4) and hydrogen (H_2), produces syngas components (CO and H_2). In the second stage, the produced carbon monoxide reacts with hydrogen through methanation, forming methane and water, which subsequently undergo electrolysis to generate oxygen and hydrogen. Oxygen is the primary product, while hydrogen and methane are recirculated within the process. This integrated configuration enhances process efficiency and enables closed-loop resource utilization, producing breathable oxygen in a sustainable manner. Results demonstrate the thermodynamic feasibility of the integrated process and identify optimal operating conditions for maximizing oxygen production.

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INDUCTIVELY HEATABLE CATALYSTS FOR AMMONIA SYNTHESIS

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Green electricity cannot be stored and transported over long distances. One option to solve the problem is to synthesize green ammonia using electricity for both the production of the reactant hydrogen and ammonia synthesis. This way, ammonia serves as energy carrier for long-term storage and long-distance transportation.[1] Electrification of the heterogeneously catalyzed NH_3 synthesis requires new materials that stay magnetic under reaction conditions to facilitate induction heating while not deactivating the catalytic species.

Magnetic nanoparticles were synthesized by impregnation of 15 wt% of inductively heatable metals on Al_2O_3, followed by impregnation of Ru as active species for ammonia synthesis.[2] Alloyed Co-Ni particles were synthesized, which resulted in higher heating efficiency than the single elements. Reducing the crystallite size increased the magnetic coercivity (h_c), optimizing the heating efficiency.

The catalysts reached the reaction temperature of up to 650 °C in less than 60 s, where the NH_3 productivity was limited by the thermodynamic equilibrium. Multiple heating-cooling cycles proved the stability of the catalyst under discontinuous process conditions, which is required for the application due to the fluctuating nature of green electricity. Doping with Cs and Ba increased the activity of the catalyst, allowing to reduce the reaction temperature, leading to higher NH_3 productivity.[3] In addition, the catalysts show no activity loss after 48 h on stream, proving the feasibility of replacing conventionally heated NH_3 synthesis with induction heated.

This work shows the potential to inductively heat NH_3 synthesis catalysts, by which the reaction temperature is reached in very short time. This allows for the design of a discontinuous process, enabling NH3 as a potential long-term energy carrier for excess electricity.

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BAYESIAN PARAMETER ESTIMATION IN MICROKINETIC MODELING OF ANISOLE HYDRODEOXYGENATION OVER NICKEL ON ALUMINA CATALYSTS

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Hydrodeoxygenation (HDO) of lignin-derived phenolic compounds offers an alternative pathway for the production of renewable biofuels, primarily through the removal of oxygenated functionalities. In this study, the deoxygenation of the model compound anisole was investigated over Ni/Al_2O_3 catalysts. Experimental observations indicated that deoxygenation is preceded by hydrogenation of the aromatic ring of anisole. A non-competitive Langmuir–Hinshelwood (LH) model was employed to describe the kinetics of the anisole hydrogenation and subsequent deoxygenation reactions. The corresponding rate expressions include kinetic parameters such as reaction rate constants and adsorption coefficients. These rate expressions were then incorporated into component mass balance equations (ODE's) for all species in the reaction network. These ODE's are solved with estimated parameters, and their likelihoods (p-value) are determined. Both the parameters and their probability distributions (initially considered as normal distribution) are updated iteratively based on the likelihood determined in the previous iteration steps navigated through Markov Chain Monte Carlo (MCMC) method.

The MCMC method uses Metropolis-Hastings algorithm which is a Bayesian technique. In this new parameters are generated randomly, and are accepted or rejected based on whether their likelihood has improved, after which the parameters and their probability distribution is updated. By repeating this process over 100000 iterations, the algorithm constructs a Markov chain. Unlike frequentist approaches that rely on optimization near a single best-fit value, MCMC explores the entire parameter space to calculate the final posterior probability distribution. Finally, The estimated parameters are used to explain the synergy between the acid and Ni sites, and the multifunctional nature of HDO catalysis.

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CHEMICAL UPCYCLING OF USED COOKING OIL TO GREEN POLYMERS FOR COMPOSITES AND ADHESIVES

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Used cooking oil (UCO) is an abundant urban waste stream with strong potential as a renewable feedstock for sustainable polymer materials. In this work, UCO collected from municipal recycling systems was purified and chemically upgraded through selective functionalization of its unsaturated fatty acid chains, demonstrating how waste lipids can be transformed into versatile platforms for green materials. Epoxidation of UCO using in situ generated peracetic acid yielded epoxidized used cooking oil (EUCO), with conversion of double bonds to oxirane groups confirmed by iodine value and epoxy value titration, FTIR, and ^{1}H NMR spectroscopy. EUCO was subsequently cured with biobased dicarboxylic acids such as sebacic acid to produce fully biobased epoxy thermosets, which were further processed into flax-fibre-reinforced composites. In parallel, UCO was also converted into carbonated oils, which were reacted with amines to form non-isocyanate polyurethanes (NIPUs) for application as sustainable wood adhesives. These complementary pathways highlight the chemical versatility of UCO as a renewable raw material for both epoxy and polyurethane-type network formation. Overall, the study demonstrates that waste cooking oil can be effectively upcycled into value-added green materials, providing sustainable routes toward biobased composites and wood adhesive systems.

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GREEN CHEMISTRY IN API SYNTHESIS: A CASE STUDY OF TWIN-SCREW EXTRUSION FOR CONTINUOUS API MANUFACTURING

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Solvent consumption is a major contributor to waste in the pharmaceutical industry [1] and significantly impacts the sustainability of Active Pharmaceutical Ingredient (API) manufacturing. Mechanochemistry provides a promising alternative, as many reactions can be performed under solvent-free conditions. Recently recognised by the International Union of Pure and Applied Chemistry (IUPAC) as one of the *Ten Chemical Innovations That Will Change Our World* [2], mechanochemistry is emerging as a powerful approach for the sustainable synthesis of pharmaceutically relevant compounds, often referred to as *medicinal mechanochemistry*. While most mechanochemical reactions are currently performed by grinding, this batch-based method presents significant challenges for industrial scale-up. Reactive twin-screw extrusion (TSE) offers a continuous mechanochemical platform that improves safety, productivity, and scalability, making it particularly attractive for API manufacturing.

The study investigated the effect of changing the extrusion parameters on the synthesis of model APIs, namely paracetamol and 1,4-dihydropyridine calcium antagonists. Using a systematic experimental design, we evaluated key factors such as the effect of processing temperature on product yield, process uniformity and repeatability, as well as the effect of the addition of grinding auxiliaries and the physical state of reagents on mixture processability during extrusion. Additionally, we explored under-researched strategies in TSE-based API synthesis, such as integrating multi-step reactions within a single TSE run and applying a mechanoenzymatic approach. These insights contribute to a better understanding of process design in mechanochemical flow synthesis and highlight the potential of twin-screw extrusion as a scalable, greener manufacturing strategy for the pharmaceutical industry.

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LIGHT-DRIVEN "ON-DEMAND SYNTHESIS" OF N/BR-CODOPED POLYMERIC CARBON DOTS AT AMBIENT TEMPERATURE AS GREEN DUAL-MODE PHOTOINITIATORS

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The development of sustainable, metal-free photocatalysts capable of operating efficiently under low-energy light remains a critical challenge in modern green polymer chemistry. While carbon dots (CDs) represent a promising biocompatible platform, their conventional synthesis relies on highly energy-intensive methodologies, such as hydrothermal treatments or high-temperature pyrolysis, followed by exhaustive purification steps. These traditional procedures often lead to irreversible nanoparticle aggregation and diminished catalytic efficacy.

Addressing these drawbacks, we report a straightforward, environmentally benign methodology for the light-induced "on-demand" synthesis of N- and Br-codoped polymeric carbon dots (N/Br-PCDs). By irradiating amino acids (e.g. glycine and L-tryptophan) in conjunction with phenacyl bromide (PAB) under 365 nm LED light at ambient temperature in a green aqueous solvent system, N/Br-PCDs are generated directly *in situ.* PAB serves as both a photochemical precursor that provides the carbon framework and as the source of bromine species. This bromine doping induces a pronounced heavy-atom effect, accelerating intersystem crossing to rapidly populate a reactive triplet state. The resulting N/Br-PCDs operate as highly efficient dual-mode photoinitiators, capable of driving both free radical and cationic polymerizations under 405 nm visible light. By utilizing the crude reaction mixture directly for subsequent polymerizations, this "on-demand" protocol completely bypasses energy-intensive pyrolysis, dialysis and lyophilization steps, maximizing the catalytic surface area and significantly improving monomer conversions compared to purified systems. This methodology adheres strictly to green engineering metrics by employing ambient temperatures, benign solvents, and *in situ* concepts.

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GENERATION OF CARBON-CENTRED RADICALS FOR GIESE REACTION

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The field of carbon-centred radical chemistry has expanded considerably through advances in radical generation, photoredox catalysis, and selective radical addition processes. Among these transformations, the Giese reaction has emerged as a key strategy for carbon-carbon bond formation. Recent developments in photoredox catalysis[1] have enabled efficient radical generation under visible light, broadening the scope of Giese-type reactions and enhancing functional group tolerance.[2] Combined with efficient radical precursors and catalytic cross-over approaches, these methods allow increasingly complex radical intermediates to be employed in Giese additions, facilitating the synthesis of structurally diverse molecular architectures.

In this work, we explore the expansion of Giese reaction chemistry through photoredox or metal catalytic systems for the synthesis of complex quinic acid-derived spiro-lactam architectures, together with preliminary studies on peroxysilanes as carbon-centred radical precursors in a Giese reaction variant.[3]

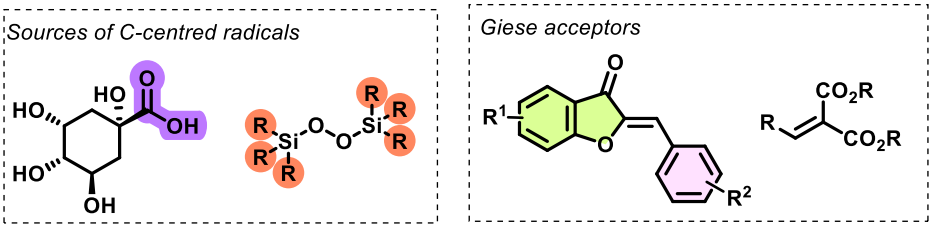


Figure 1: Unexplored Giese reaction partners

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MILD CHEMICAL RECYCLING OF PLA: HYDROLYTIC DEPOLYMERISATION ENABLED BY METAL CARBONATES

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Poly(lactic acid) (PLA) is increasingly used in packaging, food, and additive manufacturing, leading to growing PLA-based waste accumulation. [1,2] Developing sustainable chemical recycling strategies is essential for a circular lifecycle. [3] Herein, we report a mild approach for the hydrolytic depolymerisation of PLA into lactic acid using readily available alkali and alkaline-earth metal carbonates. Potassium and calcium carbonates act as effective homogeneous and heterogeneous promoters, respectively, enabling selective depolymerisation in subcritical water, while the formation of reusable by-products further enhances the sustainability of the system. The methodology was successfully applied to both technical grade PLA and real waste feedstock, including post-consumer and industrial residues, demonstrating its practical applicability. Overall, this carbonate-mediated strategy represents a promising route for a sustainable PLA depolymerization, contributing to the development of circular approaches in polymer waste management.

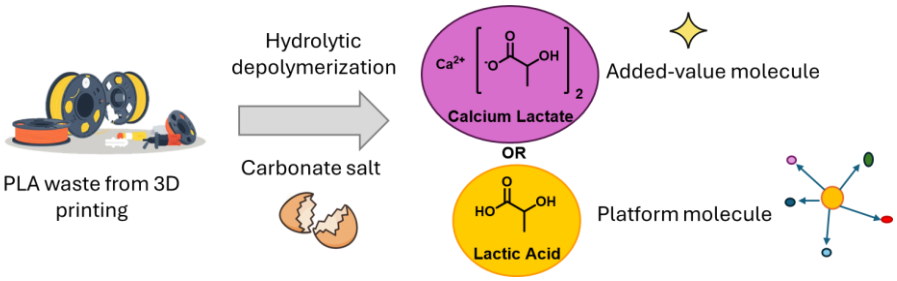


Figure. Graphical abstract

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DEVELOPMENT AND VALIDATION OF A SIMPLIFIED HPLC-UV METHOD FOR CONFIRMATORY ANALYSIS OF ANTIBIOTIC DEGRADATION VIA E-BEAM IRRADIATION

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Antibiotic residues present in wastewater effluents and aquatic environments are increasingly recognized as emerging contaminants due to their persistence and role in promoting antimicrobial resistance. As a result, it poses a significant environmental concern since conventional wastewater treatment processes cannot completely remove these micropollutants. Electron beam (e-beam) irradiation is a promising advanced oxidation-reduction process (AORP). It has shown potential to effectively degrade these contaminants through generation of reactive species such as hydroxyl radicals (•OH), solvated electrons (e^-_{aq}), and hydrogen atoms (H•)[1-2]. Therefore, a straightforward analytical method is needed to reliably confirm the degradation of the parent compounds. In this study, a simplified HPLC-UV method is developed for the simultaneous detection of Sulfamethoxazole and Ciprofloxacin in an aqueous matrix. Method development focuses on optimizing the isocratic elution to ensure adequate separation while maintaining a low flow rate to reduce solvent consumption. The method was validated in terms of linearity, repeatability, and sensitivity. Although analysis of actual wastewater matrices will require additional sample preparation, this study establishes a critical analytical foundation and contributes to the development of accessible and resource-efficient analytical tools for sustainable wastewater treatment and environmental monitoring practices.

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REPURPOSING METABOLIC WASTE: PRELIMINARY COMPUTATIONAL INSIGHTS INTO METAL SEQUESTRATION USING PYRROLIC BIOCHROMES

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Biological chromophores, or "biochromes," represent a sophisticated library of nature-derived ligands with significant untapped potential in green chemistry and sustainable development. This work explores the versatile coordination chemistry of pyrrolic scaffolds, specifically the linear tetrapyrrole bilirubin and its truncated dipyrrolic analogues (dipyrrins). Traditionally dismissed as a terminal metabolic byproduct of heme catabolism, bilirubin possesses unique structural flexibility and nitrogen-donor motifs that facilitate diverse metal-ligand interactions. Spurred by real-world environmental contamination in vulnerable municipal settings, our investigation explores the feasibility of repurposing this biological waste for environmental protection. First, computational modelling is employed to interrogate the fundamental electronic and steric drivers governing bilirubin's coordination chemistry, allowing us to evaluate preliminary binding tendencies and structural dynamics across target metal systems. We frame these theoretical insights within broader environmental and statistical contexts to outline the potential application of these scaffolds in sequestering metal pollutants. By conceptualizing biological "waste" as bio-inspired chelating agents, this research embodies the principles of green chemistry, supporting a transition from linear disposal models to circular environmental solutions. Ultimately, our preliminary findings position pyrrolic ligands as a versatile, sustainable frontier for industrial detoxification and the development of next-generation aqueous remediation technologies.

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DESIGNING RECYCLABLE BIO-BASED EPOXY–ACID THERMOSETS FOR SUSTAINABLE ADHESIVE APPLICATIONS

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Formaldehyde-based resins used in wood composites, present environmental and health concerns while offering limited end-of-life solutions due to their stable, non-recyclable crosslinked structures. Within this context, and in line with green chemistry, the European project SUSPENSE aims to develop and optimize sustainable bio-based adhesive technologies for wood-based materials.

In this work, we explore a green chemistry-driven strategy based on renewable feedstocks and cleavable network design to develop next-generation thermosetting adhesives relying on epoxidized vegetable oils and bio-based carboxylic acids, through epoxy ring-opening and esterification reactions. [1] By constructing networks containing ester linkages, the resulting thermosets are designed to combine performance with potential for chemical reprocessing under controlled conditions. [2] The curing mechanisms were investigated using rheological analysis and differential scanning calorimetry (DSC), enabling characterization of reaction progress and gelation behavior. The influence of biobased liquefiers was examined in order to tailor processing windows compatible with industrial manufacturing constraints. [3]

The resulting materials will be evaluated in wood-based panel and insulation applications, demonstrating their capacity to meet functional requirements while integrating renewable carbon content and improved circularity potential.

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CO_2 ELECTROLYSIS UTILIZING CO_2-CAPTURED FROM FLUE GAS TO CLOSE THE CARBON LOOP IN THE STEEL INDUSTRY AND BEYOND

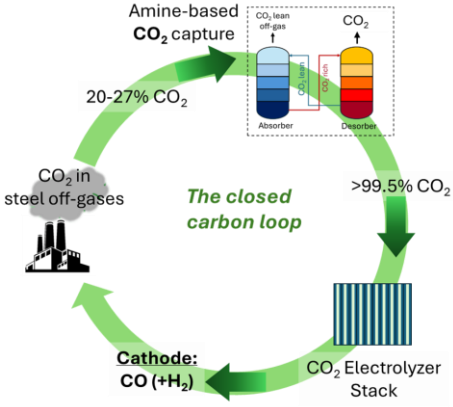
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CO_2 electrolysis emerges as a promising technology to reduce greenhouse gas emissions via electricity-driven CO_2 conversion from industrial point sources to valuable chemicals and fuels. CO_2 can be converted into a variety of valuable products with industrial relevance such as CO/syngas, methane, ethylene or ethanol and product selectivity is achieved through an appropriate catalyst material and electrode design. So far, the technology is mostly tested using pure and concentrated CO_2 feeds at lab scale.

In this study the integration of amine-based CO_2 captured from the power plant of an integrated steel mill with a pilot-plant CO_2 electrolysis unit at TRL 6 from eChemicles [1] to produce CO and its re-utilization in the steel industry is demonstrated for the first time (see **Figure** on the right). The impact of amine solvent composition on the energy demand of the capture process and the subsequent CO_2 electrolysis will be discussed. Optimized amine solvents provided finally reliable feeds of >99.5% CO_2 purity at <3.5 GJ/t energy consumption to convert up to 1t CO_2/day with 80-90% selectivity to CO. The technology operates at near atmospheric pressures and low temperatures <70°C. The influence of different operating parameters on both the electrolysis energy demand and the resulting product composition using real industrial CO_2 as feed gas will be shown. This work presents an important step towards industrial implementation of the CO_2 electrolysis technology and shows possible CCU value chains in the steel industry and beyond.



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TOWARDS A NEW GENERATION OF POLYURETHANE FOAMS ENABLED BY CO_2-BASED CYCLIC CARBONATES

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The utilization of CO_2 as a sustainable carbon feedstock is increasingly positioned as a key strategy to decarbonize the polymer industry. Five-membered cyclic carbonates (5CC) represent a promising CO_2-derived building block, as they are readily synthesized through the catalytic coupling of CO_2 with epoxides in a solvent-free process, enabling the incorporation of CO_2 into polymer precursors. When reacted with amines, 5CCs form polyhydroxyurethanes (PHUs), a CO_2-sourced alternative to conventional polyurethanes that eliminates the safety concerns associated with the use of toxic isocyanates in traditional PU chemistry.

However, replacing the efficient isocyanate chemistry without sacrificing performance remains extremely challenging. This is especially relevant in the polyurethane foam industry, which involves high-throughput production of billions of tons of materials per year. Mimicking the specific reactivity of isocyanate self-blowing formulations, able to construct the polymer matrix and generate expansion gas at low temperature within minutes, was long considered inaccessible using 5CC technology.

In the past few years, we have developed both the self-blowing reaction of 5CC and a cascade exotherm approach that enables rapid foaming of 5CC/amine formulations while retaining compatibility with existing PU foam production lines.[1],[2] This presentation will detail the underlying chemical pathways of the CO_2-based foaming mechanism and evaluate the thermo-mechanical performance of the resulting PHU foams. These results demonstrate the potential of CO_2-derived cyclic carbonates to support a scalable, non-isocyanate route toward sustainable polyurethane-like foams.

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METHYL FORMATE SYNTHESIS VIA RU-BASED HETEROGENEOUS CATALYSIS AND REACTIVE DISTILLATION

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Reducing atmospheric CO_2 concentrations has become an urgent priority in response to accelerating climate change. Among various CO_2 utilization strategies, the synthesis of methyl formate (MF) from CO_2 has attracted significant attention due to its high added value. Recent advances have demonstrated the feasibility of simultaneously accomplishing MF synthesis and separation within a single unit operation by integrating CO_2 hydrogenation with reactive distillation.[1] However, existing studies have relied exclusively on homogeneous catalysts, which present fundamental limitations with respect to catalyst recovery and recyclability.

Herein, a heterogeneous catalyst was applied to this integrated process for the first time. Employing the porous organometallic polymer structured Ru-MACHO catalyst (Ru-MACHO-POMP) with well-established activity in hydrogenation reactions, a turnover number (TON) of 2,089 was achieved, and excellent recyclability was confirmed over five successive reaction cycles.[2] Additionally, triethylamine (TEA, b.p.=89 ℃), predominantly used in prior studies as a base additive to stabilize formic acid, exhibits a boiling point insufficiently distinct from that of MF.[3] This results in poor separation efficiency in the reactive distillation stage. To address this limitations, tripropylamine (TPA, b.p.=156 ℃) was introduced as an alternative base.[3] Its markedly higher boiling point enabled complete separation of MF from the amine. These results demonstrate the viability of a heterogeneous catalyst-based integrated process for MF synthesis from CO_2. Securing catalyst reusability and improving separation efficiency are shown to contribute to the overall sustainability and thermal efficiency of the process.

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SYNTHESIS OF RENEWABLE NON-ISOCYANATE POLYURETHANES FROM ALGAE OIL AND ITS FATTY ACID METHYL ESTERS

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Sustainable pathways to production of non-isocyanate polyurethane (NIPU) are highly desirable. Algae are promising as a source of renewable chemicals because seaweeds are highly productive and do not require fertilization. Their growth has also been highlighted as an important tool toward carbon capture. Algae oil, like fish oil, contains polyunsaturated triglycerides, with a mixture of fatty acid chains including eicosapentaenoic and docosahexaenoic acids, highly unsaturated omega-3 fatty acids also found in oily fish, and palmitoleic acid, an omega-7 monounsaturated fatty acid, also found in sardine oil. Algae oil presents significant advantages as the plants grow rapidly, is plant rather than animal-sourced, and it does not compete with food production. Algae oil can be epoxidized and reacted with CO_2 to produce a cyclic carbonate-containing material. Upon reactions with amine curing agents, this leads to nonisocyanate polyurethane (NIPU) materials. The epoxidized algae oil can also be reacted with the appropriate curing agents to give cross-linked epoxy materials. In earlier work, we showed waste-derived fish oil could be used in a similar manner. The triglycerides can be transesterified with methanol to give fatty acid methyl esters (FAMEs), which are less corrosive than free fatty acids, less viscous than the parent triglyceride, and more easily purified and characterized. Multiple methods of epoxidation of the polyunsaturated triglycerides and FAMEs exist, and carbonated algae oils can be obtained through reaction of the epoxides with CO_2 with catalysts such as tetrabutylammonium bromide. Curing these carbonated intermediates is performed using polyamines, including 4,7,10-trioxa-1,13-tridecanediamine and NC-540 (a mixture of phenalkamines prepared from cardanol, derived from waste cashew nut shells) to give thin, elastomeric films. Others have performed an assessment on the potential commercialization of microalgal oil-derived NIPUs. The synthesis and properties of algae-derived NIPU and other materials and their characterization by NMR and IR spectroscopy, TGA, DSC and viscometry will be presented.

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LIPOPHILIC COMPOSITION OF *PRUNUS LUSITANICA* BY GC–MS: NUTRITIONAL QUALITY AND HIGH-VALUE METABOLITES

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Prunus lusitanica L. subsp. *lusitanica,* commonly known as 'azereiro', is a rare species native to Portugal. As a relic of the laurel forest, it has considerable ecological value and contributes to the conservation of laurel forest ecosystems and the control of invasive species [1]. Despite its ecological significance, the species is currently classified as 'Near Threatened' in Portugal [2]. Moreover, *P. lusitanica* remains chemically unexplored. Our study represents the first characterisation of the lipophilic composition of hexane extracts from the fruits, seeds, and leaves of this species by GC-MS. Numerous compounds were identified, including fatty acids and their derivatives, terpenoids, sugars and their derivatives, aldehydes, alcohols, and hydrocarbons. The seeds exhibited a favourable lipid profile supporting their nutritional potential. The leaves were particularly rich in sorbitol, rutinose, and friedelin, which are compounds associated with functional and bioactive properties. These findings establish *P. lusitanica* as a promising source of value-added metabolites for prospective applications in food and nutraceutical formulations.

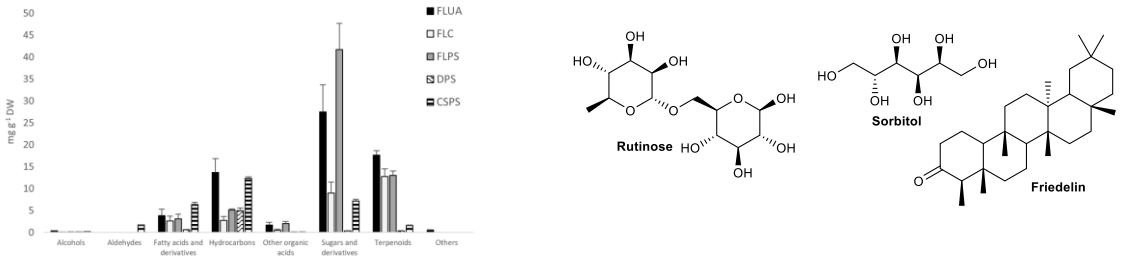


Figure 1. Average content of each class of compounds in different organs of *P. lusitanica* (FLUA, FLC, and FLPS: leaves collected from different geographic locations; DPS: fruits; and CSPS: seeds). Chemical structure of some metabolites.

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GREEN SYNTHESIS OF A BIO-BASED GUAR-GUM CROSSLINKED POLYMER COMPOSITE FOR ACTIVE PACKING APPLICATIONS

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Plastic pollution and the environmental burden of petroleum-derived packaging materials have intensified the search for renewable and biodegradable alternatives. In this work, a green and scalable strategy is presented for developing mechanically robust and functionally active biofilms based on guar gum (GG) and neem gum (NG) for sustainable active and smartpackaging applications. A series of plasticized GG–NG films were synthesized through a one-pot thermal crosslinking approach by systematically varying gum ratio, crosslinker type (glutaraldehyde, GA; N,N′-methylenebisacrylamide, MBA), ZnO nanoparticle loading (0.5–0.7% w/w), and plasticization using glycerol (30%) and PVA (5% w/w). Structural, morphological, barrier, and mechanical properties were evaluated using FTIR, XRD, AFM/SEM, hydration–barrier analyses, and tensile testing. Spectroscopic and diffraction analyses confirmed successful crosslink formation and preservation of crystalline ZnO within the largely amorphous polymer matrix. Plasticization produced smoother and more homogeneous surfaces, while GA-crosslinked systems exhibited superior structural uniformity and mechanical balance. The optimized formulation (P-GG4-NG1-GA) achieved an advantageous combination of strength and flexibility (ultimate strength ≈ 13 MPa; elongation ≈ 128%), whereas MBA-crosslinked ZnO composites formed denser but more brittle networks. Barrier performance could be tuned through formulation variables, with MBA networks reducing water solubility and ZnO incorporation enhancing resistance to dissolution.

In food-packaging trials with grapes and chicken, methyl-red–loaded GG–NG films acted as non-contact headspace indicators over ten days: yellow/orange shifts signaled alkalinization from protein spoilage (volatile amines), while pink shifts indicated acidification from fermentation/CO2 in fruit. Indicator color changes often appeared before visible spoilage, even when texture and appearance stayed unchanged, consistent with the films' antimicrobial action. These results support the potential of GG–NG films as practical smart-packaging or sample-preservation materials and provide clear formulation levers for optimizing barrier, mechanical, and indicator performance for real-world use.

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ZEOLITE CATALYST DESIGN FOR LIGNIN VALORIZATION

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Amid the global energy crisis, replacing traditional fossil resources with renewable carbon to produce fuel components, chemical intermediates, and functional materials has become increasingly urgent. To this end, the catalytic valorization of biomass has attracted significant attention in recent decades. Lignin, a major component of lignocellulosic biomass, accounts for approximately 15-30% of its total mass. Its unique aromatic ring structure provides an ideal molecular basis for the production of high-density cycloalkanes and aromatics via catalytic processes such as hydrodeoxygenation (HDO) and C-C coupling. In this context, the design of efficient catalytic systems and the innovation of reaction pathways are key to achieving the valorization of lignin.

Here, we will focus on the design of efficient catalytic systems for the valorization of lignin-derived phenolic platform molecules. Our efforts are structured around three key objectives: (1) elucidating the mechanisms by which confinement microenvironments enhance the activity and selectivity in the HDO or alkylation of phenolics; (2) based on these insights, designing and synthesizing highly efficient zeolite catalysts with excellent activity and hydrothermal stability to achieve superior HDO and alkylation performance for phenolic compounds; and (3) developing novel catalytic pathways for the high-value conversion of lignin-derived phenolics to green aromatics, thereby enabling the integrated valorization of both lignin and cellulose resources. Collectively, these findings will serve as a fundamental guidance for the high-value utilization of lignin.

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VALORISATION OF *SALICORNIA* SP. AS A SUSTAINABLE SOURCE OF POLYSACCHARIDES FOR BIO-BASED MATERIALS

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Salicornia sp. is a salt-tolerant halophyte capable of growing in saline environments where conventional crops cannot thrive, making it a promising resource for sustainable agriculture and the bioeconomy [1]. *Salicornia* sp. has attracted increasing attention as a source of valuable bioactive compounds with potential applications in food and health. However, despite growing interest, its polysaccharide content and associated bioactivities remain relatively underexplored [2]. In this work, polysaccharides were extracted from both *Salicornia* sp. edible shoots and biomass by-products, aiming at their valorisation for biomaterial development. After proximal characterization, polysaccharide extraction was performed using hot water extraction followed by ethanol precipitation. Extraction conditions were optimised to evaluate the influence of pH, temperature and pressurised autoclave on polysaccharide recovery. The extracts were characterised for composition and structure (FTIR, GC, NMR), rheological properties, and gel-forming potential, as well as for antioxidant activity and cytotoxicity to assess bioactivity and biocompatibility. The results indicated that the obtained extracts shown no cytotoxicity and suggested the presence of pectic polysaccharides. The extraction conditions and biomass source appeared to influence the characteristics of the recovered polysaccharides, which may affect their physicochemical properties and potential application in biomaterial development. This work highlights the potential of *Salicornia* sp. biomass as sustainable source of polysaccharides within a circular bioeconomy approach.

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MULTIFUNCTIONAL CATALYSTS FOR THE CONTINUOUS-FLOW VALORIZATION OF BUTANOL TOWARD HIGH-VALUE CHEMICALS AND JET-FUEL PRECURSORS

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The design of advanced heterogeneous catalysts is key to sustainable energy and chemical processes. Multifunctional materials combining redox and acid-base properties enable cascade reactions in a single reactor, improving carbon efficiency and process intensification while allowing control over C-C bond formation and product selectivity. Recently, we reported an innovative continuous-flow, upgrading pathway for renewable ethanol over Cu-based multifunctional catalysts through a complex cascade sequence leading to C6-C14 compounds [1]. Extending this strategy, biobutanol represents a promising substrate due to its longer carbon backbone, which facilitates direct access to C7+ compounds. Through cascade reactions including dehydrogenation, aldol condensation, dehydrogenative coupling (DHC) and ketonization, selective production of high-value chemicals such as butyl butyrate and 4-heptanone can be achieved, while generating heavier blends relevant for energy applications. Catalysts containing 5 wt% Cu were prepared by incipient wetness impregnation on monoclinic ZrO_2, TiO_2 (anatase) and γ-Al_2O_3, followed by calcination at 450 °C. Catalytic tests were carried out in a gas-phase fixed-bed reactor at 300 °C and atmospheric pressure, feeding 10 mol% butanol in He. 5Cu/*m*-ZrO_2 showed high butanol conversion (>90%) and tunable product distribution. Short contact times favored selective dehydrogenation to butyraldehyde, a key intermediate. Increasing residence time promoted DHC of butanol, leading to the formation of butyl butyrate, followed by ketonization to 4-heptanone. The balanced acid-base properties of *m*-ZrO_2 sustained efficient C-C bond formation, leading to a significant C7+ fraction (~50%). The cooperative interplay between Cu redox sites and oxide acid-base properties governs the reaction cascade scheme, making 5Cu/*m*-ZrO_2 an efficient multifunctional catalyst for butanol valorization into high-value chemicals also relevant for alcohol-to-jet pathways to Sustainable Aviation Fuels.

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MICROWAVE-ENHANCED MICHAEL ADDITION AS A SUSTAINABLE ROUTE TO LEVOGLUCOSENONE-BASED AMPHI

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The work presents a fast, safe, and sustainability-oriented methodology for generating a small library of amphiphilic molecules derived from levoglucosenone (LGO), a renewable platform obtained from cellulose-rich, non-edible lignocellulosic biomass. The amphiphilic character of the adducts demonstrates the feasibility of producing surfactant-like compounds entirely from lignocellulosic feedstocks, at a time when European bio-based surfactants still rely mainly on oleochemical sources. LGO undergoes a microwave-assisted Michael addition with a set of alkyl malonates (dimethyl, diethyl, dibutyl, and dibenzyl), affording structurally differentiated products under solvent-free conditions thanks to the intrinsic miscibility of the reagents. $Ca(OH)_2$, an inexpensive and non-toxic inorganic base, ensured high selectivity. A D-optimal Design of Experiments optimization consistently delivered gravimetric yields above 80%, and diastereoselectivity was confirmed by X-ray crystallography of the simplest diester. The physicochemical properties of the four adducts were assessed through a combined experimental–computational approach, including Hydrophilic–Lipophilic Balance estimations, COSMO-RS calculations, octanol/water partitioning, contact angle measurements, and emulsion tests. Overall, the results support the potential of LGO-derived amphiphiles as emerging surfactant candidates fully sourced from lignocellulosic biomass.[1,2]

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BIO-ADIPIC ACID PRODUCTION FROM THE HYDROGENATION OF MUCONIC ACID ON BIOCARBON SUPPORTED NI CATALYSTS

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Adipic acid (AA), a key industrial chemical widely used in the production of nylon-6,6 and other polymers, is industrially produced from petroleum-derived feedstocks and using HNO_3 as oxidant generating high amounts of ozone-depleting greenhouse N_2O [1]. One environmental alternative to produce bio-adipic acid is the catalytic hydrogenation of biobased muconic acid (MA) [1]. Supported noble metal catalysts have been mostly used for this reaction [2]. Commercial 5 wt % Pd/C catalyst led to 100 % of selectivity to AA for a total conversion at 70ºC, 4 bar H_2 for 2 h [2].

The aim of this work is the preparation and characterization of cheaper and greener catalysts, using Ni as active phase (5-28 wt%) and ordered mesoporous carbon (OMC), obtained from lignin extracted from almond shells [3], as support, to be applied for the hydrogenation of MA to AA, with special focus on studying the influence of different reaction conditions on the catalytic results (Figure 1).

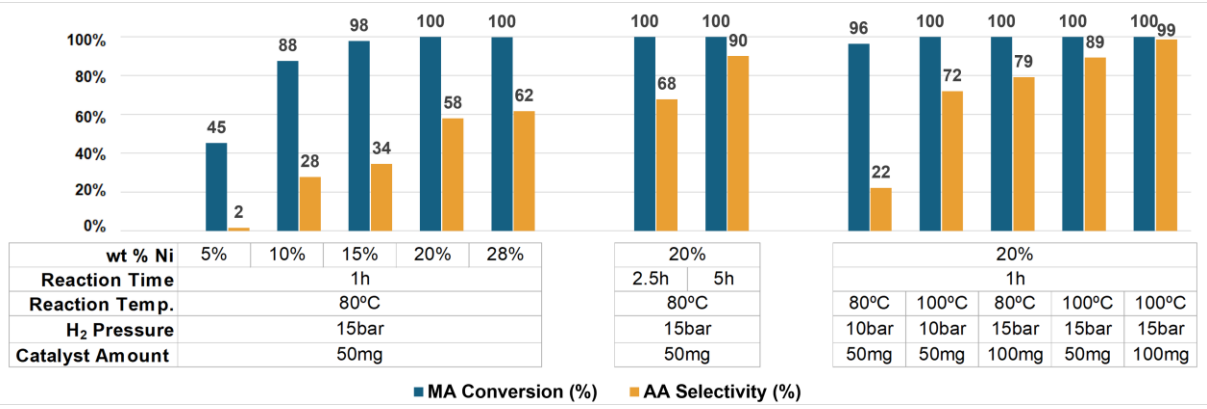


Figure 1. Catalytic results of several Ni/OMC catalysts for the hydrogenation of MA to AA.

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SELF-DISPERSIBLE MDO/CROTONATE BASED DEGRADABLE POLYMERS USING MPEG MACROMONOMERS FOR STABILIZATION

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The development of degradable waterborne polymer dispersions is of growing importance in response to increasing environmental concerns associated with persistent synthetic latex materials. While waterborne vinyl polymers are widely used in coatings, adhesives, and packaging, their carbon–carbon backbones limit end-of-life degradability, creating a need for sustainable alternatives that combine aqueous processability with controlled backbone cleavage.

Cyclic ketene acetals (CKAs), such as 2-methylene-1,3-dioxepane (MDO), offer a promising route to introduce hydrolytically cleavable ester linkages into vinyl polymer backbones through radical ring-opening polymerization. However, their implementation in conventional emulsion polymerization remains challenging due to the hydrolytic instability of CKAs in aqueous media and their relatively low reactivity, which restricts efficient incorporation.

To overcome these limitations, we explore self-dispersible polymer systems as an alternative strategy that avoids the constraints of classical emulsion polymerization since performed in bulk. In this work, MDO–butyl crotonate (BCr)[1] based terpolymers were synthesized using monomethoxy poly(ethylene glycol) (mPEG) macromonomers as internal steric stabilizers, enabling the formation of surfactant-free, degradable waterborne dispersions without exposing MDO to prolonged aqueous conditions during polymerization. The influence of mPEG content, chain length, and prepolymer chemistry (crotonate, acrylate, methacrylate, or allyl functionality) on colloidal stability and degradability was systematically investigated. The resulting dispersions exhibited excellent colloidal stability, and degradation studies confirmed backbone cleavage under both chemical and biological conditions.

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DESIGN OF HYDROPHOBIC DES FOR CRITICAL METAL RECYCLING

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The recycling of critical metals from electronic waste and other secondary resources represents a major challenge for sustainable separation technologies [1]. Deep eutectic solvents (DESs) have emerged as promising alternatives to conventional organic solvents in hydrometallurgical processes due to their tuneable physicochemical properties and potential process intensification by overcoming solubility issues through liquefaction [2]. However, it is still unclear how the selection of DES precursors and the solvent non-ideality translate to macroscopic properties relevant to their application, such as viscosity and its variation under hydrometallurgical operation. The relatively high viscosity may limit mass transfer and reduce the efficiency of metal recovery processes [3].

In this work, the viscosity behaviour of several hydrophobic DES systems based on either phosphine oxide or diglycolamide ligands with different hydrogen bond donors (decanoic acid, thymol, octanol, menthol and polypropylene glycol propyl ether) was investigated over a wide composition range. The system non-ideality was determined and dynamic viscosities were measured at 55 °C and excess viscosities were calculated using the Grunberg–Nissan equation and correlated with the Redlich–Kister model [4]. Finally, the influence of metal loading on the system properties were evaluated and correlated to the emergence of long-range ion-ion correlations. Understanding these interactions is essential for designing DES with improved transport properties for efficient recovery of critical metals.

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SUSTAINABLE THERMOCHROMIC MATERIALS FOR SMART SENSING APPLICATIONS

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Thermochromic natural polymer-based composites have attracted attention in green chemistry for smart sensing applications. The incorporation of ionic liquids (ILs) into natural polymer matrices enables multifunctional materials for sensor applications [1]. Poly(L-lactic acid) (PLLA) is a biodegradable biopolymer [2] that can be tuned with ILs to produce thermochromic materials with reversible temperature-dependent colour changes [3]. In this work, PLLA-based composites incorporating 10, 20 and 40 wt.% of the thermochromic IL bis(1-butyl-3-methylimidazolium) tetrachloronickelate ($[Bmim]_2[NiCl_4]$) were prepared by solvent casting. $[Bmim]_2[NiCl_4]$ induced porous structures, reduced Young's modulus, and enhanced electrical conductivity. The composites showed a reversible thermochromic response, turning blue at 50 °C, and the processed ink could be screen-printed onto different substrates, demonstrating their potential for sustainable sensing platforms.

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AIMING FOR THE SAN: PROCESS OPTIMIZATION OF THE DISSOLUTION-BASED RECYCLING OF ABS

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Achieving circularity for engineering plastics requires effective process refinement, particularly for acrylonitrile–butadiene–styrene (ABS), an engineering polymer whose production reached 14 Mt in 2022 and is projected to exceed 20 Mt by 2027 [1].

Owing to its multiphase structure and additive content in waste electrical and electronic equipment (WEEE), efficient recycling it's often unachievable. Thus, solvent-based selective dissolution has often been proposed, and selective dissolution of the model styrene–acrylonitrile (SAN) fraction, while phasing out polybutadiene rubber (PBR), using eutectic and bio-based solvents has been demonstrated through computational screening and laboratory validation by our research group [2]. However, translating this feasibility into a reproducible purification process for real ABS waste remains challenging. Herein, a dissolution–precipitation route was optimised to extend solvent-selection feasibility to ABS derived from WEEE. Through optimisation of key process variables and separation strategies, SAN is recovered under mild conditions with high yields (> 60%, up to 80%) and minimal residual colour. The process enables removal of inorganic fillers (mainly Ti-derivatives and carbon black) and residual additives, yielding SAN fractions that resemble virgin material. Material integrity and purity were evaluated by NMR, FTIR, Raman, DSC, TGA and XRD analyses, with quantitative NMR indicating < 2 wt.% residual PBR in the recovered SAN, establishing dissolution-based recycling as a viable strategy for engineering plastics within the circular economy.

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FROM SINGLE-CIRCUIT TO DUAL-CIRCUIT COFS: BORON–HYDROXYL MICROENVIRONMENT ENGINEERING FOR EFFICIENT PHOTOCATALYTIC H_2O_2 PRODUCTION

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Sustainable catalytic systems are crucial for green chemical synthesis. Hydrogen peroxide (H_2O_2), an important green oxidant, is still produced via energy-intensive, waste-generating processes [1]. Photocatalytic synthesis from water and oxygen provides a sustainable alternative but is hindered by inefficient proton-coupled electron transfer (PCET) and mismatched redox kinetics [2].

Inspired by natural photosynthesis, where electron and proton transport are spatially decoupled yet synchronized, we develop a biomimetic “circuit” design in covalent organic frameworks (COFs) [3]. A rapid, solvent-free, and low-energy plasma-assisted strategy enables site-specific implantation of boron-based functional units into preformed COFs under ambient conditions, providing a green route for precise microenvironment engineering [4]. This approach drives a transition from a “single-circuit” system, limited by proton diffusion, to a “dual-circuit” architecture integrating a B←N electronic pathway with a B–OH proton relay network.

The hydrogen-bonding microenvironment acts as a localized proton reservoir and transfer channel, enabling synchronized proton–electron delivery and efficient PCET while suppressing charge recombination and side reactions. Consequently, the dual-circuit BADT-COF system lowers reaction barriers and exhibits enhanced H_2O_2 production in pure water without sacrificial agents, with high selectivity, stability, and efficiency.

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OXYGEN VACANCY-DRIVEN OXIDATIVE ESTERIFICATION OF HMF OVER AU/LA CATALYSTS

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Biomass-derived 5-hydroxymethylfurfural (HMF) enables the formation of dimethyl 2,5-furandicarboxylate (FDMC), a key monomer for polyethylene furanoate (PEF), a promising biobased substitute for polyethylene terephthalate (PET) [1]. Au-supported lanthanum-based catalysts were prepared by DP and studied to establish structure–activity relationships using XRD, XPS, HAADF–STEM, CO chemisorption and operando DRIFTS (methanol and propyne), complemented by synchrotron experiments at ALBA to probe electronic structure and metal–support interactions. Au/$La_2O_2CO_3$_T300 shows the highest activity and selectivity towards FDMC, achieving the best productivity reported for noble metal catalysts under base-free conditions (86.1 mol_{FDMC} mol_{Au}^{-1} h^{-1}). This performance is attributed to oxygen vacancies in the oxycarbonate surface, which promote the adsorption of HMF-derived intermediates, while Au nanoparticles activate molecular oxygen. Combined catalytic and spectroscopic evidence (**Fig. 1**) supports a novel cooperative mechanism between Au sites and oxygen vacancies, enabling efficient oxidative esterification of HMF with high selectivity towards FDMC.

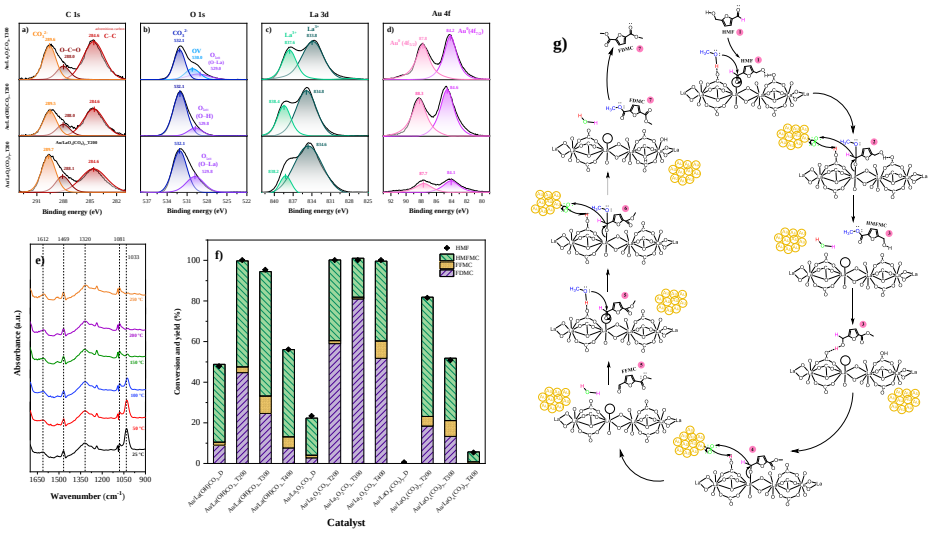


Fig. 1. (a–d) XPS of the most active catalysts for each support; **(e)** operando DRIFTS (MeOH) showing methoxy intermediates over the Au/$La_2O_2CO_3$_T300 catalyst; **(f)** catalytic performance; **(g)** proposed mechanism.

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OPTIMISING THE EFFECTIVENESS OF ZINC OXIDE NANOPARTICLES IN SUNSCREEN

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Ultraviolet (UV) radiation represents a significant hazard to both human health and the environment, highlighting the need for effective protective materials. Among these, zinc oxide (ZnO) is widely regarded as an efficient UV-filtering agent and is extensively used in sunscreens and personal care formulations. Toxicological studies have demonstrated its good biocompatibility, even at the nanoscale. ZnO provides protection primarily by absorbing and scattering both UVA and UVB radiation, thereby mitigating skin damage and reducing the risk of UV-induced carcinogenesis. [1]

Despite these advantages, the use of ZnO in long-term UV-protective applications remains challenging due to its residual photocatalytic activity. Under prolonged irradiation, ZnO can degrade a range of organic compounds, dyes, and some inorganic materials into less harmful products. While this behaviour is beneficial in areas such as water and air treatment, photodetectors, and solar energy applications, it becomes a limitation when ZnO is used to protect organic materials, coatings, and polymer-based products, as it may lead to their degradation. Therefore, there is a need to develop improved ZnO-based systems that provide effective UV protection while limiting unwanted photo-induced degradation. [2,3]

In this research, the properties of ZnO nanoparticles are adjusted to preserve their UV-filtering performance while reducing their photocatalytic activity, through the use of surface modifications and selected additives, alongside a better understanding of the underlying processes. The aim is to improve the stability and performance of both personal care and industrial formulations, leading to more reliable and safer products.

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SHRIMP SHELL VALORISATION: AN INTEGRATED BIOREFINERY APPROACH TO BIOACTIVES AND (ELECTRO)CATALYSTS

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Seafood waste, particularly shrimp shell waste (SSW), is often underutilized despite its rich chemical composition. In the context of a circular and sustainable economy, SSW represents a promising renewable resource for the integrated production of high-value compounds and functional materials [1]. This work proposes a biorefinery strategy combining green extraction processes with thermochemical conversion to maximize shrimp shell valorisation. Initially, valuable bioactive compounds such as astaxanthin and chitin-derived products, are recovery using environmentally friendly extraction methods, with potential applications in the cosmetic sector. The residual biomass undergoes pyrolysis to produce carbon-rich materials. The resulting biochars, naturally doped with nitrogen, can be further tailored to obtain efficient (electro)catalysts. Owing to their tunable surface properties and active sites, these materials exhibit promising performance in energy-related applications, including electrocatalysis [2]. By integrating extraction and pyrolysis within a single pathway, this approach enables full utilisation of shrimp shell waste, reducing environmental impact while generating multiple value streams. Overall, this work highlights how combining green chemistry and biorefinery concepts can advance the sustainable valorisation of marine biomass.

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SUSTAINABLE MECHANOSYNTHESIS OF METAL OXIDE PHOTOCATALYSTS FOR THE REMOVAL OF ORGANIC DYE POLLUTANTS

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The development of sustainable and energy-efficient synthesis routes for functional photocatalytic materials have gained increasing attention in environmental remediation studies. In this work, various metal oxide photocatalysts, namely ZnO, CuO, and Fe_2O_3, were synthesized via a mechanochemical approach as a green and solvent-minimized alternative to conventional preparation methods. The mechanosynthesis route offers important advantages such as reduced solvent consumption, simplified processing, and potential scalability, making it attractive for the preparation of environmentally relevant catalytic materials.

The obtained metal oxide materials were evaluated for the photocatalytic removal of organic dye pollutants from aqueous media under different irradiation sources. Model dye compounds were selected to represent common water contaminants, and degradation performances were comparatively investigated under UV and visible light conditions. The effects of irradiation type on photocatalytic efficiency were examined in order to better understand the light-response behavior of the synthesized materials. In addition, the relationship between synthesis strategy, material composition, and photocatalytic activity was considered in terms of process-structure-property interaction.

The results are expected to demonstrate that mechanochemical synthesis can provide a practical and sustainable route for producing active metal oxide photocatalysts for water treatment applications. This study highlights the potential of mechanochemically prepared metal oxides as promising candidates for the removal of dye pollutants and contributes to the broader development of greener photocatalytic systems for environmental applications.

Acknowledgments:

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GREEN SOLVENT SCREENING FOR BROCCOLI LEAF PHENOLICS AND FLAVONOIDS EXTRACTION

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Broccoli leaves are 47% of crop biomass and an underutilised agri-food side stream [1]. Their valorisation offers circular bioeconomy opportunity given their substantial bioactive potential [2]. Natural deep eutectic solvents (NADES) emerge as a green chemistry-aligned alternative for sustainable recovery of plant bioactives for their non-toxic and affordable components [3]. In this study, ten choline chloride (ChChl)- and betaine (Bet)-based NADES were synthesised (2h, 300rpm, 70°C, +20% H_2O w/w), characterised (pH, density, viscosity, polarity, toxicity) and evaluated for extracting (1h30, 400 rpm, 60°C) broccoli leaves total phenolic and flavonoid contents.

ChChl-based systems exhibited acidic to neutral pH, while Bet-based NADES were more neutral. At 22°C, ChChl:Lactic $Acid_{1:1}$ displayed the lowest pH (0.5±0.0), while Bet:$Urea_{1:2}$ the highest (8.1±0.2). Kinematic viscosity (40°C) ranged from 6.29±0.07 mm²/s (ChChl:$Glucose_{2:1}$) to 20.78±0.43 mm²/s (Bet:$Glu_{1:1}$), with sugar- and polyol-containing systems generally more viscous. Densities ranged from 1.073 g/cm³ (ChChl:Propylene $Glycol_{1:2}$) to 1.284 g/cm³ (Bet:$Glu_{1:1}$), and polarity was highest in lactic acid and glycerol containing systems and lowest in propylene glycol-based ones.

All systems showed biocompatibility for potential food and health applications, with Caco-2 EC50 values ranging from 7,485 mg/L (Bet:$LA_{1:2}$) to >190,000 mg/L (Bet:$Glu_{1:1}$). Bet:$Glu_{1:1}$ yielded the highest phenolic content (10.02±0.4 mg GAE/g DW, $p<0.0001$), while Bet:$U_{1:2}$ (1.32±0.1 mg QE/g DW) extracted the highest flavonoid content ($p<0.05$). These findings position Bet:$Glu_{1:1}$ and Bet:$U_{1:2}$ as the most promising green solvents for recovering bioactive compounds from broccoli leaves.

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SUSTAINABILITY ASSESSMENT OF ACID-BASED DEMINERALIZATION OF INSECT RESIDUES FOR CHITIN PRODUCTION USING THE PATH2GREEN FRAMEWORK

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Demineralization (DEM) of insect exuviae is a key step in chitin production; however, systematic sustainability assessments of DEM conditions are still limited. In this study, 36 acid-based DEM conditions, varying in acid type, concentration, temperature, and reaction time, were evaluated for their sustainability using experimental data in combination with the Path2Green framework [1]. The performance of the DEM approaches was first assessed based on demineralization yield (ΔDEM) and residual ash content (ΔASH). The resulting Path2Green scores (on a scale from −1 to +1) ranged from approximately −0.344 to values close to neutral, indicating that none of the investigated conditions can be considered clearly sustainable, while improvements relative to conventional approaches are achievable. The lowest score corresponded to HCl 1 N, 2 h, 80 °C, representing a highly severe processing condition. A slightly positive score (approximately +0.016) was only obtained for pure citric acid under mild conditions, indicating potential for organic acid systems, although their application may be limited by economic considerations. Process chemical use and wastewater management were identified as key limitations for improving overall sustainability.

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UPCYCLING FRUIT PROCESSING CO-PRODUCTS INTO FUNCTIONAL FOODS: A CIRCULAR BIOECONOMY APPROACH TO PRODUCT DEVELOPMENT AND STABILITY

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This work explores the valorisation of fruit processing co-products and the stability of phenolic compounds in fruit-based products within a circular bioeconomy framework.

Fruit pulp from juice production was used to develop functional snack formulations, while commercial smoothies were evaluated over four months under different storage temperatures.

Phenolic content and antioxidant capacity were assessed using HPLC, Folin–Ciocalteu, DPPH, and FRAP methods, alongside physicochemical characterization of snack products.

Results showed successful incorporation of co-products into functional foods with retention of bioactive compounds and improved formulation properties. In contrast, smoothie analysis indicated a decline in phenolic stability over time, with refrigeration better preserving antioxidant activity.

Overall, this study highlights the potential of co-product upcycling and optimized storage to support sustainable food systems and reduce food loss.

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COMBINATION OF ANALYTICAL SEPARATION METHODS FOR THE QUALIFICATION AND QUANTIFICATION OF HUMINS PRODUCED DURING THE DEHYDRATION OF SUGARS TO 5-HMF

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This study focuses on the characterization of "humins," by-products generated during the dehydration of fructose to produce 5-HMF **[1]**, the "sleeping giant" of sustainable chemistry **[2]**. To address the complexity of these compounds, two innovative separation techniques were coupled. The Size Exclusion Chromatography (SEC), combined with UV detection (SEC-UV), was first applied on batch samples at different reaction times to monitor the evolution of humins sizes during fructose dehydration, identifying nine subfamilies ranging from 220 to 11,440 geqPS/mol. The Centrifugal Partition Chromatography (CPC) technique, applied for the first time on humins, was then developed to decomplexify these compounds based on their polarity. A solvent system was optimized at the shake-flask scale, and CPC separation was performed on a continuous SCPC100 instrument coupled with a Spot Prep II (Gilson Purification, USA). Elution and extrusion fractions were finally collected and concentrated by evaporation, before being injected into Size Exclusion Chromatography (SEC). This two-dimensional separation (**Figure 1**) approach revealed the formation of different humins sub-families based on size (providing information on their growth process) and hydrophobicity (providing information on their degree of dehydration). Thanks to additional characterization techniques, those results are ultimately used into kinetic modelling to improve the understanding of humins formation routes during the dehydration reaction of fructose into 5-HMF. This study constitutes a solid basis to optimize the industrial process of 5-HMF production with very low by-products formation.

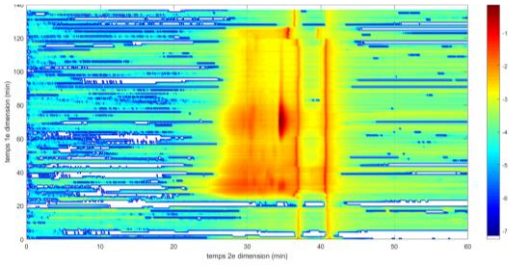


Figure 1: Identification of different families of humins via CPC x SEC

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CHEMICAL CHARACTERIZATION OF BIO-OIL OBTAINED FROM THE MICRO-PYROLYSIS OF CORN COB RESIDUES

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The European Green Deal highlights the need to improve resource circularity and advance waste recovery technologies to meet climate goals. Lignocellulosic biomass, particularly from agricultural residues like corncobs, is a significant feedstock for renewable energy. In Brazil, a major maize producer, the abundance of corncobs poses logistical challenges, while Portugal focuses on sustainable practices in its concentrated maize production, especially in Ribatejo. This biomass is important for energy and biofuel production, particularly for generating second-generation ethanol (E2G) and through thermochemical processes such as pyrolysis, liquefaction, and gasification. In both countries, corncobs can produce bio-oil and syngas and serve as direct fuel in industrial boilers because of their high energy density. Pyrolysis is a thermochemical process that decomposes residual solid biomass in an oxygen-free environment [1,2]. The objective was to perform the micro-pyrolysis of corncobs in a continuous reactor and characterize the primary bio-oil products using gas chromatography coupled with mass spectrometry (GC/MS). This rapid process allows bio-oil profiling and identification of potential applications, while also testing pyrolytic conditions (temperature, time, heating rate, etc.). The analysis identified phenols (specifically alkylphenols), saturated hydrocarbons, ketones, and aldehydes. These results provide the data to scale up the process using a continuous-feed reactor for full biomass utilization in the next research steps.

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ENVIRONMENTALLY CONSCIOUS ENERGY STORAGE DEVICES FROM MARINE-DERIVED MATERIALS

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In recent years, due to digital transformation and the persistence of linear economic models, the amount of waste generated by electrical and electronic equipment has increased significantly. Moreover, due to low recycling rates, this waste, usually composed of scarce and toxic materials, often ends up in uncontrolled landfills, from where it has been found to reach the marine environment. In this way, e-waste contributes to the current pollution problem in the marine environment, turning the oceans into global dumping grounds. Among this e-waste, specifically energy storage devices represent a relevant fraction due to the presence of hazardous materials and their recent increase in demand.

In this context, following the principles of responsible chemistry, this work focuses on developing energy storage devices whose complete life cycle is designed to align with the marine ecosystem, covering the selection of marine-derived materials to the application in ocean-related devices. The end-of-life stage is also considered through ecodesign strategies to ensure marine biodegradability.

With this vision in mind, this talk presents the study for the development of a supercapacitor using locally collected algae as the main material (See Fig. 1). The polysaccharide I-carrageenan extracted from algae is investigated as a replacement for the conventional polytetrafluoroethylene (PTFE) binder, achieving 98% of the specific capacitance obtained with the conventional formulation. In addition, pyrolysed algae-derived carbon is explored as an alternative to commercial activated carbon, also analysing the effect of the natural self-doping elements in algal biomass on the material's performance, achieving capacitance values within the same order of magnitude as the reference material.



Fig. 1 | Conceptual scheme of the developed marine-derived supercapacitor

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GREEN SURFACE-ENGINEERED NANOCELLULOSE FROM *RAPHIA FARINIFERA* INFLORESCENCE FOR MECHANISTIC CONTROL OF INTERFACIAL CHEMISTRY IN SUSTAINABLE WATER TREATMENT

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Performance in green water treatment is usually reported as removal efficiency, while the surface chemistry controlling selectivity and reversibility remains underexamined [1]. Nanocellulose from *Raphia farinifera* inflorescence was produced by aqueous delignification and low-toxicity fibrillation, yielding nanocrystalline spheres with high hydroxyl density and tunable charge.

Structural refinement altered surface electron distribution and pH-dependent electrokinetic response, while surface area increased only marginally, so interfacial charge modulation dictated performance. Spectroscopy indicates atrazine interaction is governed by hydrogen bonding and charge-assisted association with surface oxygen functionalities [2,3]. Controlled xanthation further modified interfacial electron density, strengthening surface–molecule interactions, and temperature-dependent analysis supports a chemically mediated rather than diffusion-controlled pathway.

Surface functionality remained intact after repeated mild alkaline regeneration, confirming reversible binding governed by interfacial chemistry rather than structural collapse. In agricultural wastewater under seasonal variation, contaminant reduction remained consistent, indicating that surface control translates beyond ideal conditions.

These observations show that *Raphia farinifera* inflorescence can be transformed into a renewable nanocellulose system in which interfacial chemistry, not empirical adsorption metrics, dictates performance, providing a basis for designing green nanocellulose from lignocellulosic feedstocks.

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SEQUENCIAL AND SIMULTANEOS EXTRACTION OF PHENOLIC COMPOUNDS AND BIOPOLYMERS FROM *SARGASSUM MUTICUM* USING ALTERNATIVE SOLVENTS

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Sargassum muticum is an invasive brown seaweed still underexplored. Promoting its exploitation not only generates economical value but also helps mitigate its environmental burden [1]. In line with the EU strategy for biomass valorisation through a cascade process [2], this work explores the recovery of value-added compounds from *S. muticum*. This seaweed is known to be rich in phenolic compounds (PCs) exhibiting beneficial properties [1]. *S. muticum* is also rich in structural biopolymers, namely alginates and fucoidans, widely recognized for their functional and bioactive properties [3].

This work studied sequential extractions of PCs and biopolymers (alginates and fucoidans) using biocompatible solvents. It was possible to observe improvements in yields and purities. This sequence was compared with a simultaneous extraction of PCs and biopolymers using biphasic systems, which also produced good yields and enabled compound partitioning in a single step. These results will contribute to the development of sustainable and efficient extraction strategies, supporting the implementation of integrated biorefinery approaches for invasive seaweeds.

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GREEN ADSORBENTS FOR SUSTAINABLE WATER REMEDIATION: MOF-DERIVED POROUS CARBONS AND WASTE-DERIVED CHARS

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The increasing discharge of inorganic pollutants and organic dyes into water systems poses significant environmental and health risks. The development of sustainable and efficient remediation strategies is therefore essential, in line with Green Chemistry principles and the United Nations Sustainable Development Goals.[1]

In this work, two distinct classes of adsorbent materials were explored and compared: (i) porous carbons derived from Metal–Organic Frameworks (MOFs), obtained via controlled pyrolysis, (ii) low-cost biochars derived from (agro)industrial wastes, including cork residues and shrimp shells (SS); and (iii) chitin/chitosan obtained from SS. This approach combines advanced functional materials with waste valorisation strategies within a circular economy framework.[2,3] The adsorptive performance of both types of materials was evaluated for the removal of toxic metal ions and organic dyes from aqueous media. MOF-derived carbons exhibit high surface areas and tunable porosity, while biochars offer abundant surface functional groups and low-cost sustainable production. The comparative analysis highlights the advantages and limitations of each system in terms of adsorption efficiency, selectivity, and reusability. Comprehensive characterization (FTIR, SEM/EDS, PXRD, N_2 adsorption-desorption, and zeta potential analysis) confirmed the structural and surface properties of the materials. Reusability studies demonstrated the stability of the adsorbents over multiple adsorption–desorption cycles. This work provides insight into the complementary roles of advanced and bio-based materials, contributing to the design of sustainable and cost-effective water remediation technologies.

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BIOMASS-DERIVED WOOD FIBRE-IRON COMPLEX IN GREEN VISIBLE LIGHT-ASSISTED WATER POLLUTANT REMEDIATION

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Lignocellulosic biomass is a renewable resource composed of cellulose, hemicellulose and lignin with relevant functional groups for preparation of advanced materials: surface modification is possible due to cellulose's hydroxyl groups and visible light absorbing chromophores are present in lignin [1].

In this work, wood fibres were used as a renewable biomass-derived catalyst support for iron(III) salicylate/anthranilate and iron(III) salicylate complexes, yielding the hybrid materials WF-[Fe(SalAnt)] and WF-[Fe(Sal)], respectively. The synergistic interaction between the cellulosic functional groups and lignin chromophores units was explored in visible-light assisted redox/adsorption reactions for water remediation in the removal of 4-nitrophenol and of cationic and anionic organic synthetic dyes (rhodamine B, methylene blue and indigo carmine). WF-[Fe(SalAnt)] achieved 95 % conversion within 8.8 minutes in the reduction of 4-nitrophenol using $NaBH_4$. Meanwhile WF-[Fe(Sal)] showed 97 % removal of rhodamine B after 150 minutes in oxidative dye degradation using H_2O_2, with 68 % removal in spiked real wastewater treatment plant effluent. The catalyst remained active over five cycles with no detectable iron leaching. These results demonstrate the potential of wood fibre supported iron complexes as sustainable, visible-light-active materials for water pollutant remediation [2].

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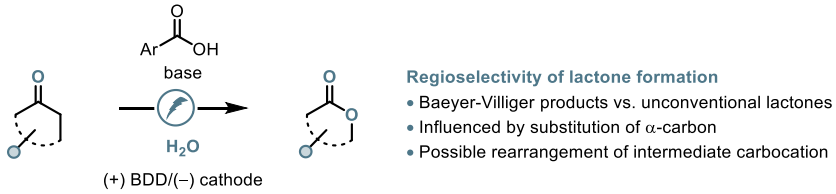
ELECTROCHEMICAL LACTONIZATION OF KETONES ENABLED BY ANODIC OXIDATION OF BENZOATES

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The Baeyer-Villiger oxidation is a key reaction in organic synthesis, involving the conversion of ketones into esters, typically using peracid oxidants [1,2]. Despite its relevance, only a limited number of electrochemical approaches to this reaction have been described. Simple, general, and stoichiometric-oxidant-free electrochemical protocols remain underdeveloped, despite their potential to provide greener and more efficient strategies [3–6]. A simple protocol for the electrochemical lactonization of cyclic ketones was developed. The method relies on the electrooxidation of benzoates to perbenzoic acids using a commercially available boron-doped diamond (BDD) anode, followed by ketone lactonization. The regioselectivity for the formation of unconventional lactones versus Baeyer-Villiger products is directly influenced by substitution on the α-carbon, suggesting that the reaction proceeds through a carbocation intermediate capable of undergoing rearrangement (**Scheme 1**).



Scheme 1. Proposed strategy for the electrochemical lactonization reaction

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EFFECT OF POLYOL-BASED BIOSOLVENTS ON LACCASE-DRIVEN DEPOLYMERIZATION OF POLY(VINYL ALCOHOL)

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Polymer-based liquid formulations (PLFs), widely used in detergents, coatings and personal care products, contribute to the release of persistent water-soluble polymers into aquatic environments. Poly(vinyl alcohol) (PVA), extensively applied in PLFs due to its film-forming properties and chemical robustness, exhibits limited biodegradability, raising environmental concerns.

Herein, a sustainable enzymatic framework for PVA oxidative transformation was established using *Trametes versicolor* laccase in bio-based polyol media under mild conditions. Polyols differing in chain length and hydroxyl density were screened as activity-modulating environments. Glycerol and xylitol enhanced catalytic performance relative to pH 4.5 buffer, with glycerol enabling measurable PVA molecular weight reduction. Process performance was optimised using a Design of Experiments (DoE) approach evaluating enzyme loading and glycerol content in the presence of ABTS or TEMPO. Response surface modelling identified operational regions maximising polymer transformation, while highlighting limitations toward complete depolymerisation.

Overall, polyol-based biosolvents act as tunable, sustainable reaction media for oxidative polymer modification, establishing a transferable biocatalytic framework to mitigate polymer persistence in polymer-based liquid formulations.

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SHAPING ZIF-8 IN CHITOSAN – IN-SITU GROWTH AND POWDER DISPERSION FOR ENHANCED CO_2 CAPTURE

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Global temperatures have consistently risen in the 21st century, with the 23 warmest years occurring in this period out of 174 recorded years [1]. Climate change is primarily driven by greenhouse gas (GHG) emissions, particularly CO_2, making emission mitigation essential [2]. Metal–organic frameworks (MOFs) are promising for gas separation due to their high surface area and tunable porosity [3], but their powder form limits industrial application. Integration into polymeric matrices offers an effective solution. Here, ZIF-8 was structured into chitosan-based macroscopic fibers via particle dispersion and in-situ growth. The latter improved MOF distribution, loading, and porosity preservation, enhancing adsorption performance. Supercritical CO_2 drying and covalent crosslinking further textural properties. The composites showed a synergistic effect at sub-atmospheric pressure, achieving higher CO_2 uptake than pristine ZIF-8 and chitosan aerogels. The best material reached 65% higher uptake than ZIF-8 at low pressure. Ideal selectivity for CO_2/N_2 and CO_2/CH_4 mixtures was calculated, showing enhanced selectivity, ranging from ~4–8.5× for CO_2/N_2 and ~3.8–8.5× for CO_2/CH_4 compared to pristine ZIF-8. All materials were obtained as macroscopic fibers, overcoming powder limitations and exhibiting enhanced CO_2 selectivity, highlighting in-situ MOF growth in biopolymers as a scalable and sustainable strategy.

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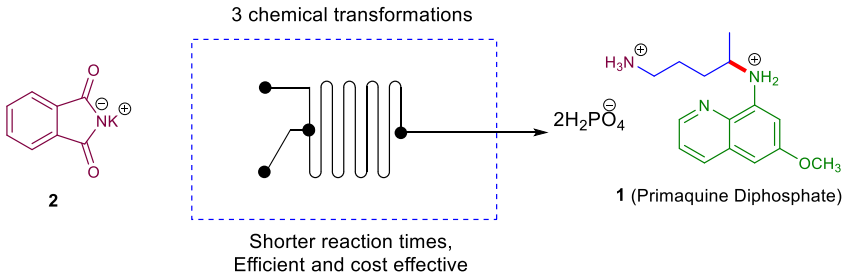
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CONTINUOUS FLOW SYNTHESIS OF PRIMAQUINE DIPHOSPHATE AN ANTI-MALARIAL DRUG

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Malaria is one of the world's most infectious diseases. It is present in over 80 countries with the most affected population being children under 5 years of age, pregnant women and HIV-AIDS patients.[1] According to the WHO's 2019 World Malaria Report, there were 229 million cases and an estimated 409,000 deaths worldwide while in 2018, 228 million cases and 411,000 deaths were recorded. The African region was reported to have accounted for 94% of all global cases and deaths; 67% of deaths worldwide were of children under the age of 5 years.[2] It is therefore paramount that access and availability to potent anti-malarials be improved especially in low developing economies. This can potentially be achieved through local drug manufacture and capacity development using cost efficient and effective technologies such as continuous flow technology. Herein, we present, the continuous flow synthesis of Primaquine Diphosphate **1**, an antihypnozoite 8-aminoquinoline compound which was furnished from readily available potassium phthalimide **2** *via* three chemical transformations; phase transfer catalyzed *n*-alkylation, reductive amination and phthalimido deprotection all in good yields and in shorter reaction times compared to the batch processes disclosed in literature.[3]



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ZERO-CARBON SEAWATER DESALINATION WITH ELECTRICITY COGENERATION VIA PROCESS INTENSIFICATION AND GENETIC ALGORITHM OPTIMISATION

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Potable water is fundamental to sustaining human life. However, its accessibility remains a critical global challenge. This is paradoxical because 71% f the Earth's surface is covered with water, yet nearly 97% of it is saline and unsuitable for direct human consumption [1]. At the same time, approximately 44.6% of the world's population lives within 150 kilometres of a coastline, which highlights the strategic potential of desalination technologies [2]. This makes seawater desalination a strategically vital solution. We propose a zero-carbon desalination system that co-generates electricity. To decouple the energy-water nexus of multi-effect distillation (MED), a solar collector is integrated with vapour compression components. An organic Rankine cycle (ORC) is coupled with the solar field and steam boiler to minimise external energy demand; the ORC-generated electricity powers the solar system, reducing both energy requirements and the MED unit's equipment load. A theoretical framework of the proposed system is developed and validated using data from three operational plants (Tripoli, Kish Island, Umm Al-Nar). A genetic algorithm identifies globally optimal parameters, yielding substantially higher productivity and lower cost than the reference plant. This sustainable approach offers strong potential to mitigate global potable water scarcity.

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Keywords: *Multi-effect desalinator; solar system; organic Rankine cycle; process integration; multi-objective optimisation; cost and productivity*



UNDERSTANDING THE PRESENCE OF THE SURFACE COORDINATED COPPER HYDRIDES FOR THE SELECTIVE HYDROGENATION OF 5-HYDROXYMETHYLFURFURAL

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Previously, we have successfully developed the atomically dispersed hydrotalcite oxide (HTO) supported copper catalysts ($Cu_{(x)}$HTO, x was denoted the mol% of Cu) through the simple coprecipitation of in aqueous solution at tuned pH. In addition, the r-$Cu_{(5)}$HTO (r was denoted as reduced) can hydrogenate hydroxylmethylfurfural (HMF) to 2,5-bis(hydroxymethyl)furan (BHMF) selectively in a high yield under mild reaction conditions.[1] Continuing our research achievements, we aim to uncover the dynamic interface of the modified surface nanostructures for the hydrogen evolution upon adsorption, i.e. driving the adsorbed hydrogen species towards either homolytic or heterolytic pathway for selective hydrogenation is the pivotal component for the surface design in precision. Recently, the $H_2/N_2O/H_2$-TPR has revealed the dispersion (D_{Cu}) of chemically exposed copper species of $Cu_{(20)}$HTO can reach 91% high with the specific surface area (S_{Cu^0}) of 618 $m^2.g^{-1}$. It indicates that the copper adducts are atomically dispersed over the HTO surface despite the high copper loading. To understand the chemical change of copper center on HTO surface during the thermal reduction, the real-time XANES measurement at Cu K-edge was recorded in conjunction with the temperature-programmed reduction under hydrogen. The results show that the oxidation state of copper on r-$Cu_{(20)}$HTO unusually increases from Cu^0 to Cu^+ in the cooling hydrogen flow and EXAFS suggests that copper adducts might structurally present a mixture of partially oxidized species which could be attributed to the structural change derived from the formation of surface coordinated molecular copper hydrides under hydrogen.

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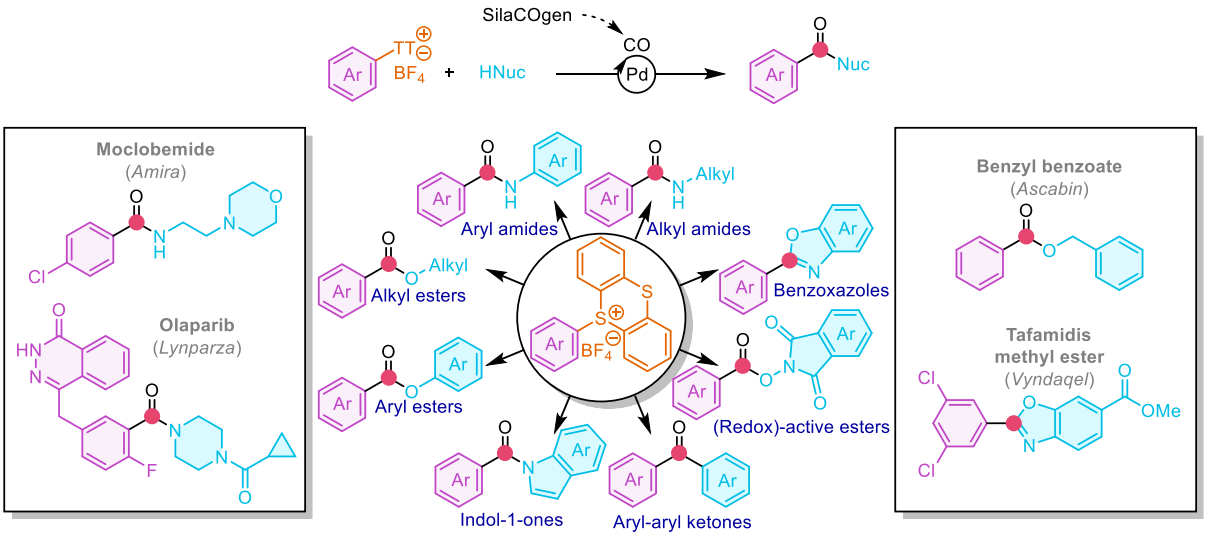
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THIANTHRENIUM SALTS ENABLE BROAD-SCOPE C–H CARBONYLATION FOR CARBON ISOTOPE LABELING

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Aryl thianthrenium salts are established as adept electrophilic coupling partners in a variety of transformations in both photoredox and transition metal-catalyzed cross-coupling reactions.[1] Though many alleys of thianthrenium reactivity have been elucidated, carbonylative cross-couplings remain underexplored. We disclose a versatile and robust method for palladium-catalyzed carbonylative transformations of aryl thianthrenium salts to afford a wide range of structurally and electronically diverse molecules. The methodology utilizes simple Pd(II) salts and phosphines and exhibits a broad substrate scope for the installation of many divergent functional groups in complex small molecules. CO generated *ex situ* from SilaCOgen,[2] facilitates carbon isotope labeling of pharmaceutically relevant compounds including aryl esters, aryl amides, and benzoxazoles.



Scheme 1. Structural motifs accessible *via* carbonylation of aryl thianthrenium salts including active pharmaceutical ingredients.

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BIOCATALYTIC PREPARATION OF ESTERS VIA HEMIACETAL OXIDATION: A NOVEL, SELF-SUFFICIENT AND INDUSTRIALLY VIABLE ESTER PRODUCTION ROUTE

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Esters are versatile organic molecules essential to numerous industrial sectors, yet their conventional chemical synthesis often relies on energy-intensive processes and corrosive catalysts [1]. While biocatalytic routes using esterases or lipases offer greener alternatives, they are frequently limited by thermodynamic equilibrium and the need for continuous water removal [1]. This study presents a novel, self-sufficient biocatalytic production route leveraging the enzymatic oxidation of hemiacetals by alcohol dehydrogenases (ADHs). We demonstrate that multiple ADHs, including Adh1 from *Saccharomyces cerevisiae* (*Sc*Adh), *Homo sapiens*, *Neurospora crassa*, and *Clostridium beijerinckii*, possess hemiacetal dehydrogenase (HADH) activity. Crucially, we discovered an intrinsic $NAD(P)^+$ regeneration pathway operated by the enzymes themselves, which utilizes the initial aldehyde substrate to re-oxidize the cofactor. This mechanism allows ester production to significantly exceed traditional stoichiometric limits, without external cofactor regeneration systems or sacrificial substrates. In batch experiments, *Sc*Adh achieved methyl formate titers 4.5 times higher than the stoichiometric threshold. Through process optimization and iterative aldehyde feeding, methyl formate titers were further increased to 11787 mg L^{-1}, approximately 65 times the expected maximum. Furthermore, the versatility of this route was confirmed by the successful synthesis of ethyl formate, methyl acetate, and ethyl acetate using various ADHs. These findings establish hemiacetal oxidation as a robust and industrially viable platform for the sustainable synthesis of high-value esters.

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PHOTOCATALYTIC HYDROGELS DERIVED FORM FOOD WASTE FOR THE REMOVAL OF ORGANIC CONTAMINANTS

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The increasing demand for clean water, driven by population growth, climate change, and the progressive depletion of freshwater resources, highlights the urgent need for sustainable and efficient water treatment technologies. In particular, emerging and persistent organic contaminants such as pharmaceuticals and dyes represent a significant environmental challenge, as they are often poorly removed by conventional wastewater treatment processes.

In this presentation, we report the development of sustainable multifunctional materials obtained through the valorization of food waste for environmental remediation, with a specific focus on water purification. This approach exploits the synergistic integration of functional components capable of capturing and degrading different classes of organic pollutants, including dyes and pharmaceutical residues. In particular, we describe a multifunctional system based on chitosan-derived hydrogels incorporating photocatalytic units within the polymeric network. Chitosan, a biopolymer obtained from food-processing waste such as shrimp shells, represents an environmentally benign platform that promotes circular use of biomass while providing intrinsic adsorption capability. The resulting hybrid material combines the adsorption properties of the chitosan matrix with photocatalytic activity, enabling the simultaneous capture and catalytic degradation of organic pollutants under mild conditions. The performance of the system is evaluated in aqueous solutions containing dyes and pharmaceutical compounds, also in the presence of inorganic ions to simulate realistic water matrices. Degradation pathways and by-products are carefully investigated to assess environmental safety and to explore routes toward enhanced pollutant mineralization.

Overall, this work demonstrates a sustainable strategy for water remediation that integrates waste-derived materials, green catalytic processes, and advanced treatment technologies.



POLYMER FILM / NANOMATERIAL MODIFIED ELECTRODES BY ELECTROPOLYMERIZATION IN TERNARY DEEP EUTECTIC SOLVENTS AND APPLICATION

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The electropolymerization of the redox-active brilliant cresyl green (BCG) and brilliant cresyl purple (BCP) on glassy carbon electrodes (GCE) modified with gold nanoparticles (AuNP) and graphene quantum dots (GQD) [1] dispersed in chitosan has been explored by potential cycling in ternary DES, composed of choline chloride (ChCl) as hydrogen bond acceptor plus acetic acid (AcA) and ethylene glycol (EG) as hydrogen bond donors and $HClO_4$ as acid dopant. Deep eutectic solvents (DES) are easy to prepare and exhibit lower toxicity, and are more environmentally-friendly, than ionic liquids and non-aqueous solvents, with sufficient conductivity to act as electrolytes, due to strong hydrogen-bond interactions [2]. $GQD_{chitosan}$ was synthesized by a simple procedure using citric acid as carbon source in a chitosan solution containing 1% v/v acetic acid [1]. AuNP were mixed with $GQD_{chitosan}$ in a 70/30% (v/v) ratio. The polymer-modified electrode platform was characterized by cyclic voltammetry and electrochemical impedance spectroscopy, and the morphology by scanning electron microscopy, with better characteristics than the equivalent polymer film modified electrodes formed in aqueous media. Biosensors prepared by immobilization of glucose oxidase (GOx), were employed for glucose determination by amperometry at -0.2 V vs. Ag/AgCl, up to 200 µM for GOx/PBCG/$(AuNP+GQD)_{chitosan}$/GCE and 140 µM for GOx/PBCP/$(AuNP+GQD)_{chitosan}$/GCE. Limits of detection were 2.3 µM and 3.1 µM, respectively, with high selectivity. The biosensors were successfully applied to wine samples with good recoveries which augurs well for their application as GOx enzyme inhibition biosensors for diagnosis of environmental toxicity, as in [3].

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FOOD-INSPIRED OXIDATIVE COUPLING OF CAFFEATES: A NEW TOOL FOR THE GREEN SYNTHESIS OF BENZACRIDINES

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Benzacridines are nitrogen-based heterocyclic compounds derived from acridines, a class long recognized for its pharmacological and photophysical properties. [1] A distinct subclass, benz[kl]acridines, was unexpectedly identified as green byproducts of food processing through oxidative coupling of caffeic acid derivatives with primary amines from proteins and amino acids. [1]

This biomimetic one-step synthesis is highly innovative, since it is conducted in water with inexpensive basic catalysts, representing a greener alternative to conventional multicomponent reactions. Yet, its potential as a green synthesis tool for producing new benzacridines has never been explored. This research is focused on developing and optimizing the scope of this synthetic protocol and assessing the core photophysical properties of these derivatives.

Herein, we report the synthesis of new benzacridine derivatives from caffeic acid derivatives and butylamine, including optimization data and full characterization. Photophysical properties, like UV-Vis spectra, pKa values, molar absorptivity, and fluorescence data, are also reported. These findings demonstrate successful manipulation of this food-inspired process towards novel chromophores and pharmacophores via green chemistry.

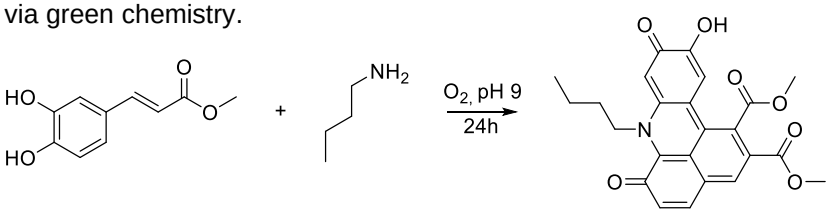


Figure 1: Synthesis of benzacridine with methyl caffeate and butyl amine

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Acknowledgments:

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SMART AND SUSTAINABLE AZETIDINE SYNTHESIS: INTEGRATING FLOW CHEMISTRY WITH MACHINE LEARNING

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Azetidines are important nitrogen-containing motifs in medicinal chemistry and industrial synthesis [1,2] but are often prepared by conventional batch methods. Continuous-flow chemistry and data-driven optimization offer a promising route to greener and more robust synthetic processes [3,4].

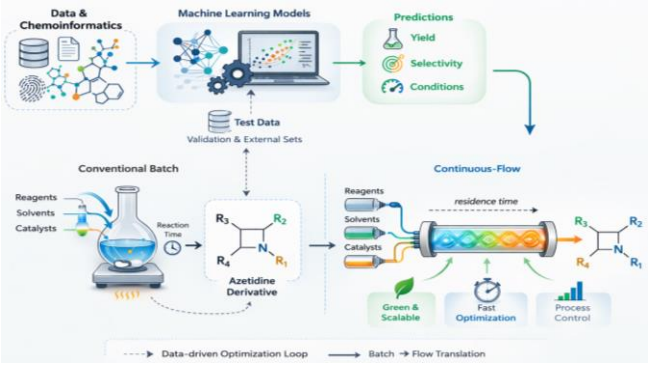


Figure1. Conceptual overview of the data-driven workflow for sustainable azetidine synthesis under continuous-flow

This work is part of an ongoing project on sustainable azetidine synthesis under continuous-flow conditions. Experimental work has focused on selected synthetic routes to target compounds, while a preliminary reaction database was assembled from literature and related synthetic examples to support future model development, validation, and external evaluation.

Preliminary kinetic and optimization studies were performed to identify relevant parameters and define an experimental space for implementation in flow. These efforts establish the basis for future machine learning-assisted optimization of azetidine synthesis.

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GREEN CHEMISTRY AND TEACHING ABOUT MICROPLASTICS TO PROMOTE OCEAN LITERACY: POTENTIAL THROUGH THE STEAM APPROACH

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This study, situated within the field of Science Education, is guided by the following research question: how does Green Chemistry, articulated with the theme of Ocean Literacy, contribute to the learning of scientific concepts related to microplastics among basic education students? The target audience consisted of second-year high school students from a state public school located in Vitória, Espírito Santo, Brazil. The activities were carried out through a didactic sequence grounded in the STEAM approach (Science, Technology, Engineering, Art and Mathematics) [1]. The choice of this theme is justified by the ongoing “United Nations Decade of Ocean Science for Sustainable Development” (2021–2030), established by the United Nations (UN), which aims to foster actions for the preservation and sustainable use of the oceans. Experimental activities, such as analyzing the density of different types of plastics, enabled students to understand the mechanisms underlying the dispersion of microplastics in aquatic environments, while also critically examining the impacts of these materials on marine ecosystems and human health. By incorporating Green Chemistry principles, such as pollution prevention and the development of more sustainable materials, the teaching process encouraged critical reflection on alternatives to the linear model of production and consumption, contributing to the development of students who are more aware of and engaged with sustainability. The construction of solutions to mitigate microplastic pollution, such as the prototypes developed by the students, demonstrated the translation of scientific knowledge into action, a central feature of Education for Sustainability.

Thus, by guiding the teaching of microplastics, Green Chemistry contributed significantly to promoting Ocean Literacy in high school, aligning with contemporary demands for science education committed to social and environmental transformation.

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HOMOGENEOUS CO(II) CRYPTATES FOR LIGHT-DRIVEN CO2 TRANSFORMATION: OPTIMISATION AND SCALE-UP

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In recent decades, population growth and industrialisation have increased atmospheric CO2 levels thought fossil fuel combustion and other human activities, disrupting the natural carbon cycle and intensifying climate change. To mitigate these effects, research have focused on carbon capture and storage (CCS) and carbon capture and utilisation (CCU). Within CCU, photoreduction of CO2 has offer a promising strategy to convert CO2 into value-added chemicals and liquid fuel precursors, using catalytic systems capable of driving this transformation under light irradiation. In homogeneous media, CO2 photoreduction typically relies on three key components: the catalyst (which in the active form, converts CO2), the sacrificial donor (donates electrons and is consumed) and the photosensitizer (absorbs light and mediates the electronic transfer between the catalyst and the sacrificial donor).

We present the synthesis and characterization of Co(II)/Co(II)[1] and Co(II)/Zn(II)[2] dinuclear cryptates bearing a bromo substituent in the aromatic ring, together with their application in CO2 photoreduction and optimisation. System optimisation led to TONCO values exceeding those previously reported for this catalyst family.[3] We also present preliminary scale-up studies were performed at laboratory scale.

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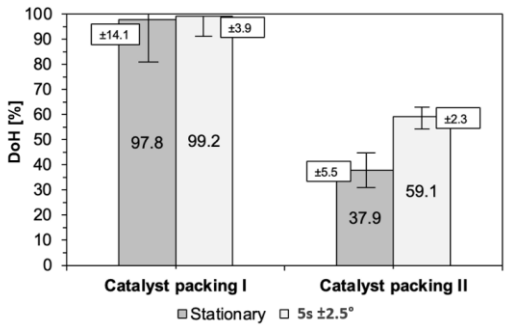
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BENZYLTOLUENE HYDROGENATION UNDER OFFSHORE CONDITIONS IN A TRICKLE BED REACTOR

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The cubic dependence of wind power on wind velocity makes offshore regions particularly attractive for green hydrogen production via water electrolysis using desalinated seawater. However, hydrogen storage and transport remain as a critical challenge. In this context, Liquid Organic Hydrogen Carriers (LOHCs) provide a promising solution by enabling hydrogen storage via exothermic catalytic hydrogenation reaction [1]. On the other hand, the effect of the oscillatory wave motion on reaction performance is still unknown, since the previous studies in the literature only conducted for onshore applications. To understand the movement effect on hydrogenation performance, a trickle bed reactor with a motorized arm was assembled. The setup enabled constant inclination and oscillatory motion with adjustable inclination amplitudes and oscillation periods. It was observed that oscillation has a positive effect on degree of hydrogenation (DoH) as it can be seen in the figure thanks to weakening of liquid channels and better catalyst wetting. With the increasing inclination amplitude, DoH increased, while increase in the oscillation period resulted in decrease in DoH.



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TUNGSTEN CARBIDE-BASED CATALYSTS FOR HYDROGEN EVOLUTION REACTION

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Objectives: Green hydrogen production by water electrolysis is a promising strategy for clean energy production. However, large-scale implementation is limited by the high overpotential for the oxygen evolution reaction (OER), and the reliance on Pt-based catalysts for the Hydrogen Evolution Reaction (HER). Although Pt shows outstanding catalytic activity and stability, its scarcity, high costs, environmental impact and supply risks motivate the development of earth-abundant alternatives. Among the investigated materials, tungsten carbides (WC, W_2C and W_xC) have attracted attention due to their high chemical and thermal stability, corrosion resistance, mechanical robustness, electrical conductivity and Pt-like catalytic behavior. This work aims to develop a low-cost WC based catalyst with HER performance comparable to conventional Pt/C.

Methods: WC nanostructures were synthesized following the approach reported by Han et al. [1] Initially, WO_3 was synthesized hydrothermally directly on a C-based substrate and subsequently converted into WC via chemical vapor deposition (CVD). The effect of various carbon sources (sucrose, dopamine, waste rice husk, melamine, ABS, or urea) and their amounts on the morphology, chemical composition and catalytic activity were investigated. The prepared electrodes were characterized through X-Ray Diffraction, Raman Spectroscopy and Scanning Electron Microscopy and tested for the HER inside a three-electrode electrochemical cell, using H_2SO_4 0.5 M as electrolyte.

Results: All the prepared samples exhibited an increase of current density associated to the HER after the conversion of WO_3 into tungsten carbides. Among the tested samples, the one synthesized using 2g of dopamine as the carbon source resulted in a mixture of different tungsten carbides, WO_3 and W_xN and showed particularly promising results in terms of overpotential and current density.

Conclusions: This study highlights the potential of WC–based nanomaterials as efficient and sustainable catalysts for HER. The combination of chemical stability, cost-effectiveness, and Pt-like catalytic activity makes them promising candidates for applications in green hydrogen production.

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Acknowledgements:

The work was carried out with the financial support of A2A S.p.A.



PHASE-TUNABLE ELECTROLYTES BASED ON IONIC HYDROPHOBIC EUTECTIC SYSTEMS FOR SUPERCAPACITORS

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The growing demand for safe and sustainable energy storage devices has driven the search for alternatives to commercial organic-based electrolytes, which present safety and toxicity issues.[1] Here, we present Ionic Hydrophobic Eutectic Systems (IHES) based on natural compounds, combining fatty acids and their corresponding organic salts of earth-abundant metals such as potassium and sodium.[2] Water addition is essential for their use as electrolytes, as it significantly enhances ionic conductivity and results in a variety of physical states (e.g., homogeneous liquid, biphasic systems, gels, or solids). By tuning their composition, these systems can form conductive gels, attractive for quasi-solid-state devices as they reduce leakage issues typical of liquid electrolytes. Although these IHES-based electrolytes exhibit a relatively narrow electrochemical potential window (1.0–1.2V), liquid formulations display promising performance, with rate capability above 80% at 10 A/g and capacitance retention over 80% after 10,000 charge–discharge cycles.

This study highlights the potential of IHES as greener, safer alternatives for energy storage, enabling the development of low-cost, environmentally friendly supercapacitors based on widely available resources.

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SUSTAINABLE ETHYLBENZENE SYNTHESIS VIA IN SITU HYDROGEN-DRIVEN STYRENE HYDROGENATION

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Metal/support nanocatalysts composed of different metal oxides not only retain the intrinsic acidity characteristics of each component but also exhibit enhanced catalytic activity due to synergistic kinetic interactions. The catalysts were designed to promote a reaction process in which hydrogen produced in situ dehydrogenation of ethanol and directly utilized for the styrene hydrogenation to form ethylbenzene. Strong interactions between Ga, Cu and the SiO_2 support to contribute to enhanced dispersion and superior catalytic performance. In this study, bimetallic Ga–Cu catalysts supported on silica were synthesized via an impregnation method, with varying Ga/Cu loadings to optimize catalytic performance for the indirect hydrogenation of styrene to ethylbenzene. The ethanol dehydrogenation to carbonyl compounds without an oxidant as hydrogen acceptor is an economic and important synthetic approach for the production of valuable chemicals. The results indicate that the Ga/Cu weight ratios significantly affects the catalytic activity. The optimized Ga-Cu support on SiO_2 based catalyst exhibits high stability and reusability. Our finding provides a robust and effective catalytic system with significant potential for tandem hydrogenation and related applications, which would be applied to wide catalytic reactions.

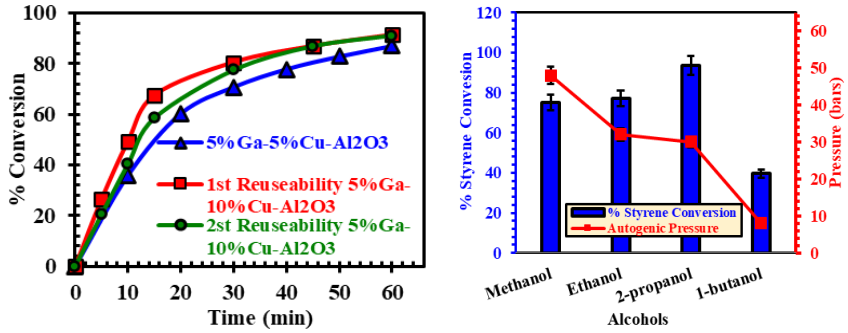


Fig. 1. (a): Catalytic Performance of Ga/Cu-SiO2 catalysts; (b): Influence of different alcohol.

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CYCLOHEXANONE OXIDATION WITH ACID-FUNCTIONALISED SBA-15 CATALYSTS FOR SUSTAINABLE ADIPIC ACID OBTENTION

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Adipic acid (AA) is one of the most demanded compounds in the chemical industry owing to its role in the production of nylon 6,6 [1]. It is typically obtained from the oxidation of fossil-derived mixtures of cyclohexanol and cyclohexanone (C-ONE) with HNO_3, releasing large amounts of N_2O linked to ozone depletion and global warming [1]. This work aims to explore the use of SBA-15 functionalised with Brønsted acid sites of different strength and number, in the fashion of other oxidation reactions [2], as catalysts for the oxidation of C-ONE with air as a greener AA obtention alternative.

SBA-15 was functionalised with 0.2, 0.4 and 0.7 g of 2-(4-chlorosulphonylphenyl)ethyltrimethoxysilane by microwave-assisted reflux at 40 ºC for 2 h (C1-SBA-15, C2-SBA-15 and C3-SBA-15 respectively), with H_3PO_4 by impregnation followed by calcination at 400 ºC for 3 h (P-SBA-15) and with $ClSO_3H$ by addition at 0 ºC (S-SBA-15). X-Ray Diffraction showed that acid functionalisation did not alter the lattice structure of any SBA-15 catalyst. C-ONE conversion gradually rose in S-SBA-15 and C-SBA-15 catalysts with increasing acidity while AA selectivity held steady between 26 % and 33 % (Figure 1), comparable to the 35 % achieved by Dandapat et al [1]. Moreover, P-SBA-15 led to the lowest C-ONE conversion and AA selectivity despite its higher acidity, showing that acid site strength has a greater effect on AA selectivity than acid site number.

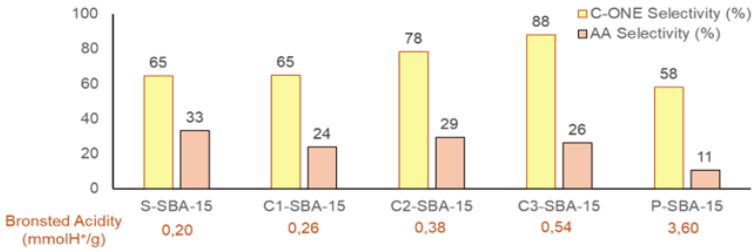


Figure 1. C-ONE oxidation results of functionalised SBA-15 catalysts vs Brønsted acidity measured by titration. Reactions run with 110 µL of C-ONE and 0,1 g of catalyst, at 120 ºC and 30 bar of air for 6 h

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MAKING THE ELUSIVE TANGIBLE: LONG-LIVED BENZYL CATIONS STABILIZED IN ZEOLITES

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The benzyl cation (benzylium, Bn^+) is a fundamental molecule in organic chemistry. Some pioneering works[1, 2, 3] early demonstrated that the benzyl and the tropylium (Tr^+) cations were in equilibrium after the ionization of toluene ($Bn^+ \leftrightarrow Tr^+$), but that both molecules rapidly reacted with the starting aromatic precursor. In this study we demonstrated the spontaneous formation of a stable Bn^+. It requires the following premises: a non–nucleophilic starting material; the ultrafast physical isolation of the so–formed Bn^+, in the absence of any nucleophilic reagent, including any other aromatic precursor; and an extremely soft counter anion (host) able to further stabilize the carbocation. The first requirement could be fulfilled by the same Tr^+. For the second and third requirements, a highly delocalized but micro structured anion would be necessary. The zeolite´s aluminosilicate framework can be considered one of the biggest and softer anions known, with an extremely high degree of negative charge delocalization. The native structure of the zeolites makes them ideal hosts for carbocations, as widely demonstrated for a variety of organic cations, provided that the cation is sterically accommodable inside the zeolite pores.[4] Herein, the present work was able to demonstrate that the spontaneous unimolecular rearrangement reaction of homogeneously distributed Tr^+ inside zeolites produces Bn^+, which stays for weeks within the confined structure of the zeolite. Various techniques were used such as UV–vis, NMR, TAS, computational calculations, and reactivity results, everything supporting the existence and stability of Bn^+ in the solid state. These results bring this fundamental organic textbook carbocation to our laboratories as a manageable organic compound for further mechanistic and reactivity studies in zeolites.

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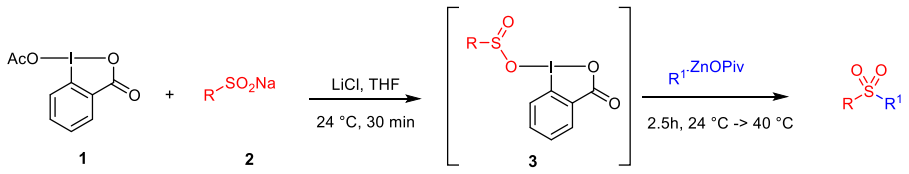
HYPERVALENT IODINE-MEDIATED SYNTHESIS OF SULFONES USING ORGANOZINC PIVALATES AND SULFINATE SALTS

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Sulfones are highly valuable organic molecules due to their widespread presence in pharmaceuticals, agrochemicals, biologically active compounds, and polymer materials.[1,2] Despite the synthetic efforts towards sulfones,[3] reported methods often suffer from limitations such as narrow substrate scope and substitution patterns. Our group has been investigating the umpolung reactivity of hypervalent iodine reagents (HIR), particularly the benziodoxolones, in the synthesis of sulfonamides[4] and sulfinyl hydrazides.[5] In this work, we present a new approach to sulfone synthesis.[6] By taking advantage of our know-how on the generation of sulfonyl-containing HIR intermediate, we achieved high to quantitative yields of diverse sulfones using stable sulfinate salts in combination with organozinc pivalates (Scheme 1).



Scheme 1: General scheme for Sulfone Synthesis

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A GREEN APPROACH TO 2-ARYLQUINOLINES VIA PALLADIUM-CATALYSED C–H ACTIVATION

Nuno Viduedo*[1], Leonardo Pirvu[1], Ângelo Alves[1], Fábio Santos[2], M. Manuel B. Marques[1]

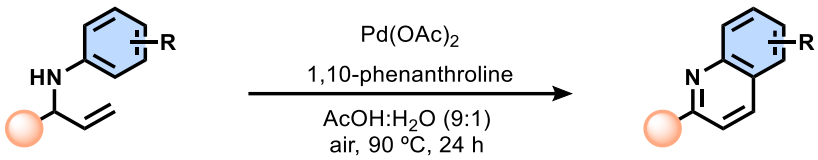
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Quinoline derivatives constitute an important class of nitrogen-containing heterocycles frequently encountered in pharmaceuticals, agrochemicals, and biologically active molecules. Among them, 2-arylquinolines are particularly relevant due to their broad spectrum of biological activities, including antimalarial and anticancer properties.[1–2] Over the years, several synthetic methodologies have been established for the preparation of these compounds; nevertheless, many reported procedures still depend on severe reaction conditions.

In this context, we report a practical and straightforward approach for the synthesis of 2-arylquinolines via palladium-catalyzed intramolecular cyclization of allyl amines through C−H activation (Scheme 1).[3]



Scheme 1: Synthetic Approach to 2-Arylquinolines via Palladium-Catalyzed C-H Activation.

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Acknowledgments:

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SINGLE-AMINE CO_2 HYDROGENATION TO FORMIC ACID: PROCESS SIMPLIFICATION WITH NBIM AND HETEROGENEOUS RU CATALYSIS

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The catalytic hydrogenation of carbon dioxide (CO_2) to formic acid (FA) is a promising route for carbon utilization and hydrogen storage. However, conventional dual-amine processes are limited by the energy-intensive amine-exchange step required for FA recovery.[1] To address this issue, we investigated a single-amine process in which N-butylimidazole (NBIM) serves as both the reaction and separation amine, simplifying the overall process.

Because the relatively low basicity of NBIM creates a kinetically demanding reaction environment, the key challenge in this process is to identify a catalyst capable of sustaining high activity under single-amine conditions. In this context, Ru-MACHO-POMP proved particularly effective, showing the highest FA productivity in 1.0 M aqueous NBIM together with stable recyclability. These results demonstrate that a highly active Ru-based heterogeneous catalyst can make the NBIM single-amine platform practically workable. Since the maximum equilibrium acid-to-amine ratio (AAR) is a key design parameter in this process, temperature-dependent studies were conducted to determine the practical operating window. These results identified 80 °C as the optimal temperature, providing a favorable balance between productivity and AAR, with the AAR approaching ~0.9 under the NBIM/H_2O condition.

The experimental results were further analyzed by Aspen-based process simulation and techno-economic assessment. The analysis estimated a levelized FA cost of \$0.583 kg^{-1} for 85 wt% FA, while also identifying steam demand for water removal as the major contributor to cost and environmental burden. To address this issue, mechanical vapor recompression (MVR) was introduced, reducing external steam consumption by 50–70% and lowering cradle-to-gate global warming potential. This work establishes the first practical single-amine CO_2-to-FA platform and demonstrates a scalable route to simplified and sustainable formic acid production.

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NATURAL SOLVENTS FOR SUSTAINABLE POLYPROPYLENE RECYCLING: DISSOLUTION-PRECIPITATION

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The plastic sector generates an enormous amount of waste each year, with the yearly consumption surpassing 460 Mt, in 2019. However, recycling rates remain below 15%.[1] The urge to shift to a more circular paradigm is intertwined with the need for greener sustainable recycling processes, that yield polymers of sufficient quality to fulfil the requirements of most applications, including those with severe restrictions, such as food packaging. Common recycling techniques fail to handle many materials that are commonly used in packaging and other applications, namely mixed-polymer materials, and materials containing colorants and other additives. Physical recycling, and particularly dissolution-precipitation, has the potential to fill this gap. It allows the purification, separation, and recovery of polymers similar to the pristine, while still consisting of an overall simple process, but state-of-the-art solvents carry strong safety and environmental concerns.[2]

This work delves into the design of dissolution-precipitation processes for polyolefins, using widely available, natural-based solvents: α- and β-pinene. The impact of key operating conditions, including initial polymer content, dissolution temperature, and solvent composition, was evaluated. The process' performance show high robustness across different polymer samples and mixtures, achieving high polymer and solvent recoveries while preserving the recyclates' structural and thermal properties. In particular, small variations in solvent's composition in the two isomers did not yield significant changes in the recyclates quality and recovery. The great robustness and adaptability of the developed process, while resorting to naturally sourced solvents, represent an important step towards truly sustainable recycling routes for polyolefins.

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PROCESS DEVELOPMENT FOR HYDROGEN PRODUCTION FROM AMMONIA DECOMPOSITION AT HIGH PRESSURES

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The growing demand for hydrogen requires efficient storage and transportation solutions. Ammonia is a promising hydrogen carrier due to its high hydrogen density and ease of liquefaction, enabling large-scale energy storage and distribution [1,2]. Catalytic ammonia decomposition provides a clean pathway for hydrogen recovery, avoiding NOx emissions associated with direct combustion. In this work, a high-pressure membrane reactor is proposed to enhance hydrogen production from ammonia. The system integrates a packed-bed reactor with Ni- or Ru-based catalysts and a Pd/Ag selective membrane for in situ hydrogen separation. This configuration shifts the reaction equilibrium, enabling higher ammonia conversion and high-purity hydrogen production at reduced temperatures. The reactor design ensures efficient heat management and stable operation. The results demonstrate that reaction–separation integration under high-pressure conditions is a promising strategy for sustainable hydrogen production.

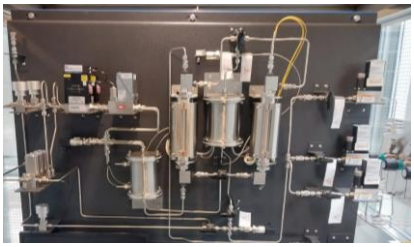


Figure 1- Photograph of the developed high-pressure ammonia decomposition system, showing two reactor configurations for hydrogen production.

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DESIGN AND DEVELOPMENT OF MULTIFUNCTIONAL MATERIALS FOR CO2 CAPTURE AND VALORIZATION

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Developing sustainable CO2 management strategies remains challenging despite significant progress in capture and valorization technologies. Current capture processes are still dominated by amine-based systems associated with high regeneration energy requirements [1]. At the same time, CO2 valorization strategies are increasingly focusing on the production of higher-value chemicals and fuels. Synthetic alcohols are attractive targets due to their potential use as energy carriers and fuel additives, contributing to the development of a carbon circular economy and the transition toward more sustainable energy systems [2].

In CO2 capture, an initial exploration with amino acid-based ionic liquids derived from proline paired with the tetrabutylphosphonium cation (P4444) was conducted as greener absorbents [1]. CO2 uptake tests showed loadings of ~0.9 mmol CO2 mmol-1. Regeneration recovered ~98% capacity after repeated cycles. Current work focuses on supported ionic liquids to improve mass transfer and evaluate performance under CO2 concentrations relevant to flue gas and ambient air.

In CO2 conversion, multifunctional catalysts are being developed for the production of alcohols. The synthesis of the heterogeneous catalysts is performed by combining Cu and Fe active phases, a mesoporous support, and silatrane-based surface modifiers which provide CO2-activating and hydrophobic functionalities. The silatrane-based modifiers enable homogeneous surface functionalization of silica, achieving ~71% surface coverage and their catalytic performance is being evaluated to assess the impact of surface engineering on CO2 hydrogenation.

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P2-3 **Effect of Polyol-Based Biosolvents on Laccase-Driven Depolymerization of Poly(Vinyl Alcohol)**
Mariana I. S. Aguiar, Daniela L. Espínola, Maria Inês C. Santos, João A. P. Coutinho, Ana P. M. Tavares, Frederik R. Wurm, Andreia F. Sousa, and Ana M. Ferreira

P2-4 **Understanding the Presence of the Surface Coordinated Copper Hydrides for the Selective Hydrogenation of 5-Hydroxymethylfurfural**
Po-Wen Chung

P2-5 **Thianthrenium Salts Enable Broad-Scope C–H Carbonylation for Carbon Isotope Labeling**
Vitus J. Enemærke, Rasmus S. Grarup, Prof. Troels Skrydstrup

P2-6 **Biocatalytic Preparation of Esters Via Hemiacetal Oxidation: A Novel, Self-Sufficient and Industrially Viable Ester Production Route**
M. Zago, S. Ceccarossi, I. Serra, P. Branduardi

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P2-7 **Photocatalytic Hydrogels Derived from Food Waste for the Removal of Organic Contaminants**
B. Cerea, A. Gianoncelli, G. Ribaudo, I. Vassalini, I. Alessandri

P2-8 **Polymer Film / Nanomaterial Modified Electrodes by Electropolymerization in Ternary Deep Eutectic Solvents and Application**
J.M.S. Almeida, C.M.A. Brett

P2-9 **Food-Inspired Oxidative Coupling of Caffeates: A New Tool for the Green Synthesis of Benzacridines**
R. Pereira, N. Mateus, V. Freitas

P2-10 **The Ion Behavior and Storage Mechanism of 2D MnO_3 Layer Structure in an Air-Stable Hydrated Eutectic Electrolyte for Aluminum-Ion Energy Storage**
F. H. Hsu, S. Y. Hsu, K. T. Lu, J. M. Chen

P2-11 **Ultrafast Bromide-Free Mechanochemical TEMPO Oxidation of Cellulose**
Nashwa L. Attallah, Yao Yu, Valentina Guccini, Isaac Miranda Valdez, Eero Kontturi, Sandra Kaabel

P2-12 **Photochemical Valorization of Lignin**
L. Cid Gomes, A. Riddell, H. M. Khalid, D. Bernin

P2-13 **Direct Access to Primary Amines Via Electrophilic Amination Mediated by Hypervalent Iodine Reagents**
Gabriel G. Rocha, José C. Cunha, Catarina Cipriano, Rafael Gomez, Fábio Santos, Stefan Bräse, M. Manuel B. Marques

P2-14 **Sustainable Design of Photoactive Metal Complexes for Low-Toxicity Therapeutic Applications**
E. Wieczorek-Szweda, E. Ewert, I. Pospieszna-Markiewicz, M. Fik-Jaskółka

P2-15 **Extraction of Nitrosoamines by Stir Bar Sorptive Extraction with Natural Deep Eutectic Solvent**
R. Halko, L. Mikulcová, I. Boháčová, M. Kaykhaii

P2-16 **In-Syringe Rapid Synergistic Mixed Micelle Cloud Point Extraction as "Smart" Extraction for Determination of Copper in Pharmaceutical Preparative**
M. Mihályová, A. Gajdošová, J. Šandrejová

P2-17 **The Influence of DES on the Esterification of Levulinic Acid Catalysed by Biomass Porous Carbon**
I. Matos, M. Bernardo, M.E. Zakrzewska, N. Lapa

P2-18 **Low Temperature Phase-Separating Hydro-Alcoholytic Depolymerisation of Polyurethanes**
A. S. Sarala, G. Rossignolo, T. Andersen, J. G. Brøgger, B. S. Donslund, T. Skrydstrup

P2-19 **Biopolymers from Different Species of Boraginaceae Family and their Synthetic Analogue**
M. Merlani, L. Amiranashvili, L. Gogilashvili, V. Barbakadze, N. Sukhishvili, K. Mulkijanyan

P2-20 **Enabling High-Turnover Methanol-to-Syngas Reforming**
Andreas Bonde, Gabriel M. F. Batista, Michal Gurský, Troels Skrydstrup

P2-21 **Multicomponent Reactions for Sustainable Chemistry**
G. Bosica

P2-22 **Evaluation of Catalytic Sulfoxidation Reactions for Obtaining Sulfonyl and Sulfinyl Containing Compounds**
Noémi Deak, Gabriela Nemeș

P2-23 **Unified Photochemical Approach to C(sp^3) Chlorinated Compounds from Cyclopropanes, Olefins, and C–H Bonds using Willgerodt-Type Reagents**
Tin V. T. Nguyen, Jerome Waser

P2-24 **Sustainable Microwave-Assisted Hydrothermal Conversion of Biomass Residues into Bio-Oil and High-Performance Carbon Materials**
Tânia Frade, Laura Ferreira, Diogo Amaro, Rui Galhano dos Santos

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P2-25 **Modulating Nucleic Acids Solubilization and Stabilization with Tailored Non-Conventional Solvents**
Bruna F. L. Guerreiro, Rafaela A. L. Silva, Andreia A. Rosatella, Carlos A. M. Afonso

P2-26 **Bio-Oils from Food Waste: Turning Waste into Sustainable Solutions**
Joana Madeira, Raquel Gonçalves, Maria Sousa, Tânia Frade, R. Galhano dos Santos

P2-27 **Synthesis of Cellulose Methacrylate and its Use for Artificial Lung Applications**
S. Ximenes, V. Teixeira, T. Fruleux, J. Wang, C. Vallejo-Giraldo, M. Biggs, R. Chagas, L.M. Ferreira

P2-28 **Natural Products Derivatives for the Treatment of Parkinson's Disease**
R. D. Felisberto, C. A. Montargil, M. A. G. Fortunato, F. Siopa, C. A. M. Afonso

P2-29 **Green Access to Trans-2,4,5-Triamino-Cyclopent-2-Enones from Biomass-Derived Furans**
A. S. G. M. Verde, T. M. P. Santos, S. M. E Cabral, R. F. A. Gomes, C. A. M. Afonso

P2-30 **Photoinduced 1,3-Dipolar Cycloaddition on Bicyclic Aziridines Towards the Synthesis of New Pyrazolines**
Mariana C. Monteiro, Sara O. Antunes, Filipa Siopa, Carlos A. M. Afonso

P2-31 **Structural and Surface Engineering of PtCo Nanowires for Enhanced Durability in Oxygen Reduction Reaction**
Daeun Kim, Sang-Il Choi

P2-32 **Boosting Acidic Hydrogen Evolution Kinetics through Tensile Strain on Pt(111)**
Selim Park, Sang-Il Choi

P2-33 **Dynamic Surface Transformation of Ruthenium Carbide During Hydrogen Evolution Reaction Promotes Activity and Stability in Acidic Media**
Saehyun Park, Sang-Il Choi

P2-34 **Vertical-ß-NiOOH on Fe-Doped (111)-Faceted Ni Nanoplates for Highly Durable Oxygen Evolution**
Gwanho Lee, Sang-Il Choi

P2-35 **Stereoselective Electrochemical 1,4-Dicyanation of Abietanes**
Inês S. Martins, Jaime A. S. Coelho, Carlos A. M. Afonso

P2-36 **Photochemical Oxidation of Enaminones**
A. Peralta, J. R. Vale, R. Gomes, C. A. M. Afonso

P2-37 **Selective Allylic Oxidation of Cyclohexene and Ionone for the Production of Fine Chemicals**
S. Thomas, A. Neri, M. Offidani, T. Tabanelli, F. Cavani

P2-38 **Bile Acid Valorization through Bacterial Biotransformation: A Circular Economy Approach**
V. Scorza, C. Garcia, V. Giorgi Dilacio

P2-39 **Synthesis of Sustainable Binders for Agglomeration in Cork from Renewable Raw Materials**
Luciana Barbosa da Silva, Raquel Pereira, R. Galhano dos Santos

P2-40 **Upcycling Coffee Waste: Supercritical CO_2 Extraction**
G. Moroni, F. Aurum, J. Ruef, M. Pignitter, K. Bica-Schröder

P2-41 **Cannabidiol Biotransformation as a Green Strategy for Developing Antibiofilm Agents**
V. Giorgi, S. Raffaelli, S. Alborés, S. Fernández, C. García, P. Rodríguez Bonnecarrere

P2-42 **Valorization of Rice Husks through Functionalization with Futectic Mixture**
G. A. Nogueira, H. W. Ferreira, H. N. Miyazaki, J.O. Fernandes, S. C. Cunha, M. H. Gonzalez

P2-43 **Systematic Functionalization of Silk Sericin Via Acetylation: A Design of Experiments Approach Toward Sustainable Biomaterials**
Rony Aad, Luca Leuzzi, Diletta Ami, Greta Bianchi, Marco Mangiagalli, Antonino Natalello, Laura Cipolla, Simone Vesentini

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P2-44 **Ionic and Non-Ionic Porous Organic Materials for Advanced Water Purification**
Sunny K. S. Freitas, Leticia R. C. Corrêa, Maria João Nunes, Pierre M. Esteves, Luis C. Branco

P2-45 **Intensification of Supercritical CO_2 Extraction of Lipids from Insect Meal: Extraction Performance and Process Efficiency**
J.M. Lopes, A. B Paninho, M. José, B. Monteiro, P. Simões, A. I. Aguiar-Ricardo, T. Casimiro, A. V. M. Nunes, L. C. Branco

P2-46 **MW Irradiation and Flow Chemistry Approaches for a More Efficient Synthesis of 2H-Aminochromenes**
M. I. L. Soares, G. F. M. Mourinho, J. Macedo, T. M. V. D. Pinho e Melo

P2-47 **Synthesis of 5-Bromopyrrole-2-Carboxylate Towards the Total Synthesis of (-)-Agelastatin A**
João Jorge, João R. Vale, Carlos. A. M. Afonso

P2-48 **Exploration of N-Terminal Functionalization of Peptides through Photocatalytic Processes**
Helena S. Ramos, Tiago M. P. Santos, Rafael F. A. Gomes, Carlos A. M. Afonso

P2-49 **A Hybrid Electrolyte Strategy Enabling Water-Derived Protons in Li-Mediated Ammonia Synthesis**
Hyung Chul Yoon, Kim, Jae Hyung, Baek, Jiyeon, Shim, Joonmok, Kim, Sun Hyung

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P2-50 **Supercritical Water Liquefaction of Mixed Plastic Waste Contaminated with PET: Influence on Yields and Product Composition**
M. Mathew, M.A. Nahil, C. Quarton, P.T. Williams

P2-51 **Valorisation of Coffee Silverskin using Subcritical Water Extraction**
B. Monteiro, A. Paiva, P. Simões

P2-52 **GC-MS Based Chemical Profiling of Portuguese *Cistus Spp.* and Assessment of Bioactivity**
Carolina Nunes, Eliana F. C. Simões, Rafael Mamede, Sofia Santos, Carlos A. M. Afonso, Artur M. S. Silva, João Nunes

P2-53 **Molecular Engineering of Carbazolophane Donors Derived from PCP Scaffolds for TADF Applications**
Jasmin Seibert, Somayeh Asgharnasl, Stefan Bräse

P2-54 **Conjugation Tuning of Porphyrin Linkers for Green Photoactive MOFS**
M. Najafi, S. Bräse

P2-55 **Design and Optimization of Aqueous Two-Phase Systems for Biotechnological Applications and Waste Valorization**
Nuria Mouronte, Mª Salomé Álvarez, Mª Asunción Longo, Francisco J Deive, Ana Rodríguez

P2-56 **Impregnating Ionic Liquids into a MOF: Cationic and Anionic Effects and Impact on Sorbent Properties**
T. J. Ferreira, C. Cabral, L. M. Esteves, T. O. Carvalho, J. Pais, L. P. C. Silva, P. M. Reis, J. M. S. S. Esperança, I. A. A. C. Esteves

P2-57 **PVDF Dissolution by Bio-Based Solvents for Improved Lithium-Ion Battery Recycling**
B. Bengui, F.H.B. Sosa, J.A.P Coutinho, N. Schaeffer

P2-58 **Tailoring Iron Oxides by Surfactant-Assisted Pechini Route with Application in Pollutants Detection**
J. C. S. Cardoso, G. H da Silva, E. A. de Almeida, G. T. Tractz

P2-59 **Sustainable Approaches to Tear Biofluid Analysis by LC-MS/MS**
M. Costa, J. P. Noronha, O. Flores, L. C. Branco, M. João Nunes

P2-60 **pH-Responsive Delivery of Tyrosol using Molecularly Imprinted Polymers Prepared in Supercritical CO_2**
R. Hipólito, F. Teixeira, A.V.M. Nunes, R. Viveiros, T. Casimiro

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P2-61 **Sustainable Xylanase Production through Valorization of Olive Oil By-Product**
L. Gioia, C. Barrera, A. Larocca, G. Blanco, C. Dauber, V. Aldabalde, I. Vieitez, P. Rodríguez

P2-62 **Balancing Adsorption Efficiency and Sustainability: A Green Metrics Approach to Selecting Biochar for Deferiprone Removal**
James Phil Flores, Apichat Imyim

P2-63 **Biooxidation of Graphite Foil with White-Rot Fungi**
Wojciech Dunaj, Stanislaw. Dunaj

P2-64 **Waste Tire Pyrolysis as an Integrated Carbon Recovery Route: Direct CO_2 Emissions from Energy Fractions and Carbon Retention in Recovered Carbon Black**
A. O. Goulart, P. H. P. T. Porto, P. C. C Araújo, C. A. O. Nascimento

P2-65 **Porous Carbon Materials Derived from Invasive Seaweeds as Efficient Recovery Agents for Neodymium**
M. Bernardo, M. Stasi, C. Rodrigues, I. Matos, L. Branco, N. Lapa, A. Martins, C. Alves

P2-66 **Green Fabrication of Chitosan-Based Microcapsule Structures for Sustainable Material Applications**
Sujin Ryu

P2-67 **Lignin Upcycling on Biodegradable Composites for Food Packaging**
M. Cabaço, C. Costa, F. Magalhães, A. Rodrigues

P2-68 **Development of Sustainable Bio-Based Microcapsules for Textile Functionalization**
A. Silva, A. Rodrigues, I. Martins

P2-69 **Shaping ZIF-8 in Chitosan – In-Situ Growth and Powder Dispersion for Enhanced CO_2 Capture**
Thiago O. Carvalho, Tiago J. Ferreira, Joana Pais, A. B. Paninho, A. V. M. Nunes, José M.S.S. Esperança, Isabel

P2-70 **Continuous Flow Synthesis of Primaquine Diphosphate an Anti-Malarial Drug**
F. M. Akwi, P. Watts

P2-71 **Zero-Carbon Seawater Desalination with Electricity Cogeneration Via Process Intensification and Genetic Algorithm Optimisation**
R. Thakran, A. K. Jana

Topic: Carbon Dioxide Utilization

P2-72 **Homogeneous Co(Ii) Cryptates for Light-Driven CO_2 Transformation: Optimisation and Scale-Up**
R. T. Marques, S. Realista, R. G. Santos, P. N. Martinho

P2-73 **CO_2 Hydrogenation to Formic Acid Assisted by Mn Catalysts**
L. Pereira, S. Friães, A.V.M. Nunes, L.B. Maia, B. Royo, L.C. Branco

P2-74 **Fe_3O_4 Enhances Chain Elongation from CO_2 and H_2**
Nikash Naorem, Shashidhar Thatikonda

P2-75 **Ferrihydrite-Based Catalysts for Synthetic Wax Production Via Fischer-Tropsch Synthesis**
G. B. Rhim, K. W. Kim, Y. E. Kim, C. Choe, H. S. Lee, M. H. Youn, D. H. Chun

P2-76 **Interfacial Mechanism of CO_2 Electroreduction on Cu/Zn-Modified Electrodes Investigated by EIS–DRT Analysis**
D. Montini, I. Vassalini, I. Alessandri

P2-77 **Study and Development of Innovative Processes and Materials for the synthesis of Hydrogen Carriers from CO_2**
Gaetano Maria D'Onofrio, Jacopo De Maron, Francesco Basile, Rosanna Viscardi

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P2-78 **Mesoporous TiO_2 as Support for Co-Ce PROX Catalysts**
S. Todorova, J.-L. Blin, B. Lebeau, B. Grahovski, H. Kolev, D. Filkova, L. Vidal, L. Michelin, Z. Geshkova

P2-79 **Scanning Electrochemical Microscopy: In Operando Analysis of Electrocatalytic, Bio-Interfacial, and Gas-Evolving Surfaces**
Hyun S. Ahn

P2-80 **Selective Leaching of Li-Ion Battery Metal Scrap without External Reducing Agents**
Jaeyeong Heo, Haesung Jung

P2-81 **Four-Component Nickel-Based Catalyst for Efficient Hydrolysis of Sodium Borohydride**
G. Valeckytė, Z. Sukackienė, J. Vaičiūnienė, L. Tamašauskaitė-Tamašiūnaitė, E. Norkus

Topic: Bioeconomy

P2-82 **Green Surface-Engineered Nanocellulose from Raphia Farinifera Inflorescence for Mechanistic Control of Interfacial Chemistry in Sustainable Water Treatment**
E. Agboeze, I. P. Udeozo, H. O. Agboeze, V. A. Ofordile

P2-83 **Sequencial and Simulataneos Extraction of Phenolic Compounds and Biopolymers from Sargassum Muticum using Alternative Solvents**
Bárbara C. Jesus, Maria Miquel-Gonzalez, Alice Martins, Isabel M. Marrucho

P2-84 **Green Adsorbents for Sustainable Water Remediation: MOF-Derived Porous Carbons and Waste-Derived Chars**
D. S. S. Flores, C. M. R. Almeida, A. F. Peixoto, C. M. Granadeiro

P2-85 **Sustainable Extraction and Phytochemical Characterization of Bioactive Compounds from Marrubium Deserti for Pharmaceutical Applications**
S.Boutebba, C.Manceri, Y.Meraihi

P2-86 **Sustainable Synthesis of Artificial Humic Substances from Biomass for Environmental Remediation**
K. Pakzad, A. Volikov, M. Antonietti

Topic: AI in Green Chemistry

P2-87 **Smart and Sustainable Azetidine Synthesis: Integrating Flow Chemistry with Machine Learning**
J. Azuaje, F. Pereira, J. Antunes, L. Ferreira

Topic: Green Chemistry Education

P2-88 **Green Chemistry and Teaching about Microplastics to Promote Ocean Literacy: Potential through the Steam Approach**
J.R.P.M. Barros, B.F. Barcellos, D.A. Garcia, V.R. Terra, D.R. Sena

P2-89 **Advancing Green Chemistry through AI-Driven Synthesis Planning and Data-Enabled Insights**
M. Da Pian, A. S. Helmy, M. Stella

P2-90 **Educating Green Chemistry Leaders: Integrating Education, Research, and Innovation for Global Impact**
Muhammad Farooq Zia, Marko. D. Mihovilovic

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P3-1 **Sustainable Ethylbenzene Synthesis Via in Situ Hydrogen-Driven Styrene Hydrogenation**
P. Kumar, U.L. Stangar

P3-2 **Cyclohexanone Oxidation with Acid-Functionalised SBA-15 Catalysts for Sustainable Adipic Acid Obtention**
L. Arrieche-Hernández, J. Granados-Reyes, Y. Cesteros

P3-3 **Making the Elusive Tangible: Long-Lived Benzyl Cations Stabilized in Zeolites**
Francesco Orlando, Raúl Pérez–Ruíz, German Sastre, Antonio Leyva-Pérez

P3-4 **Hypervalent Iodine-Mediated Synthesis of Sulfones using Organozinc Pivalates and Sulfinate Salts**
José C. Cunha, Gabriel G. Rocha, Stefan Bräse, M. Manuel B. Marques

P3-5 **A Green Approach to 2-Arylquinolines Via Palladium-Catalysed C–H Activation**
Nuno Viduedo, Leonardo Pirvu, Ângelo Alves, Fábio Santos, M. Manuel B. Marques

P3-6 **Synthesis, Physical Properties and Hydrolytic Degradation of Novel Biobased Poly(Hexamethylene Furandicarboxylate-Co-Oxalate) Copolyesters**
Zhaobin Qiu

P3-7 **Cobalt-Catalyzed C-H Activation/Annulation of a Benzothiophene Amide With Alkynes in γ-Valerolactone**
Juliana P. Sousa, Maria-João R. P. Queiroz

P3-8 **NaY Zeolite-Supported Pd(II) for Green Sonogashira Coupling of Heteroaryl Halides in Eucalyptol**
Francisco Ribeiro, António M. Fonseca, P. Parpot, Isabel C. Neves, Maria-João R. P. Queiroz

P3-9 **Sustainable Polyester Plastic Chemical Transformation and Valorisation**
H. Araújo, Z. Petrovski, Diana Tomázio, Luís C. Branco, N. Lapa

P3-10 **Sustainable Hydrotrope-Based Extraction of Artemisinin from *Artemisia Annua***
I.W. Cordova, A.M. Ferreira, M.S. Ferreira, N. Papaiconomou, O. Ferreira, S.P. Pinho, J.A.P. Coutinho

P3-11 **Greener Synthesis to Enhance the Competitiveness of New Antifouling Additives as Sustainable Alternatives to Toxic Biocides in Marine Coatings: Supporting SDG 14**
M. Correia-da-Silva, B. Loureiro, R. Ribeiro, S. Cravo, Frederico Maia

P3-12 **Metal-Free Carbon Nitride for Enhanced Continuous-Flow Vicinal Halotrifluoromethylation of Vinyl Compounds**
Shilpa Palit, Gianvito Vilé

P3-13 **Parametrisation of the Oxidation of Acetol using Green Chemistry Principles**
I. Prediger, M. Al Akrami, M. Schmeide, C. Albers, J. Witzorke, S. Schwarze, N. Kulak

P3-14 **Thermoelectrochemistry-Enabled Phase and Morphology Control of Metal Phosphide**
Hyokyum Ahn, Yunwoo Nam, Taeyeon Kang, Hyun S. Ahn

P3-15 **Grinding and Flowing with Nitroso- and Azoalkenes**
Bruna D. P. Costa, João C. S. Simões, Marta Pineiro, Teresa M. V. D. Pinho e Melo

P3-16 **Synthesis of 2D π-d Conjugated Conductive Thin-Film MOF via Electrochemical Anodic Deposition**
T. Kumar, F. Keshavarz, E. Repo, P. Macchi, N. Rezaei

P3-17 **N-Heterocycle Formation Via Yn(Di)Amide Reactivity**
Ana R. Reis, Edward A. Anderson, Maria Manuel B. Marques

P3-18 **Exploring Titania-Based Photocatalysts for Hydrogen Generation Via Glycerol and Ammonia Photoreforming**
Lisa Della Vecchia, Giulia Toro, Cristiana Cesari, Jacopo De Maron, Francesco Basile

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P3-19 **Flurbiprofen Ionic Liquids as a Green Strategy for Sustainable Transdermal Formulations**
K. Bilska, P. Ossowicz-Rupniewska

P3-20 **Reverse Water–Gas Shift Reaction over $Ru_xCo_yCe_{1-x-y}O_2$ Catalysts: Insights into Apparent Activation Energy and Enthalpy**
C. H. J. Franco, K. Ledwa

P3-21 **N-Glycosylation Via Hypervalent Iodine**
C. Cipriano, Rafael F. A. Gomes, M. Manuel B. Marques

P3-22 **Ionic Liquid Derivatives of Mefenamic Acid: A Green Strategy to Improve Drug Solubility and Skin Delivery**
K. Zyburtowicz-Ćwiartka, P. Ossowicz-Rupniewska

P3-23 **Selective Electrochemical Bromination of Furans**
L. Van Coillie, D. Prusov, C. V. Stevens, T. S. A. Heugebaert

P3-24 **Cyclodextrin-Based Supramolecular Deep Eutectic Solvents for Green Extraction of Phenolic Compounds from Pinus Sylvestris Needles**
A. Kalyniukova, V. Andruch

P3-25 **Merging Light and Electricity: Electrophotocatalytic Heteroarylation of Pyrazoles**
J. De Ketelaere, V. Tormans, A. Bytyci, O. Van Hecke, T. S. A. Heugebaert

P3-26 **Green Chemistry: New Catalytic Pathways with Phosphate-Zirconia Hybrid**
Salma Dehhaoui, R. Galhano dos Santos, Abdelkrim Chahine

P3-27 **Turning Cork Industrial Waste into Low-Cost Effective Catalysts for Desulfurization of Fuels**
L. Dias, S. M. Bruno, F. Mirante, S. S. Balula

P3-28 **Bio-Based Maleic Anhydride from 1-Butanol : Process Optimization and Reaction Scheme Investigation**
Marco Brocchi, Anna Gagliardi, Ludovica Conte, Annalisa Sacchetti, Gianluca Moroni, Carlotta Cortelli, Annamaria Catalano, Matteo Pompei, Tommaso Tabanelli, Fabrizio Cavani

P3-29 **Exploring Metastable Fcc-Ru Via Surface-Heated Electrodeposition of Faceted Nanoseeds for Electrocatalytic Applications**
Taeyeon Kang, Hyun S. Ahn

P3-30 **A Recyclable Heterogeneous Catalyst for the Chemo and Enantioselective Hydrogenation of C=C Bonds**
Nils H. Rendel, Himadri Sekhar Sasmal, Arne Nalop, Christian Gutheil, Lisa Schlichter, Felix Wessels, Frank Glorius

P3-31 **Three-Component Cyclisation Enabled by Tripletsensitized Biradical Interception using Photocatalysis**
Madina Lenz, C. Stein, I. Dey, L. Schlosser, T. J. Schoffels, C. G. Daniliuc, F. Glorius

P3-32 **Organic Carbonate Mediated Functionalization of Isosorbide and Its Epimers**
D. Dalla Torre, G. Trapasso, F. Aricò

P3-33 **Green Hydrothermal Synthesis and Characterization of Magnetic Core-Shell Particles from Leaf Extracts of Cinnamomun Camphora**
Chun-Rong Lin, Hsin-Yi Yeh, Chien-Chih Chen

P3-34 **Eco-Friendly Synthesis of Ag-NPs On HOPG for Sustainable Applications: Experimental and Computational Studies**
B. Ocampo Cárdenas, G. Román, G. Dodero, E. Noseda Grau, A. Díaz Compañy, S. Simonetti

P3-35 **Collaborative Stereocontrol in Enantioselective Hydroarylation: A Sustainable Approach to Chiral Molecule Synthesis**
Xin Cui, Weinan Tan, Nguyen Tran, Binjita Pandey

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P3-36 **Green Synthesis of 1,2,4-Triazole-Thioacetamide Derivatives and Their Antimicrobial Activity**
A. Šermukšnytė, K. Kantminienė, Maryna Stasevych, Olena Komarovska-Porokhnyavets, I. Tumosienė

P3-37 **Cyclometalated Ruthenium(II) Catalysts for Ester Hydrogenation**
R. Sara, B. Maurizio, B. Arolla, Z. Daniele, B. Walter, B. Jonathan, G. Damian, Z. Antonio

P3-38 **Synthesis and in Silico Testing of Novel Nitrogen-Rich Cantharidin Analogs Promoted by Ultra High Pressure**
Tiago M. P. Santos, Sabrina M. E. Cabral, Catarina I. B. Cipriano, Rafael F. A. Gomes, Carlos A. M. Afonso

P3-39 **Mechanochemical Reactivity of Biomass-Derived Bis-Furans Toward Nitrosoalkene Cycloadditions**
Mariana Peixoto, Daniel-Almeida Santos, Teresa M. V. D. Pinho e Melo, Marta Pineiro

P3-40 **Solvent-Free Tin(IV) Chloride–Catalyzed Strecker-Type Cyanation of Benzaldehyde Dimethyl Acetal: Mechanistic and Experimental Studies**
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P3-41 **Green Processing-Induced Development of In-Situ Generated PTFE Nanofibrils and Halloysite Nanoclays Delineated for PLA Foaming**
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MULTIFUNCTIONAL CATALYSTS FOR THE CONTINUOUS-FLOW VALORIZATION OF BUTANOL TOWARD HIGH-VALUE CHEMICALS AND JET-FUEL PRECURSORS

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The design of advanced heterogeneous catalysts is key to sustainable energy and chemical processes. Multifunctional materials combining redox and acid-base properties enable cascade reactions in a single reactor, improving carbon efficiency and process intensification while allowing control over C-C bond formation and product selectivity. Recently, we reported an innovative continuous-flow, upgrading pathway for renewable ethanol over Cu-based multifunctional catalysts through a complex cascade sequence leading to C6-C14 compounds [1]. Extending this strategy, biobutanol represents a promising substrate due to its longer carbon backbone, which facilitates direct access to C7+ compounds. Through cascade reactions including dehydrogenation, aldol condensation, dehydrogenative coupling (DHC) and ketonization, selective production of high-value chemicals such as butyl butyrate and 4-heptanone can be achieved, while generating heavier blends relevant for energy applications. Catalysts containing 5 wt% Cu were prepared by incipient wetness impregnation on monoclinic ZrO_2, TiO_2 (anatase) and γ-Al_2O_3, followed by calcination at 450 °C. Catalytic tests were carried out in a gas-phase fixed-bed reactor at 300 °C and atmospheric pressure, feeding 10 mol% butanol in He. 5Cu/*m*-ZrO_2 showed high butanol conversion (>90%) and tunable product distribution. Short contact times favored selective dehydrogenation to butyraldehyde, a key intermediate. Increasing residence time promoted DHC of butanol, leading to the formation of butyl butyrate, followed by ketonization to 4-heptanone. The balanced acid-base properties of *m*-ZrO_2 sustained efficient C-C bond formation, leading to a significant C7+ fraction (~50%). The cooperative interplay between Cu redox sites and oxide acid-base properties governs the reaction cascade scheme, making 5Cu/*m*-ZrO_2 an efficient multifunctional catalyst for butanol valorization into high-value chemicals also relevant for alcohol-to-jet pathways to Sustainable Aviation Fuels.

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MICROWAVE-ENHANCED MICHAEL ADDITION AS A SUSTAINABLE ROUTE TO LEVOGLUCOSENONE-BASED AMPHI

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The work presents a fast, safe, and sustainability-oriented methodology for generating a small library of amphiphilic molecules derived from levoglucosenone (LGO), a renewable platform obtained from cellulose-rich, non-edible lignocellulosic biomass. The amphiphilic character of the adducts demonstrates the feasibility of producing surfactant-like compounds entirely from lignocellulosic feedstocks, at a time when European bio-based surfactants still rely mainly on oleochemical sources. LGO undergoes a microwave-assisted Michael addition with a set of alkyl malonates (dimethyl, diethyl, dibutyl, and dibenzyl), affording structurally differentiated products under solvent-free conditions thanks to the intrinsic miscibility of the reagents. $Ca(OH)_2$, an inexpensive and non-toxic inorganic base, ensured high selectivity. A D-optimal Design of Experiments optimization consistently delivered gravimetric yields above 80%, and diastereoselectivity was confirmed by X-ray crystallography of the simplest diester. The physicochemical properties of the four adducts were assessed through a combined experimental–computational approach, including Hydrophilic–Lipophilic Balance estimations, COSMO-RS calculations, octanol/water partitioning, contact angle measurements, and emulsion tests. Overall, the results support the potential of LGO-derived amphiphiles as emerging surfactant candidates fully sourced from lignocellulosic biomass.[1,2]

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BIO-ADIPIC ACID PRODUCTION FROM THE HYDROGENATION OF MUCONIC ACID ON BIOCARBON SUPPORTED NI CATALYSTS

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Adipic acid (AA), a key industrial chemical widely used in the production of nylon-6,6 and other polymers, is industrially produced from petroleum-derived feedstocks and using HNO_3 as oxidant generating high amounts of ozone-depleting greenhouse N_2O [1]. One environmental alternative to produce bio-adipic acid is the catalytic hydrogenation of biobased muconic acid (MA) [1]. Supported noble metal catalysts have been mostly used for this reaction [2]. Commercial 5 wt % Pd/C catalyst led to 100 % of selectivity to AA for a total conversion at 70ºC, 4 bar H_2 for 2 h [2].

The aim of this work is the preparation and characterization of cheaper and greener catalysts, using Ni as active phase (5-28 wt%) and ordered mesoporous carbon (OMC), obtained from lignin extracted from almond shells [3], as support, to be applied for the hydrogenation of MA to AA, with special focus on studying the influence of different reaction conditions on the catalytic results (Figure 1).

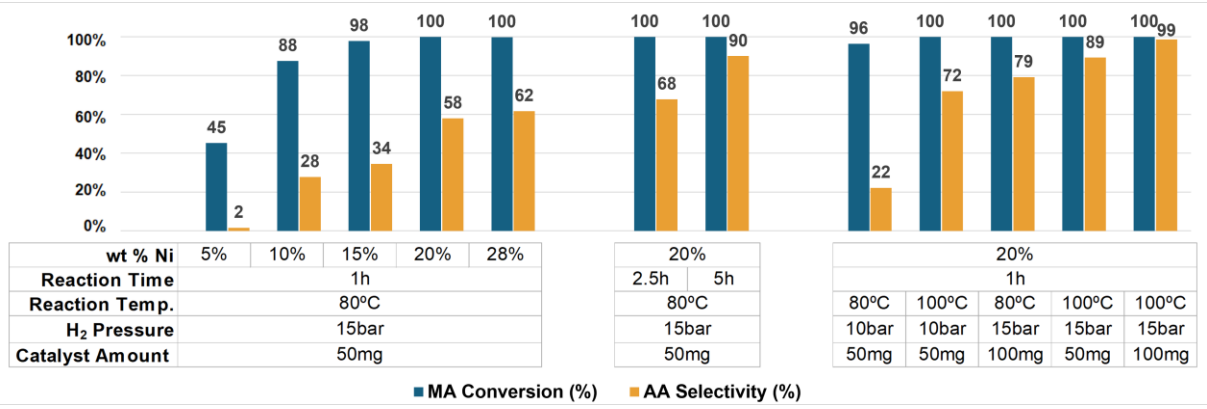


Figure 1. Catalytic results of several Ni/OMC catalysts for the hydrogenation of MA to AA.

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Acknowledgments:

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AIMING FOR THE SAN: PROCESS OPTIMIZATION OF THE DISSOLUTION-BASED RECYCLING OF ABS

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Achieving circularity for engineering plastics requires effective process refinement, particularly for acrylonitrile–butadiene–styrene (ABS), an engineering polymer whose production reached 14 Mt in 2022 and is projected to exceed 20 Mt by 2027 [1].

Owing to its multiphase structure and additive content in waste electrical and electronic equipment (WEEE), efficient recycling it's often unachievable. Thus, solvent-based selective dissolution has often been proposed, and selective dissolution of the model styrene–acrylonitrile (SAN) fraction, while phasing out polybutadiene rubber (PBR), using eutectic and bio-based solvents has been demonstrated through computational screening and laboratory validation by our research group [2]. However, translating this feasibility into a reproducible purification process for real ABS waste remains challenging. Herein, a dissolution–precipitation route was optimised to extend solvent-selection feasibility to ABS derived from WEEE. Through optimisation of key process variables and separation strategies, SAN is recovered under mild conditions with high yields (> 60%, up to 80%) and minimal residual colour. The process enables removal of inorganic fillers (mainly Ti-derivatives and carbon black) and residual additives, yielding SAN fractions that resemble virgin material. Material integrity and purity were evaluated by NMR, FTIR, Raman, DSC, TGA and XRD analyses, with quantitative NMR indicating < 2 wt.% residual PBR in the recovered SAN, establishing dissolution-based recycling as a viable strategy for engineering plastics within the circular economy.

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Acknowledgments: This work was developed within CICECO-Aveiro Institute of Materials, UID/50011/2025 & LA/P/0006/2020 & UID/PRR/50011/2025, financed by national funds through the FCT/MCTES (PIDDAC). The FCT is acknowledged for the research contract to AMF, FHBS and AFS (CEECIND/00361/2022, CEECIND/07209/2022, and CEECINSTLA/00002/2022). The European Commission is acknowledged by VP for a doctorate grant, and CFA for a research contract, under Horizon Europe (HORIZON-CL4-2021-RESILIENCE-01-Project: 101058636).



FROM SINGLE-CIRCUIT TO DUAL-CIRCUIT COFS: BORON–HYDROXYL MICROENVIRONMENT ENGINEERING FOR EFFICIENT PHOTOCATALYTIC H_2O_2 PRODUCTION

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Sustainable catalytic systems are crucial for green chemical synthesis. Hydrogen peroxide (H_2O_2), an important green oxidant, is still produced via energy-intensive, waste-generating processes [1]. Photocatalytic synthesis from water and oxygen provides a sustainable alternative but is hindered by inefficient proton-coupled electron transfer (PCET) and mismatched redox kinetics [2].

Inspired by natural photosynthesis, where electron and proton transport are spatially decoupled yet synchronized, we develop a biomimetic “circuit” design in covalent organic frameworks (COFs) [3]. A rapid, solvent-free, and low-energy plasma-assisted strategy enables site-specific implantation of boron-based functional units into preformed COFs under ambient conditions, providing a green route for precise microenvironment engineering [4]. This approach drives a transition from a “single-circuit” system, limited by proton diffusion, to a “dual-circuit” architecture integrating a B←N electronic pathway with a B–OH proton relay network.

The hydrogen-bonding microenvironment acts as a localized proton reservoir and transfer channel, enabling synchronized proton–electron delivery and efficient PCET while suppressing charge recombination and side reactions. Consequently, the dual-circuit BADT-COF system lowers reaction barriers and exhibits enhanced H_2O_2 production in pure water without sacrificial agents, with high selectivity, stability, and efficiency.

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OXYGEN VACANCY-DRIVEN OXIDATIVE ESTERIFICATION OF HMF OVER AU/LA CATALYSTS

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Biomass-derived 5-hydroxymethylfurfural (HMF) enables the formation of dimethyl 2,5-furandicarboxylate (FDMC), a key monomer for polyethylene furanoate (PEF), a promising biobased substitute for polyethylene terephthalate (PET) [1]. Au-supported lanthanum-based catalysts were prepared by DP and studied to establish structure–activity relationships using XRD, XPS, HAADF–STEM, CO chemisorption and operando DRIFTS (methanol and propyne), complemented by synchrotron experiments at ALBA to probe electronic structure and metal–support interactions. Au/$La_2O_2CO_3$_T300 shows the highest activity and selectivity towards FDMC, achieving the best productivity reported for noble metal catalysts under base-free conditions (86.1 mol_{FDMC} mol_{Au}^{-1} h^{-1}). This performance is attributed to oxygen vacancies in the oxycarbonate surface, which promote the adsorption of HMF-derived intermediates, while Au nanoparticles activate molecular oxygen. Combined catalytic and spectroscopic evidence (**Fig. 1**) supports a novel cooperative mechanism between Au sites and oxygen vacancies, enabling efficient oxidative esterification of HMF with high selectivity towards FDMC.

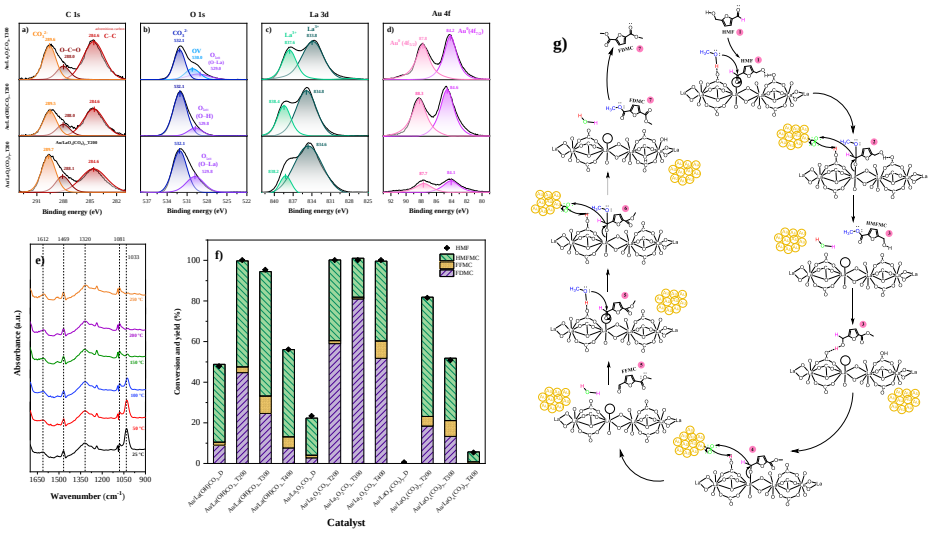


Fig. 1. (a–d) XPS of the most active catalysts for each support; **(e)** operando DRIFTS (MeOH) showing methoxy intermediates over the Au/$La_2O_2CO_3$_T300 catalyst; **(f)** catalytic performance; **(g)** proposed mechanism.

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OPTIMISING THE EFFECTIVENESS OF ZINC OXIDE NANOPARTICLES IN SUNSCREEN

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Ultraviolet (UV) radiation represents a significant hazard to both human health and the environment, highlighting the need for effective protective materials. Among these, zinc oxide (ZnO) is widely regarded as an efficient UV-filtering agent and is extensively used in sunscreens and personal care formulations. Toxicological studies have demonstrated its good biocompatibility, even at the nanoscale. ZnO provides protection primarily by absorbing and scattering both UVA and UVB radiation, thereby mitigating skin damage and reducing the risk of UV-induced carcinogenesis. [1]

Despite these advantages, the use of ZnO in long-term UV-protective applications remains challenging due to its residual photocatalytic activity. Under prolonged irradiation, ZnO can degrade a range of organic compounds, dyes, and some inorganic materials into less harmful products. While this behaviour is beneficial in areas such as water and air treatment, photodetectors, and solar energy applications, it becomes a limitation when ZnO is used to protect organic materials, coatings, and polymer-based products, as it may lead to their degradation. Therefore, there is a need to develop improved ZnO-based systems that provide effective UV protection while limiting unwanted photo-induced degradation. [2,3]

In this research, the properties of ZnO nanoparticles are adjusted to preserve their UV-filtering performance while reducing their photocatalytic activity, through the use of surface modifications and selected additives, alongside a better understanding of the underlying processes. The aim is to improve the stability and performance of both personal care and industrial formulations, leading to more reliable and safer products.

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SHRIMP SHELL VALORISATION: AN INTEGRATED BIOREFINERY APPROACH TO BIOACTIVES AND (ELECTRO)CATALYSTS

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Seafood waste, particularly shrimp shell waste (SSW), is often underutilized despite its rich chemical composition. In the context of a circular and sustainable economy, SSW represents a promising renewable resource for the integrated production of high-value compounds and functional materials [1]. This work proposes a biorefinery strategy combining green extraction processes with thermochemical conversion to maximize shrimp shell valorisation. Initially, valuable bioactive compounds such as astaxanthin and chitin-derived products, are recovery using environmentally friendly extraction methods, with potential applications in the cosmetic sector. The residual biomass undergoes pyrolysis to produce carbon-rich materials. The resulting biochars, naturally doped with nitrogen, can be further tailored to obtain efficient (electro)catalysts. Owing to their tunable surface properties and active sites, these materials exhibit promising performance in energy-related applications, including electrocatalysis [2]. By integrating extraction and pyrolysis within a single pathway, this approach enables full utilisation of shrimp shell waste, reducing environmental impact while generating multiple value streams. Overall, this work highlights how combining green chemistry and biorefinery concepts can advance the sustainable valorisation of marine biomass.

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SUSTAINABLE MECHANOSYNTHESIS OF METAL OXIDE PHOTOCATALYSTS FOR THE REMOVAL OF ORGANIC DYE POLLUTANTS

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The development of sustainable and energy-efficient synthesis routes for functional photocatalytic materials have gained increasing attention in environmental remediation studies. In this work, various metal oxide photocatalysts, namely ZnO, CuO, and Fe_2O_3, were synthesized via a mechanochemical approach as a green and solvent-minimized alternative to conventional preparation methods. The mechanosynthesis route offers important advantages such as reduced solvent consumption, simplified processing, and potential scalability, making it attractive for the preparation of environmentally relevant catalytic materials.

The obtained metal oxide materials were evaluated for the photocatalytic removal of organic dye pollutants from aqueous media under different irradiation sources. Model dye compounds were selected to represent common water contaminants, and degradation performances were comparatively investigated under UV and visible light conditions. The effects of irradiation type on photocatalytic efficiency were examined in order to better understand the light-response behavior of the synthesized materials. In addition, the relationship between synthesis strategy, material composition, and photocatalytic activity was considered in terms of process-structure-property interaction.

The results are expected to demonstrate that mechanochemical synthesis can provide a practical and sustainable route for producing active metal oxide photocatalysts for water treatment applications. This study highlights the potential of mechanochemically prepared metal oxides as promising candidates for the removal of dye pollutants and contributes to the broader development of greener photocatalytic systems for environmental applications.

Acknowledgments:

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FEED TEMPERATURE AND MIXING TIME INFLUENCE IN AQUEOUS SPRAY-DRYING SYNTHESIZED UiO-66-NH2 MOF

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Metal organic frameworks (MOFs) are a class of crystalline porous solids developed over the last decades that have emerged as promising materials for a wide range of applications, including gas storage, adsorption, catalysis, etc [1]. Even though there are over 100.000 types of MOFs its applications must deal with production scalability issues and the adoption of sustainable inexpensive industrial processes.

Spray drying is a well-established, one-step industrial technique with high space-time yield that can be used to produce micron-sized MOFs particles [2]. This technique has strong potential to bridge the gap between laboratory-scale synthesis and industrial production, especially when combined with green chemistry routes [3].

In this work we study the influence of precursors feed temperature and mixing time on the synthesis process of UiO-66-NH2 through aqueous spray-drying. The resulting particulate materials were characterized by powder X-ray diffraction, scanning electron microscopy and thermogravimetric analysis to evaluate crystallinity, morphology and stability and defects content, respectively.

Results show that MOF crystals are formed prior to the drying process and that the increasing of both time of precursors mixing prior to the drying process and the temperature of this mix lead to the obtention of bigger nanocrystals forming the micron-sized particles.

These results provide key insights for the obtention of green synthesized MOFs and its scalability.

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GREEN HYDROTHERMAL CONVERSION OF CELLULOSE INTO CARBON QUANTUM DOTS FOR METAL ION DETECTION

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Carbon quantum dots (CDs) have emerged as promising nanomaterials for optical sensing, even their synthesis often relies on corrosive reagents, multiple solvents and multistep purification procedures [1]. In this work, a solvent-free hydrothermal procedure is reported for the direct conversion of renewable commercial cellulose into CDs adapted from Ren, H. et al. [1]. Since the CDs exhibit high intensity luminescence and interact with contaminants, generating a turn-off or turn-on effect, it could be applied as a sensor for detecting toxic metal ion in water. Cellulose powder (320 mg) was placed in a hydrothermal autoclave reactor at 200 °C for 4h to obtain CDs. Afterward, the system was cooled to room temperature and the brownish product was macerated in acetone for 30 minutes, to remove aromatic by-products, followed by drying at 40 °C for 3h. The CDs had a mass yield of 64.25% with an average particle size of approximately 16 ± 3 nm. The CDs aqueous suspension was prepared at 0.05% (w/w) and sonicated for 30 minutes. Luminescence spectra showed a maximum emission and excitation peaks at 435 and 358 nm, respectively, and the UV-Vis spectra resulted a maximum extinction peak at 279 nm. Luminescence quenching was evaluated after successive additions (100 µL) of Cu(II) (10^{-4} mol/L) [2]. A preliminary minimum concentration of Cu(II) limit of $6.25x10^{-5}$ mol/L was detected, indicating potential metal ion detection in water. This work highlights a sustainable and facile route to produce CDs from renewable cellulose through a solvent-free hydrothermal process.

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MECHANOCHEMICAL AMMONIA DECOMPOSITION AT ROOM TEMPERATURE FOR HYDROGEN PRODUCTION

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As carbon neutrality emerges as a critical global challenge, ammonia decomposition technology—now attracting significant attention for the commercialization of hydrogen energy—still suffers from operational limitations like high reaction temperature.[1] To address these issues, this study explores mechanochemical ammonia decomposition at room temperature using ball milling. A batch-type synthesis process was employed. 500 g of steel balls, 15 g of catalyst, and ammonia gas was loaded to a 250 mL vessel. After loading, the sealed container was ball-milled for 3 hours at 550 rpm. Through this process, the optimal catalyst composition was identified, and the decomposition performance—including hydrogen production rate and nitrogen desorption rate—was systematically analysed using gas chromatography (GC). The Fe+Ni/CeO_2+ZrO_2 catalyst with the ratio of Fe:Ni:CeO_2:ZrO_2=9:9:7:35 exhibited the best performance, achieving a hydrogen production rate of 13,037 μmol h^{-1} and a nitrogen desorption rate of 792.33 μmol h^{-1}. To evaluate industrial feasibility, the same reaction conditions were applied to a continuous process and compared with the batch system. Postreaction powders were analysed via SEM, XRD, and XPS to elucidate the effects of milling on catalyst structure. The continuous process achieved an NH_3 conversion rate of 58.65% at 200°C, a remarkably high energy efficiency compared to prior Fe/CeO_2-based studies, which reported a 64.68% conversion rate at 400°C.[2]

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GREEN SONOCHEMICAL BIOENGINEERING OF BASIL-DERIVED TITANIUM DIOXIDE NANOPARTICLES FOR SELECTIVE ANTICANCER ACTIVITY

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Herein, titanium dioxide nanoparticles (TiO2 NPs) were bioengineered through an ultrasound-assisted process using greenly extracted *Ocimum basilicum* essential oil as a natural reducing and capping medium. Gas chromatography-mass spectrometry (GC-MS) identified 58 constituents, dominated by linalool (46.55%). XRD confirmed the crystalline anatase phase, SEM/EDX supported the high purity and elemental composition, and TEM revealed spherical nanoparticles ranging from 5.55 to 13.89 nm in size, with a mean diameter of 8.69 ± 1.93 nm. The greenly synthesized TiO_2 NPs showed selective anticancer activity against MCF-7 breast and A-549 lung cancer cells, with IC50 values of 1.73 and 4.79 µg/mL, respectively, while remaining cytocompatible toward MCF-10A normal cells. Mechanistic studies showed that the NPs promoted apoptosis and cell-cycle arrest, increased *expression of the apoptotic genes Bax and Bak*, and elevated caspase-3/7 protein levels, supporting mitochondria-mediated cell death. Docking suggested interactions with caspase-3 and EGFR-TK. Overall, this work highlights a sustainable, bio-assisted pathway for producing high-purity TiO2 nanomaterials with potential relevance to biomedical green chemistry and anticancer nanotechnology [1].

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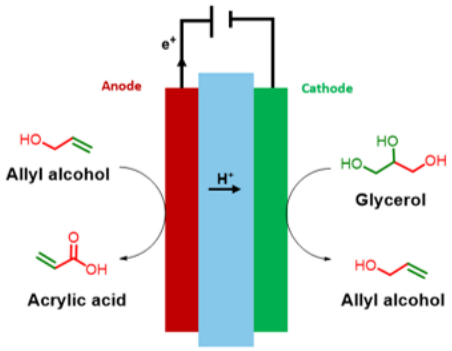
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ELECTROCHEMICAL DEOXYGENATION OF VICINAL DIOLS TOWARDS OLEFINS

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The selective conversion of oxygen-rich substrates into valuable unsaturated compounds is an important objective in sustainable organic synthesis. Vicinal diols are readily accessible from olefins, biomass-derived feedstocks, and renewable carbon sources, making them attractive intermediates for the preparation of olefins through deoxygenation. However, conventional deoxygenation methods often rely on stoichiometric chemical reductants, harsh reaction conditions, or waste-generating reagents, which limit their environmental and practical efficiency.



In this work, we investigate the electrochemical deoxygenation of vicinal diols as a greener and more controllable approach for the synthesis of olefins. The reaction was carried out using a ligand-supported rhenium catalyst in a quasi-divided electrochemical cell. Hydrobenzoin, diethyl tartrate, and glycerol were selected as representative substrates to evaluate the applicability of the methodology across structurally different vicinal diols. This reaction proceeds through a paired electrolysis strategy, in which valuable transformations occur at both electrodes. At the cathode, glycerol undergoes deoxygenation to form allyl alcohol, while at the anode, allyl alcohol is further oxidized to acrylic acid. This paired approach improves the overall efficiency of the electrochemical process by combining reductive and oxidative transformations within the same system. This study highlights the potential of rhenium-catalysed paired electrolysis for the valorisation of oxygenated feedstocks and the development of sustainable alternatives to traditional reductive transformations. The approach may contribute to more environmentally responsible pathways for producing olefins and acrylic acid derivatives, which are key building blocks in fine chemicals, polymers, and functional materials.

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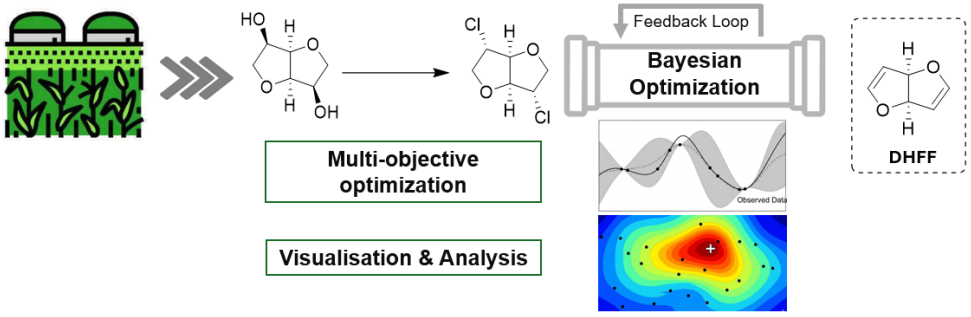
MECHANISTIC INSIGHT TO ACCESS NEW ISOMANNIDE-DERIVED PLATFORM CHEMICALS VIA BAYESIAN OPTIMIZATION

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The development of platform chemicals from biomass is essential for decoupling the chemical industry from fossil-derived carbon.[1] This work establishes a selective synthetic route from carbohydrate-derived feedstock isomannide into dihydrofurofuran (DHFF), a previously unexplored bicyclic scaffold, via a controlled double b-elimination strategy. Systematic screening revealed that selectivity is depending on base identity. To navigate the complex interplay of competing pathways, Bayesian Optimization (BO) was integrated with mechanistic insights to precisely map the parameter space (T, t, $[C]_{substrate}$, $[C]_{base}$) This data-driven approach enabled the maximization of DHFF formation while suppressing side reactions. Beyond the bicyclic target, the reaction network yields two reactive dialdehyde derivatives: a competing fragmentation pathway generates glutaconaldehyde potassium salt, marking a rare instance of its formation from an isohexide substrate. Furthermore, we demonstrate that DHFF can be used to access muconaldehyde, providing a novel entry to conjugated C_6 dialdehydes from renewable feedstocks. Collectively, these results illustrate how the synergy between mechanistic understanding and algorithmic optimization enables selective access to novel biomass-derived intermediates.



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Acknowledgments:

The authors thank Ghent University for financial support.



SUSTAINABLE ANTIBIOTIC RECOVERY: OPTIMISING ETHYL LACTATE AND CHOLINE-BASED AQUEOUS BIPHASIC SYSTEMS FOR ENVIRONMENTAL PROTECTION

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Removing antibiotics from water is a critical step in the global fight against antimicrobial resistance (AMR). However, many current extraction methods rely on toxic, petroleum-based solvents. This research offers a sustainable alternative by developing Aqueous Biphasic Systems (ABS) using ethyl lactate (a bio-derived solvent) and choline salts (low-toxicity, nutrient-based building blocks).

In this work, phase equilibria for four different choline salt systems were first established to characterise the biphasic systems. Tie-line data was then used to define phase compositions. The partitioning behaviour of three individual antibiotics was then investigated using UV–Vis spectroscopy to determine extraction efficiencies and partition coefficients.

Results showed that extraction performance was highly dependent on salt type and tie-line length, with stronger phase separation promoting improved partitioning. Variations in antibiotic behaviour were linked to differences in molecular properties, including hydrophobicity and ionisation. To test practical use, the top-performing system was applied to a real wastewater matrix. Despite the complexity of real water, the system remained effective at capturing the target contaminants.

This work demonstrates that ethyl lactate-based systems are a powerful, eco-friendly tool for water purification. It provides a clear framework for using green chemistry to protect aquatic environments while moving away from harmful traditional solvents.

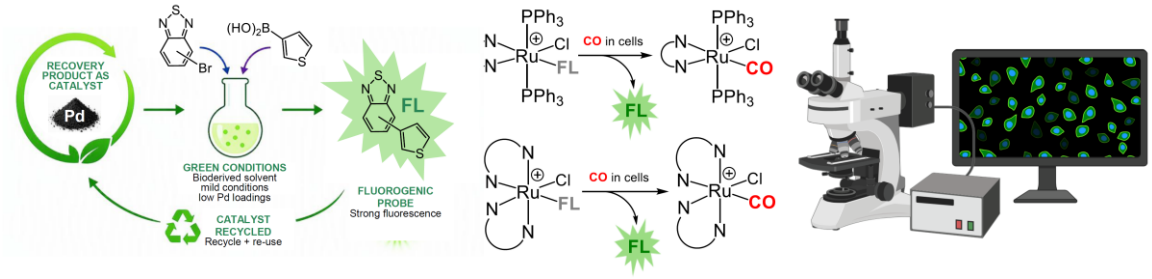
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SUSTAINABLE SYNTHESIS OF FLUOROGENIC PROBES USING CATALYSTS DERIVED FROM WASTE

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Probes for biological and medical imaging are widely used but are often prepared using low-yielding, atom-inefficient routes in environmentally-damaging solvents. Many fluorophores are prepared using cross-coupling reactions involving palladium catalysis, however, conditions are often unoptimized and use high loadings. The sustainability of such transformations [1] is further undermined by the low abundance and high energy cost of mining palladium (3880 kg of CO_2e per kg of Pd) as well as the environmentally-damaging extraction of the metal. In this contribution, we demonstrate how a palladium recovery complex derived from end-of-life automotive three-way catalytic converters (TWCs) can be used as an effective catalyst system for the synthetic transformations needed to prepare fluorogenic probes used to detect endogenous carbon monoxide as a marker of disease [2,3].



The palladium recovery product can be obtained selectively from TWC material in a mild recovery process based on inexpensive organic triiodide reagents at room temperature. Low loadings (<0.1 mol%) of this complex are able to produce much higher yields than previously reported of different fluorophores, including highly emissive substituted benzothiadiazoles [4]. This approach offers a more sustainable route to fluorophores widely used in medical imaging without relying on mined palladium.

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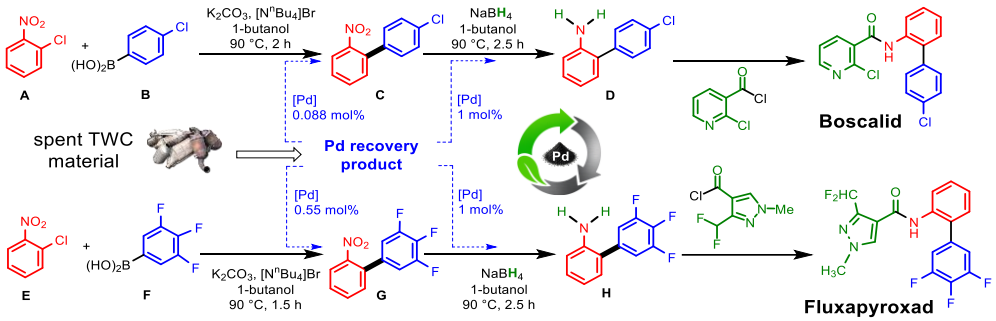
GREENER SYNTHESIS OF AGROCHEMICALS USING PALLADIUM RECOVERED FROM WASTE

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Palladium-mediated catalysis is an essential synthetic tool in modern synthetic chemistry as well as a crucial component in automotive three-way catalytic converters (TWCs). However, the supply of palladium is severely limited by its low natural abundance and its extraction from ore is environmentally-damaging. A promising alternative is to recover palladium from end-of-life TWCs and directly apply it in catalytic transformations, avoiding the reliance on primary extraction and minimising palladium waste [1]. Building on previous work [2-4], we show how a molecular palladium recovery product obtained from TWCs under mild conditions can be used as a pre-catalyst for the synthesis of key agrochemical intermediates. Its catalytic utility was demonstrated in the Suzuki-Miyaura coupling (to form **C** and **G** below) and nitro reduction steps (to form **D** and **H** below) in the formation of Boscalid and Fluxapyroxad, two major fungicides produced annually on a kiloton scale. The sustainability was further enhanced by the use of bioderivable solvents, recovery and re-use of the palladium content and chromatography-free purification steps. This approach offers a more sustainable and globally-accessible alternative to catalytic transformations using palladium derived from mining.



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ECOLOGICAL COMPOSITIONS FOR THE DETECTION AND DECONTAMINATION OF HAZARDOUS TOXIC SUBSTANCES

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The rapid detection and identification of dangerous toxic substances (chemical warfare agents CWAs and toxical industrial compounds TICs), as a hazard control measure, constitute particularly important operations for the safe conduct of activities, reducing the risk of personnel coming into contact with toxic chemical agents and rapid intervention to limit the spread of contamination and decontaminate personnel and equipment. Research and development of effective means of detection and decontamination of the chemical toxic compounds is a permanent concern of institutes and laboratories specialists, both those in the field of national security and in other civilian fields (environmental protection, medicine, mining exploration, chemical synthesis and analysis, etc.).

This paper presents the results of experimental laboratory research on the design, development and testing of: i) new colorimetric compositions for the rapid detection of highly toxic substances, colorimetric detectors representing simple, modern, lightweight, reliable, "environmentally-friendly" means for detection and identification, which ensure the rapid (5-10 seconds to a maximum of 2 minutes) and unequivocal identification of highly toxic chemical agents in vapour or aerosol form in the atmosphere or in enclosed spaces; ii) new decontamination system based on metal-complexes catalyzed alcoholysis under highly basic conditions, which are a far better alternative to other reported decontamination materials, due to their inexpensive and environmentally benign character, the decontamination process occurring at ambient conditions and, most importantly, advancing rapidly; this system is very efficient for the decontamination of sensitive materials, surfaces and equipment, the dangerous toxic substances deposited on different surfaces being almost fully destroyed, in accordance with the requirements of AEP 58 - Operational features, technical specification, tests procedures and assessment criteria for CBRN defence equipment.

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SYNTHESIS AND TRANSFORMATION OF IODINATED FERROCENE KETONES

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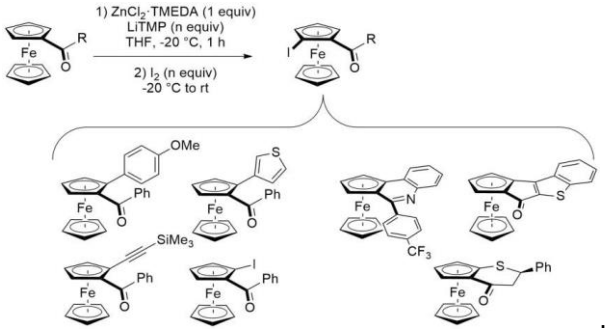
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Ferrocene ketones are fundamental organometallic building blocks for the synthesis of functionalized ferrocenes as well as structurally complex polycyclic systems. A regioselective deprotometallation method using LiTMP and $ZnCl_2$·TMEDA as an *in situ* trap has been developed and applied **to** a wide range of aroyl- and heteroaroylferrocenes. The subsequent iodination provided a versatile library of 2-iodoferrocene ketones with yields ranging from modest to excellent. [1]

The synthetic value of these iodinated intermediates was demonstrated through a series of post-functionalization reactions. Suzuki-Miyaura and Sonogashira cross-coupling reactions enabled the efficient introduction of aryl, heteroaryl, and alkynyl substituents, while the combination of the ketone function and the carbon–iodine bond offered unique possibilities for intramolecular cyclizations.[1]

Consequently, several novel ferrocene-based heterocyclic frameworks were synthesized, including thiopyranoferrocenones, ferroceno[c]quinolines, and an enantiopure tetracyclic benzothiophene-fused ferrocene obtained via a highly efficient cyclization strategy. [1]



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SMALL CHANGES, GREENER OUTCOMES: SUSTAINABLE SYNTHESIS OF QUATERNARY AMMONIUM SALTS

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Contemporary chemical research increasingly prioritises sustainable development and the principles of green chemistry, aiming to reduce environmental impact without compromising functional performance [1].Quaternary ammonium salts (QAS) are well-established organic ionic compounds with a long history of application in both academic research and industrial practice. Their broad and continuously expanding use across diverse sectors has contributed to a steady increase in global consumption [2]. Their increasing environmental burden highlights the need to reduce the overall footprint of QAS across their life cycle, including the development of cleaner and more resource-efficient synthetic routes.

This study revisits the classical Menschutkin quaternization through the lens of green chemistry, asking whether small changes in a well-known reaction can translate into measurable environmental benefits. A systematic reaction matrix was designed to correlate the type of quaternizing agent and solvent system with key process variables, including reaction time, temperature, yield, purity, and green chemistry metrics. This integrated assessment moves beyond conventional synthetic efficiency and enables the selection of conditions according to both product performance and environmental burden. In this way, the work provides a practical framework for choosing more sustainable synthetic routes to QAS depending on their intended application. The results demonstrate that established transformations can still offer substantial room for improvement when evaluated through a broader, metrics-guided perspective.

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CFD SIMULATION OF A LAB-SCALE PACKED BED REACTOR FOR IN-SITU CATALYTIC FAST PYROLYSIS OF BIOMASS

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The environmental impacts of fossil fuel overconsumption have increased the need for adopting biomass as a renewable source to produce fuels and chemicals via thermochemical conversion. In-situ catalytic fast pyrolysis (CFP) of lignocellulosic biomass offers a promising route for sustainable synthesis of hydrogen-rich gases and upgraded bio-oil. In this study, CFD simulations of a packed bed reactor for CFP were conducted in COMSOL Multiphysics 6.2 to obtain gas velocity, species concentrations, and temperature profiles. The experimental set-up includes a tubular furnace to heat a quartz tube and maintain 800 °C operating temperature. A quartz boat (half-cylinder geometry) is inserted and houses the packed bed, made of corn straw (6 g) and Ni-CaO catalyst (3 g) particles. Nitrogen is used as inert gas carrier crossing the boat, wherein pyrolysis occurs. Under Laminar Flow physics, Navier-Stokes equation describes the fluid velocity change in the quartz tube, $\rho(\mathbf{u} \cdot \nabla)\mathbf{u} = \nabla \cdot [-p\mathbf{I} + \mathbf{K}] + \mathbf{F}$, together with the continuity equation, $\nabla \cdot u = 0$, for mass conservation. The Brinkman equation, $0 = \nabla \cdot [-p2\mathbf{I} + \mathbf{K}] - (\mu\chi^{-1} + \beta\varepsilon_p\rho|\mathbf{u2}| + Q_m / \varepsilon_p^2)\mathbf{u2} + \mathbf{F}$, describes fluid flow in porous medium when viscous effects and velocity gradients are not negligible inside the pores. The experiments (30 min) achieved 46.5 wt% gas,18.33 wt% bio-oil, and 21.67 wt% char yields. The figure below shows a velocity profile from CFD simulations. Ongoing work will include concentration and temperature profiles, a complete description on reaction kinetics and optimisation of CFP reactor.

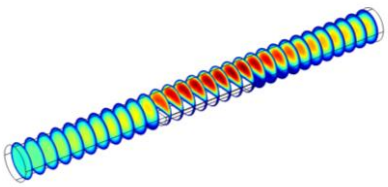


Figure 1. Velocity profile of the gases



ANTIBACTERIAL AND ANTIOXIDANT PROPERTIES OF HUMIC ACID-DERIVED WITH METAL NANOPARTICLES

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The development of multifunctional antioxidant and antibacterial materials based on biocompatible and environmentally safe matrices is an important direction in modern pharmacology. Humic acids attract considerable attention due to their intrinsic redox activity, chemical versatility, and ability to stabilize metal nanostructures. In this study, novel noble metal-containing bionanocomposites were synthesized using humic acids as functional polymeric matrices. The presence of phenolic, quinone, hydroxyl, methoxyl, and carboxyl groups provides humic acids with pronounced electron-donating and electron-accepting properties, enabling radical scavenging and participation in redox processes.

Coordination-active sites in humic acids promote stable interactions with noble metal nanoparticles, resulting in highly stable bionanocomposites resistant to aggregation. Incorporation of noble metal nanoparticles into the humic matrix creates a synergistic effect, combining the antioxidant properties of humic substances with strong antibacterial activity of metal nanostructures, significantly enhancing the antimicrobial potential of the obtained materials.

The antioxidant activity of the synthesized bionanocomposites was evaluated using the DPPH assay and electrochemical methods with ascorbic acid as a reference standard. All synthesized nanocomposites exhibited pronounced antioxidant activity and effective electron transfer properties. Overall, the obtained bionanocomposites preserve the antioxidant activity of the humic matrix while benefiting from enhanced antibacterial properties provided by noble metal nanoparticles, highlighting their potential for anti-inflammatory and pharmaceutical applications.

Acknowledgments:

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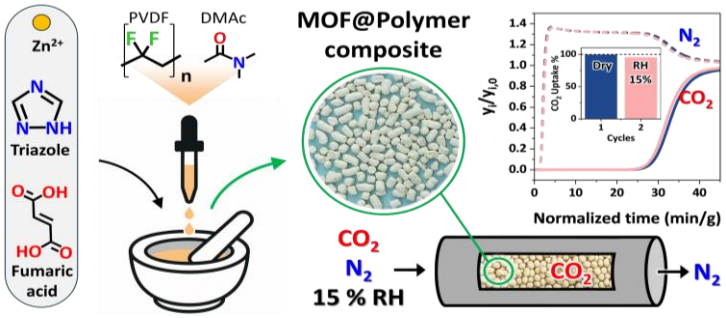
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SUSTAINABLE SYNTHESIS OF A Zn-TRIAZOLE MOF AND ITS PVDF COMPOSITE FOR EFFICIENT CO_2 CAPTURE

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The development of sustainable porous materials for carbon capture is essential for low-emission industrial processes.[1] Herein, we report a low-environmental-impact synthesis of a Zn-triazolate fumarate Metal–Organic Framework (Zn-TRF MOF) based on liquid-assisted mechanochemistry combined with solvent incubation (LAG-IN).[2] Compared to conventional solvothermal synthesis, this approach drastically reduces solvent consumption and reaction time while maintaining excellent scalability and reproducibility.The obtained Zn-TRF exhibits high CO_2 uptake and remarkable CO_2/N_2 selectivity, together with excellent stability over repeated adsorption/desorption cycles. To improve processability and practical applicability, the MOF was directly synthesized in situ within a poly(vinylidene fluoride) matrix, yielding self-supporting Zn-TRF@PVDF pellets through a single integrated process.Breakthrough experiments demonstrated selective CO_2 capture even under humid conditions, where CO_2 effectively competes with water for the adsorption sites, similarly to next-generation hydrophobic adsorbents developed for industrial carbon capture. Overall, this work highlights mechanochemical synthesis and in situ composite fabrication as sustainable and scalable strategies for the development of advanced adsorbents for greenhouse gas capture.



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TOWARDS SUSTAINABLE RECOVERY OF PHENOLIC ANTIOXIDANTS FROM ROSE HIPS: GREEN SOLVENTS AND ASSISTED EXTRACTION TECHNIQUES

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The sustainable recovery of plant-derived antioxidants requires the integration of environmentally preferable solvents with efficient extraction technologies. In this study, γ-valerolactone (GVL), Cyrene™ and ethyl lactate (EL), used alone or in mixtures with ethanol, were evaluated for extracting phenolic compounds from rose hips (*Rosa canina* L.) by maceration, ultrasound-assisted extraction (UAE) and microwave-assisted extraction (MAE) [1]. MAE provided the highest overall extraction yield, while markedly reducing energy demand compared with conventional maceration. The highest total phenolic content was obtained using UAE with a 70:30 ethanol/GVL mixture (9.67 ± 0.15 mg GAE/g dry mass), demonstrating that binary solvent systems can improve phenolic recovery. Ethanol/GVL mixtures also retained substantial antioxidant activity in the DPPH assay, confirming the functional relevance of the recovered phenolic fraction. MALDI-TOF MS revealed differences in extraction selectivity, while Cyrene™ showed interference in the Folin-Ciocalteu assay. In contrast, ethyl lactate was compatible with spectrophotometric phenolic determination, highlighting its potential as an analytically convenient green extraction medium. None of the tested extracts was cytotoxic to L929 fibroblasts at 0.5 mg/mL. These findings identify ethanol/GVL mixtures combined with assisted extraction as a promising strategy for sustainable recovery of functional rose hip bioactives.

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FROM CYRENE™ TO NOVEL MOLECULAR FRAGMENTS: DEVELOPING A DIVERSE LIBRARY OF BIO-BASED SCAFFOLDS

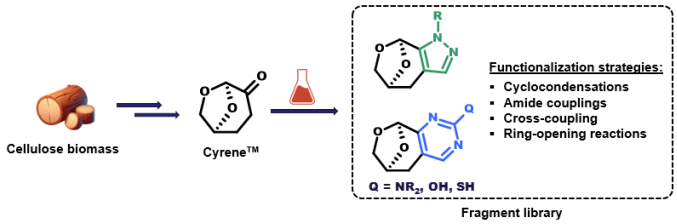
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The transition from fossil-based resources toward sustainable biomass-derived alternatives is an essential step in modern chemical manufacturing. Dihydrolevoglucosenone (Cyrene™), a bio-based green solvent obtained from cellulose-derived biomass, represents a promising platform for the development of novel molecular fragments [1]. While previous studies mainly focused on modifications of the carbonyl functionality, the enol-type reactivity of Cyrene™ remains unexplored [2,3].

In this work, we developed a diverse library of heterocyclic Cyrene™-based scaffolds to expand the accessible chemical space for fragment-based drug discovery. Various pyrazole and pyrimidine derivatives were synthesized in cyclocondensations using for example different hydrazines and guanidines under both conventional and microwave-assisted conditions. The obtained intermediates were further diversified through e.g. cross-coupling, amide coupling, and ring-opening reactions, enabling the generation of structurally diverse fragments.

The resulting molecular library demonstrates the versatility of synthetic transformations of Cyrene™ and highlights its potential as a renewable starting material for the preparation of novel condensed chiral heterocyclic derivatives.



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Acknowledgments:

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BIENZYMATIC DYNAMIC KINETIC RESOLUTION OF SECONDARY ALCOHOLS BY ESTERIFICATION/RACEMIZATION IN WATER

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Dynamic kinetic resolution (DKR) is a highly efficient method for the synthesis of optically pure compounds. However, despite its efficiency, DKR has certain limitations, including the high cost of catalysts, the necessity for anhydrous and anaerobic conditions, and the requirement for high temperatures. To address these challenges, we have developed an alternative DKR method that utilizes recombinant enzymes in an aqueous environment [1].

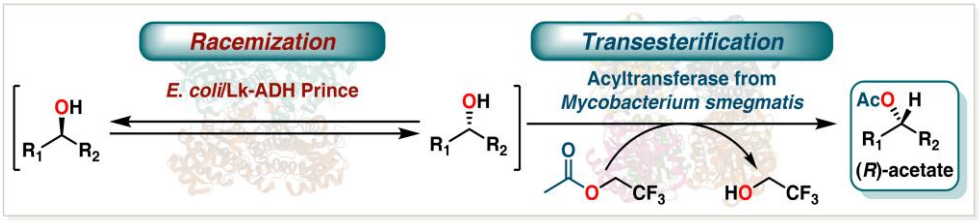


Figure 1. Dynamic kinetic resolution of secondary alcohols using two biocatalysts in an aqueous environment.

We employed a variant of alcohol dehydrogenase from *Lactobacillus kefir*, which facilitates rapid racemization of substrates through a reversible sequence of oxidation-reduction reactions. In parallel, we utilized acyltransferases from *Mycobacterium smegmatis*, which enable enantioselective transesterification of alcohols in aqueous media. By integrating these two reactions into a DKR process, we successfully synthesized a broad spectrum of optically active secondary alcohol esters with high yields (up to 87%) and excellent enantiomeric excesses (>99%), even at the 1 g scale.

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Acknowledgments:

This research was funded by the National Science Centre, Poland grant "OPUS 24" (Grant No. 2022/47/B/ST4/00139). A.R. was supported by the "L'Oreal UNESCO For Women in Science" program in Poland and START program by Foundation for Polish Science. The Faculty of Chemistry at the Warsaw University of Technology, and the University of Graz are acknowledged for their financial support.

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OBTAINING HIGH-VALUE BIOACTIVE COMPOUNDS FROM AGROINDUSTRIAL WASTE USING GREEN TECHNOLOGY

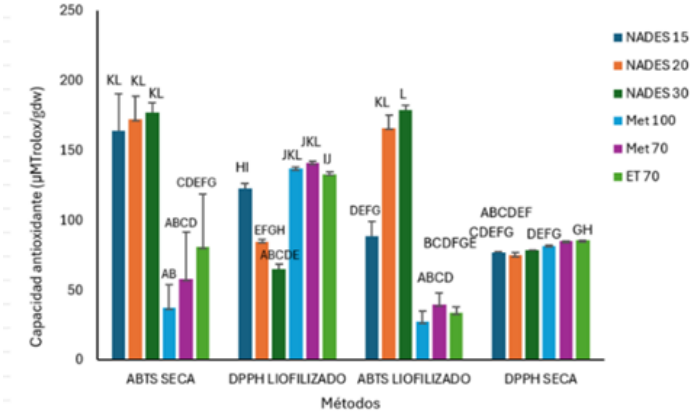
S. Alfaro Araya [1*], M. Jarpa-Parra[1], Y. Rivas Tiznao[2], E. Castro Inostroza[3].

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Abstract:

This study evaluated total polyphenol (TP) extraction and antioxidant activity (DPPH and ABTS) from maqui leaves obtained from pruning using green (NADES) and conventional solvents. Samples from Biociclo Orchard were processed at the Protein and Natural Resources Laboratory, Adventist University of Chile. NADES containing 30% water showed the highest recovery of antioxidant compounds. NADES 30% extracts from freeze-dried leaves reached 179 ± 12.7 µM Trolox Eq/g d.w., compared with 33.9 ± 15.0 µM Trolox Eq/g d.w. for 70% ethanol. HPLC-UV showed greater compound complexity in NADES extracts, identifying gallic and caffeic acids, rutin, myricetin, and possible quercetin derivatives. Significant differences were observed among treatments ($p < 0.0001$), with an efficiency gradient of Met/Et < NADES 15–20 < NADES 30. Conclusions: NADES 30% showed the highest antioxidant activity, supporting its potential as a sustainable and high-performance alternative for recovering antioxidant compounds from maqui pruning waste.

Graphic No. 1: Antioxidant concentrations vs. dehydration method by treatment



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COPPER-CATALYZED ALKYL-ALKOXYLATION OF AURONES USING BIS(SILYL)PEROXIDES AS SAFER RADICAL PRECURSORS

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Bis(silyl)peroxides (BSPs) emerge in the context of Green Chemistry as attractive alternatives to classical organic peroxides, combining ionic and radical-type reactivity while overcoming the limitations associated with low thermal and chemical stability. The electronic influence of silicon on the O–O bond grants BSPs tunable and controllable reactivity, mitigating the uncontrolled decomposition pathways typical of conventional peroxide systems. As a result, BSPs can be regarded as cleaner, safer, and more atom-efficient radical precursors.[1],[2]

In this work, we present preliminary results on the catalytic alkyl-alkoxylation of aurones using BSPs in combination with a copper catalyst. This dual functionalization strategy installs two new bonds in a single step, improving step- and atom-economy in the synthesis of auronol derivatives.

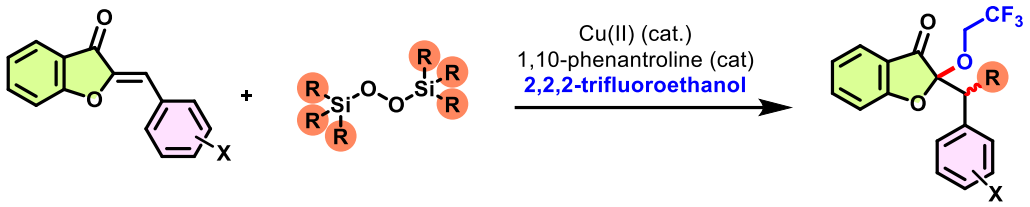


Figure 1: Alkyl-Alkoxylation of aurones with BSPs.

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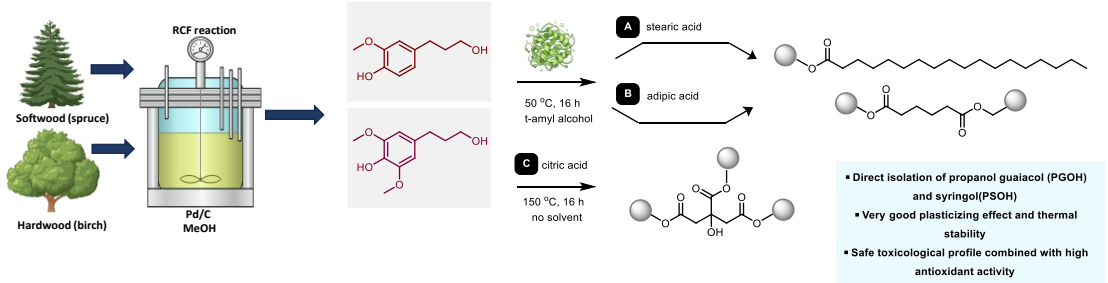
Sustainable Synthesis of Lignin-Derived Plasticizers from RCF-Derived Aromatic Building Blocks

A. Zogu*[1], L. Trullemans[1], R. Vroemans[2], T. Çalik[3], T. Hendrickx[1], G. Preegel[1], I. Scodeller[1], D. Cappoen[3], B. Maes[2], B. Sels*[1]

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Bio-based plasticizers derived from renewable resources have emerged as promising alternatives to conventional phthalate plasticizers owing to increasing concerns regarding their toxicity, environmental impact, and stricter regulatory restrictions. Among renewable feedstocks, reductive catalytic fractionation (RCF) of lignin provides aromatic platform molecules, such as propanol guaiacol and propanol syringol, whose free phenolic hydroxyl groups enable further functionalization and confer antioxidant properties, yet remain unexplored for plasticizer synthesis. Herein, a green esterification strategy was developed to convert these lignin-derived monomers into a new family of aromatic bio-based plasticizers.



Acknowledgments:

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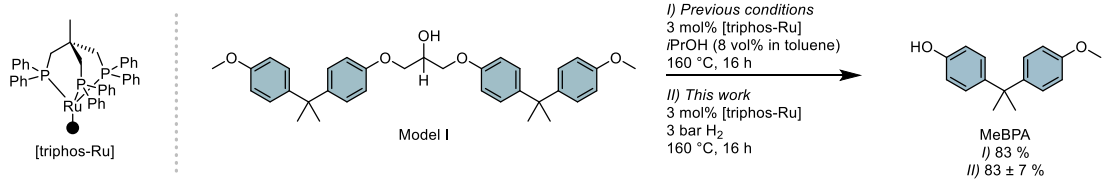
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ADVANCING TRIPHOS-RUTHENIUM CATALYSED C–O BOND DISCONNECTION IN THERMOSET EPOXY RESINS

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Epoxy resins reinforced with glass or carbon fibres are widely used in wind-power applications, but the lack of closed-loop recycling has made incineration and landfilling the dominant disposal routes [1–3]. In 2023, Ahrens, Skrydstrup et al. reported the first selective C–O bond cleavage method for thermoset epoxy resins, enabling recovery of reinforcing fibres and bisphenol A [4]. Mechanistic and DFT studies revealed a high activation barrier for the triphos-Ru precatalyst and catalyst deactivation pathways, requiring high loadings and long reaction times. Herein, we present an improved catalytic system with a more readily activated precatalyst, modified ligands, and an alternative reductant (Scheme 1).



Scheme 1 - Previous and altered conditions for catalytic C–O bond cleavage in Model I.

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UMPOLUNG NITROGEN TRANSFER: ADVANCING THE SYNTHETIC UTILITY OF HYPERVALENT IODINE(III) REAGENTS

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The presence of C–N bond is central to biologically active compounds[1], motivating the search for efficient C–N bond formation methods[2]. Leveraging the umpolung reactivity of benziodoxol(on)es – hypervalent iodine(III) reagents (HIRs), our group developed platforms for transferring sulfonyl groups[3] and primary amines[4–6] to diverse nucleophiles. Continuing our interest in the development of new electrophilic group-transfer processes, we are investigating the broader synthetic potential of these reagents for C–N bond formation. In this context, the application of HIRs to new classes of carbon-based nucleophiles may provide further opportunities for the development of efficient amination strategies and expand the synthetic utility of hypervalent iodine-mediated transformations.

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TWO PILES OF WASTE, MANY SOLUTIONS: FROM LANDFILL TO VALUE ADDED MATERIALS

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Large quantities of household and industrial waste continue to be landfilled despite containing high-value materials, since conventional recycling processes remain too labor- or cost-intensive to be broadly implemented. Textile waste is a prominent example: it contains polymer and cellulose fibers that do not, or only slowly degrade, and therefore accumulate in the environment. Similarly, elemental sulfur as a by-product of the oil industry, often ends up stockpiled in environmentally harmful deposits. Yet, both waste streams represent feedstocks, for which we herein present strategies for upcycling into functional materials. First, cellulose is extracted from waste textiles and chemically modified using a more sustainable approach compared with industrial methods. The resulting polymer serves as precursor for hydrogel formation, enabling biomedical applications and further be processed via 3D-printing, for patient-specific treatments and customizable biomaterials. Second, elemental sulfur is transformed through inverse vulcanization with a wide range of comonomers. This allows tuning of thermal, optical, and mechanical properties of sulfur-rich polymers for applications in optics, energy storage, and environmental remediation. While sulfur polymers synthesized from (used) vegetable oils offer low environmental impact and simple processing, they suffer from poor mechanical strength. Introducing textile-derived fillers enhances their structural integrity and broadens their potential applications. Importantly, these composites remain reprocessable, supporting circular material flows. Despite growing interest in these materials, their long-term stability under realistic environmental conditions remains insufficiently studied. To address this gap, we systematically expose polymers derived from fossil-based and renewable monomers to heat, radiation, moisture, pH variations, and biological attack. By correlating structural changes with performance degradation, we provide a comprehensive understanding of their ageing behavior and durability. Finally, we combine both waste streams by incorporating textile fibers as filler materials into inverse vulcanized polymers.

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INSIGHTS INTO THE ELECTROCHEMICAL REACTIONS OF ARYL KETONES

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In conventional organic synthesis, benzylic oxidation of toluene-based substrates usually requires multistep oxidation-reduction sequences involving hazardous reagents and significant waste generation.[1] In this context, organic electrosynthesis emerges as a potentially more viable alternative, enabling direct oxidation of benzylic methyl groups in a single step by using electricity as the sole redox agent, without the need for external oxidants, enabling efficient redox transformations under mild and sustainable conditions.[2] The objective of this work is to develop an electrochemical methodology to achieve this transformation, enabling the oxidation of benzylic methyl groups (**Figure 1. A**). In collaboration with ASCENZA Agro, this approach was specifically applied to metrafenone (**Figure 1. B**), a fungicidal active ingredient, as a representative and industrially relevant substrate.

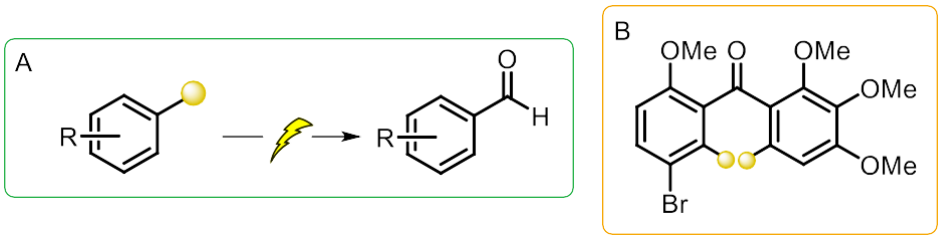


Figure 1. General scheme for benzylic oxidation of methyl (A) groups. Structure of metrafenone with positions susceptible to oxidation (B).

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$Mg(H_2O)_6^{2+}$ AS THE CATALYST IN FENTON LIKE REACTION: A GREEN STRATEGY FOR POLLUTANT REMOVAL

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For decades, Fenton-like reactions have dominate environmental remediation, typically relying on low-valent transition metals such as Fe^{II}. However, recent evidence suggests that non-redox active main group metal cations can activate peroxides to catalyse the decomposition of organic pollutants via the formation of a metal-hydroperoxide complex[1]. This study presents a paradigm shift in oxidative catalysis by introducing a magnesium-based alternative. In contrast to the traditional reliance on redox-active metals like iron, we demonstrate a system of $Mg(H_2O)_6^2$ effectively activates peroxide to generate potent oxidizing species under mild, ambient conditions.

Mechanistic Novelty & Application: The fundamental distinction of this system lies in Lewis-acid-mediated O–O bond activation, enabling oxidation without requiring radical formation as the initiating step, while allowing substrate-dependent radical pathways. Sludge-Free Process: Eliminates the metal-hydroxide precipitation and secondary contamination typical of iron-mediated systems.

Greener Methodologies: Offers a blueprint for designing sustainable oxidation strategies in both aqueous and organic media without the need for hazardous or critical transition metals.

Conclusion: By redefining the role of non-transition metals in peroxide activation, this work contributes to the development of high-efficiency, sustainable catalytic technologies for water remediation and beyond.

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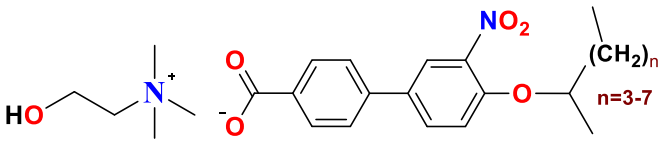
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BEYOND ALKYL CHAINS: DESIGN OF FLUORESCENT BIPHENYL-BASED CHOLINE SAILS WITH TUNABLE MICELLIZATION BEHAVIOR

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A new class of intrinsically fluorescent biphenyl-based choline surface-active ionic liquids (SAILs) with varying alkyl chain lengths (C_5-C_9) was synthesized and systematically investigated to elucidate the role of structural rigidity and hydrophobicity on aggregation behavior in aqueous media. The incorporation of a rigid biphenyl moiety alongside tunable alkyl chains provides a unique combination of π–π interactions and hydrophobic effects, offering an alternative design strategy to conventional surfactants.



Micellization was evaluated using conductivity, surface tension, and fluorescence spectroscopy (288.15–308.15 K). All SAILs formed micelles, with CMC decreasing as alkyl chain length increased, reflecting stronger hydrophobic interactions [1, 2]. The biphenyl moiety further stabilizes aggregation, while intrinsic fluorescence enables direct monitoring without external probes. Thermodynamic analysis confirmed spontaneous micellization with negative Gibbs free energy. Enthalpy–entropy compensation indicates competing solute–solute and solute–solvent interactions. Surface parameters show efficient adsorption and packing at the air–water interface.

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GALLIUM-MAGNESIUM LIQUID METAL ALLOYS AS EARTH ABUNDANT CATALYSTS FOR SELECTIVE ESTER SYNTHESIS

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The development of sustainable catalytic systems based on earth-abundant metals represents a central priority in green chemistry. [1,2] Liquid metal alloys offer unique advantages as a catalyst, including dynamic surface properties, tunable composition and operation under mild conditions without precious metals or complex ligand frameworks. [3,4]

Gallium-Magnesium (Ga-Mg) liquid metal alloys, as selective catalysts for ester synthesis from aldehydes, achieve a 100% atom-economic transformation of significant synthetic value. [5] Comparative screening of gallium-based alloys revealed a striking dependence of product selectivity on alloy composition, with Ga-Mg demonstrating unique reactivity distinct from related systems. [3,6] Optimisation of reaction conditions afforded high conversions under mild, solvent-free conditions using low catalyst loadings of earth-abundant metals.

Scope investigations revealed a pronounced electronic dependence on reactivity, with systematic trends observed across a range of aromatic aldehydes. Preliminary mechanistic studies indicate catalytic rather than stoichiometric behaviour and point to an interesting interplay between surface- and solution-phase pathways that is currently under investigation.

These results establish Ga-Mg liquid metal alloys as a promising, earth-abundant catalytic platform for selective ester synthesis and motivate further exploration of liquid metal systems in sustainable organic transformations.

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INTEGRATION OF BOPHY AND BODIPY INTO PORPHYRIN-BASED CONJUGATED MICROPOROUS POLYMERS FOR PHOTOCATALYTIC APPLICATIONS

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Keywords: Conjugated Microporous Polymer, Porphyrin, BOPHY, BODIPY, Photocatalysis

Abstract: Conjugated microporous polymers (CMPs) have garnered significant research interest due to their high porosity and structural tunability.[1] In particular, porphyrin-based CMPs, featuring an extended π-conjugated system, are highly promising candidates for efficient photocatalysis.[2]

To the best of our knowledge, porphyrin-based CMPs integrating BOPHY or BODIPY as auxiliary chromophoric units, as well as their comparative investigations, remain largely unexplored.

Herein, we report two porphyrin-based CMPs, designated as PorB-CMP and PorD-CMP, featuring BOPHY and BODIPY subunits, respectively. The formation of conjugated polymer networks was confirmed via FT-IR and structural analyses. Furthermore nitrogen sorption (BET) measurements revealed high surface areas (~800 $m^2 g^{-1}$), confirming their permanent microporosity.

Both CMPs efficiently promoted the selective oxidation of sulfides and NH_2SCN-mediated thiocyanation of electron-rich arenes under solar-simulator irradiation.

These results demonstrate that porphyrin-based CMPs integrated with distinct chromophoric units can serve as robust metal-free photocatalysts, while providing valuable insights into chromophore-dependent photocatalytic behavior.

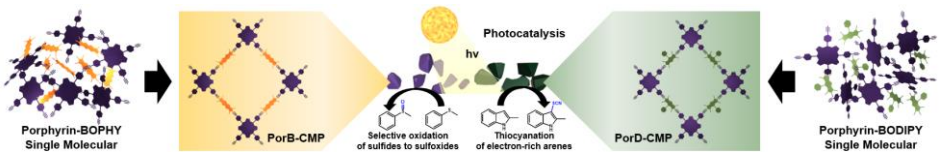


Figure 1. Structural representation of the PorB-CMP, PorD-CMP and its photocatalysis performance

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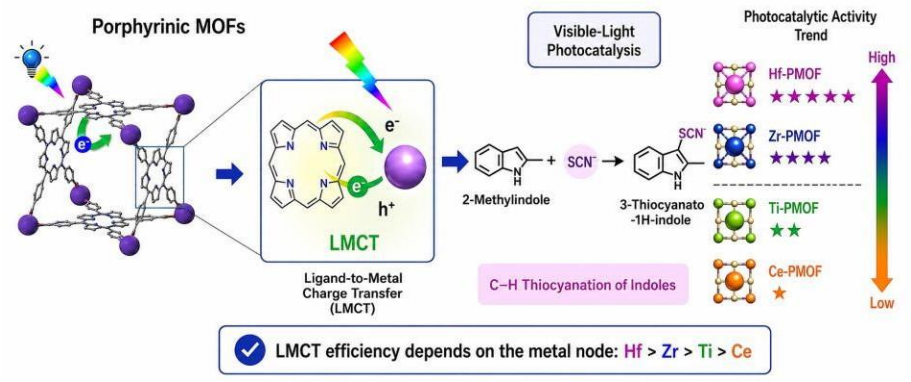
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LMCT-DRIVEN PHOTOCATALYSIS IN M(IV) PORPHYRINIC MOFs FOR SUSTAINABLE VISIBLE-LIGHT C–H FUNCTIONALIZATION

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Metal-organic frameworks (MOFs) have emerged as versatile platforms for heterogeneous photocatalysis, where ligand-to-metal charge transfer (LMCT) suppresses electron-hole recombination and enhances both efficiency and stability- key hallmarks of sustainable photocatalysis. Herein, we present a systematic study of porphyrinic MOFs (PMOFs) assembled from a porphyrin linker and a series of tetravalent metal-oxo clusters (Ti, Zr, Hf, Ce), to elucidate how the metal node governs charge-transfer dynamics and catalytic turnover. Varying the metal node identity induces pronounced changes in topology, morphology, surface area, and pore size, which collectively modulate charge-separation efficiency. Electronic structures were probed by UV-Vis DRS and Mott-Schottky analysis, while transient absorption spectroscopy quantified the lifetimes of the photoinduced CT states. Photocatalytic performance was benchmarked on a visible-light-driven model reaction- oxidative C-3 thiocyanation of indoles- and assessed through conversion, turnover number (TON), and turnover frequency (TOF). A clear structure-activity relationship emerges: TOF scales linearly with LMCT-state lifetime, with Hf-PMOF standing out as the most active catalyst owing to its exceptionally long-lived LMCT state (τ = 1.41 ns). These findings provide a rational, node-directed strategy for designing next-generation sustainable visible-light photocatalysts.



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SYNTHESIS AND UV STABILITY OF MAGNESIUM-BASED FUNCTIONAL MATERIALS

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Currently, the accelerating pace of global warming and climate change is the primary challenge facing humanity. The main causes of this situation are pollutants released into the environment -CO_2 emissions, heavy metals, organic compounds and residues from various synthesis processes -as well as the lack of more sustainable materials that can be used in a variety of application.

Following the 12 principles of green chemistry, we synthesized metal-organic frameworks (MOFs), based on etidronic acid (HEDP) and a bivalent metal, magnesium (Mg^{2+}), using alternative synthesis methods, namely hydrothermal synthesis [1,2], sonochemical synthesis, and microwave-assisted synthesis, at different ratios and pH, using water as solvent. The obtained materials (MgHEDP) were further characterized by X-ray Diffraction (XRD), Thermogravimetric Analysis (TGA), Fourier Transformed Infrared Spectroscopy (FTIR) and Elemental Analysis (EA). From the FTIR it was observed that the P-OH bond corresponding peak was not present due to P-O-Mg bond formation, confirming that the MgHEDP materials were obtained. XRD was used to study the degradation process under UV-Vis radiation of MgHEDP. According to the XRD spectra, all peaks decrease almost uniformly, which indicates a uniform mechanism, not selective, as there is no abrupt disappearance of the peak at 5°, nor a rapid collapse at 28°, hence there is no violent photolysis or aggressive oxidation occurring. The peak at ~5° does not move significantly with increasing UV-Vis exposure time; instead, only the intensity decreases. This indicates that there is no additional water intercalation but rather a stabilised structure that was likely initially hydrated and that UV exposure does not significantly eliminate it (in the range of 1–9h). The material undergoes modest amorphization, as seen by the small deviations in the 30–35° area that decrease consistently. In other words, it is a moderately UV-stable system, where the Mg–O network withstands and the lamellar structure persists. There is little variation in the degradation constants. Given that k(5°) = k(28°) and k(28°) >> k(5°), it can be inferred that both structural and chemical degradation processes take place concurrently, with the breakage of the C–P bond predominating, suggesting a mild and consistent deterioration.

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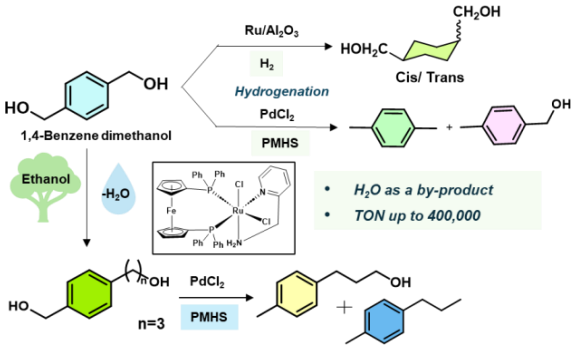
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TRANSFORMATION OF PET-DERIVED 1,4-BENZENEDIMETHANOL TO MAKE USEFUL ALCOHOLS

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The development of efficient and cost-effective chemical recycling methods for polyethylene terephthalate (PET) waste is essential for advancing a circular economy. However, the economic viability of chemically recycled PET remains a challenge, as its cost often exceeds that of PET derived from crude oil. Upcycling PET into higher-value products via catalytic hydrogenation has gained attention as a cleaner approach for PET depolymerisation, yielding ethylene glycol and 1,4-benzenedimethanol under mild conditions. Even though the limited market demand for 1,4-benzenedimethanol restricts its utility. We report here the upgradation of PET derived 1,4-benzenedimethanol to 3-(4-(hydroxymethyl)phenyl) propan-1-ol via Guerbet coupling reaction, a catalytic method involving a hydrogen-borrowing mechanism which serve as key intermediates for synthesising carboxylic acids, esters, and amides by using ethanol and a ruthenium catalyst, a high TON of up to ***400,000*** has been achieved. In future these precursors will be further investigated for synthesising long-chain aromatic alkyl components used in sustainable jet fuel. [1]



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Acknowledgments:

To my supervisor Dr Amit Kumar and the funding bodies UKRI, ERC-Starting grants and Handsel Scholarship by the University of St Andrews.



DESIGN OF NOVEL PATHWAYS FOR PRODUCTION OF HIGH VALUE-ADDED CHEMICALS IN MULTI-ENZYME CASCADES

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Multi-enzymatic cascades (MEC), i.e., the combination of several enzymatic transformations in one pot, show considerable advantages over classical synthesis approaches. Nowadays, accessible databases offer the basic and updated information of different enzymes. For example, databases of biological reactions such as Retrobiocat, BRENDA, Rhea, KEGG, and UniProt offer essential services in capturing the function of enzymes and synthetic biotransformation [1]. However, most of the existing databases do not offer the capability for a meta-analysis of what the synthetic substrate scope for an enzyme class is, what the best enzymes are, or how enzymes are related to each other. MØD [2] is a chemistry-inspired graph transformation software package developed together with our partners from the University of Southern Denmark. The package makes chemistry “programmable” from a computer science perspective, and includes a large visualization module that makes it possible to automatically layout and draw molecules, reactions, and reaction networks. Chemical reaction networks can be computed via iterative expansion of a graph grammar. Such approaches offer an immense potential for a systematic exploration of vast chemical reaction spaces and more specifically for synthesis planning. Conceptually enzyme reactions are encoded as graph transformation rules, and molecules as graphs. Finding reaction sequences between building blocks and goal compounds is framed as a flow optimization problem on the reaction network, which allows us to explore the diversity of the MEC design space in-silico prior to wet-lab implementation.

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GREEN SYNTHESIS OF BIOHYBRID METAL-FREE CARBON NITRIDE PHOTOCATALYSTS FOR PHARMACEUTICAL REMOVAL

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The accumulation of pharmaceutical pollutants, particularly non-steroidal anti-inflammatory drugs (NSAIDs) such as Ketoprofen, in water sources poses serious risks to ecosystems and human health. The development of metal-free, environmentally friendly, and sustainable photocatalytic systems is critical for removing such persistent pollutants, where traditional treatment methods fall short. In this study, a metal-free g-C_3N_4-based triple nanocomposite modified with biochar and chitosan obtained from fruit peel waste was synthesized, and its effectiveness in the photocatalytic degradation of Ketoprofen was investigated. The synthesis process began with obtaining pure g-C_3N_4 through the thermal polycondensation of melamine at 500°C. Subsequently, biochar obtained from different fruit peels via pyrolysis was ground with melamine in a mortar to prepare biochar/g-C_3N_4 composites. In the final step, this structure was added to a chitosan solution, and a chitosan-biochar/g-C_3N_4 composite was obtained using a 25% glutaraldehyde cross-linking agent. The structural and morphological characterization of the synthesized materials was detailed using FTIR, XRD, SEM, and TGA techniques. Photocatalytic studies were performed using a UV-Vis spectrophotometer under UV, visible and sun light. The results showed that the integration of chitosan and biochar into the g-C_3N_4 structure increased the separation efficiency of charge carriers and created a synergistic effect in Ketoprofen removal. The effects of parameters such as pH, catalyst amount, and contact time on degradation efficiency were investigated. The findings demonstrate that these waste-based nanocomposites offer a high-performance and environmentally friendly alternative for sustainable water treatment technologies

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SUSTAINABLE RECOVERY OF POLYPHENOLS FROM *ALPERUJO* VIA ULTRASOUND-ASSISTED EXTRACTION

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In recent years, olive groves have emerged as a significant fruit production alternative in Uruguay, leading to the growth of the olive oil industry and, consequently, generating large amounts of waste. Alperujo, a byproduct of olive oil production, is a rich source of phenolic compounds with outstanding antioxidant properties, including hydroxytyrosol (HT), and tyrosol (TY) (Figure 1). Among these, hydroxytyrosol stands out for its high antioxidant capacity and potential applications in the food and cosmetic industries [1]. This work focuses on the sustainable recovery of polyphenols from alperujo using ultrasound-assisted extraction (UAE) with hydroethanolic mixtures.



Figure 1: Polyphenols extraction from olive pomace

Different ethanol:water ratios, extraction times, and temperatures were evaluated to optimize the process. Under the best conditions (5:5 v/v ratio, 25ºC, and 20 min), a total extract yield of 31% was achieved. The resulting extracts were analysed by HPLC, confirming the presence of hydroxytyrosol. Currently, these extracts are being further characterized by HPLC-MS/MS to identify additional polyphenols with potential biological activity.

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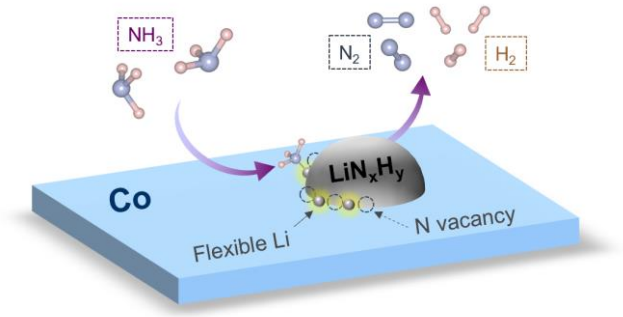
AMORPHOUS LiN_xH_y BOOSTS LOW-TEMPERATURE AMMONIA DECOMPOSITION OVER THE Co/MgO CATALYST

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Replacing fossil fuels with green energy-derived hydrogen is a potential solution to reducing carbon dioxide emissions. Ammonia is considered an attractive hydrogen storage carrier because of its carbon-free nature and high energy density. The catalytic production of hydrogen from ammonia is thus an important reaction to reclaim H_2 from NH_3. Here, we demonstrate that the incorporation of lithium species significantly enhances the ammonia decomposition rate of a cobalt-based catalyst by up to 5-fold at 623 K and achieves almost the best low-temperature activity among reported Ru-free catalysts. Structural characterization and density functional theory calculations suggest that Li sites with NH_x vacancies, located at the interface between the amorphous LiN_xH_y species and the Co surface, serve as the active sites for ammonia decomposition. For the N–H bond scission step during ammonia cracking, Li atoms located at this vacancy site exhibit a displacement of 1.7 Å per Li atom under a direct weak interaction with the Co surface to construct the energy-favourable geometry.[1] Furthermore, the stepwise feeding of NH_3 and inert gas was employed to dynamically construct the vacancy-rich interface, boosting the performance of the state-of-the-art Li/Co catalyst system.



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DIMETHYL ISOSORBIDE: A RENEWABLE SOLVENT FOR SUSTAINABLE DRUG DISCOVERY CHEMISTRY

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As regulatory and environmental pressures intensify, the replacement of hazardous solvents with safer and more sustainable alternatives remains a central objective in Green Chemistry.

Dipolar aprotic solvents such as N,N-dimethylformamide (DMF), N,N dimethylacetamide (DMAc), and N-methylpyrrolidone (NMP) are widely used in organic synthesis due to their unique solvating properties. However, their CMR (carcinogenic, mutagenic, reprotoxic) properties and poor environmental profile have led to increasing regulatory scrutiny, notably under the EU REACH framework.

As a result, identifying renewable and less toxic substitutes with comparable performance has become a priority, particularly in pharmaceutical and fine chemical manufacturing, where solvents often account for 80–90% of the non-aqueous waste. Dimethyl isosorbide (DMIso), derived from biomass, has emerged as a sustainable dipolar aprotic solvent alternative to traditional CMR solvents like DMF, DMAc and NMP.

This poster will present a comprehensive assessment of DMIso in key synthetic transformations relevant to medicinal chemistry like amide and ester couplings, nucleophilic aromatic substitutions, alkylations, and protection group chemistry. Our findings demonstrate that DMIso supports efficient reactions, tolerates strong bases such as NaH, and facilitates straightforward isolation of products.[1]

By sharing this work, we hope to inspire others in the scientific community to embrace and further explore the use of DMIso as a further step towards more sustainable and green synthetic methodologies.

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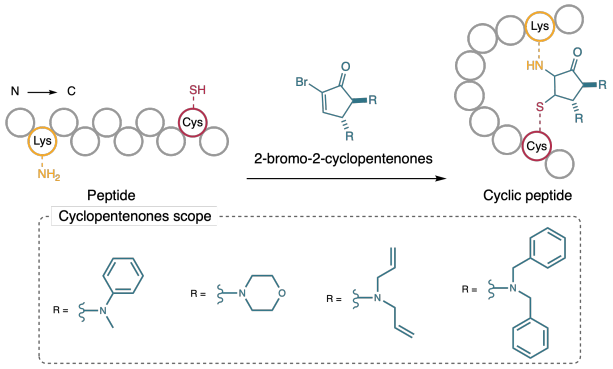
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CYCLOPENTENONES-BASED SCAFFOLDS ENABLE A NEW MACROCYCLIZATION STRATEGY FOR ANTIMICROBIAL PEPTIDES

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The cyclopentenone scaffold has attracted significant attention in medicinal chemistry owing to its antibacterial, antifungal, and antitumor activities [1,2]. Cyclopentenones display selective reactivity toward cysteine residues in peptides, even in the presence of other nucleophilic amino acids [3]. Peptide cyclization expands chemical space, as cyclic peptides often show greater rigidity, metabolic stability, bioavailability, and cellular permeability than linear analogues [4]. In this study, biomass-derived bromo-diamino-cyclopentenones were explored as novel agents for the macrocyclization of antibacterial peptides, aiming to stabilize their three-dimensional structures and enhance antibacterial activity through the cyclopentenone scaffold. Four cyclopentenone-derivatives, along with a series of peptide sequences, were synthesized to examine how the spacing of reactive residues influences cyclization efficiency. The cyclic peptides were tested against gram-positive and gram-negative bacteria, showing measurable activity, especially against gram-positive strains, and highlighting cyclopentenone-mediated macrocyclization as a promising antimicrobial strategy (**Scheme 1**).



Scheme 1: Cyclopentenone-mediated macrocyclization of antimicrobial peptides.

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THE PROGRESS OF RESEARCH AND INDUSTRIAL DEMONSTRATION ON BIOREFINERY OF LIPIDS

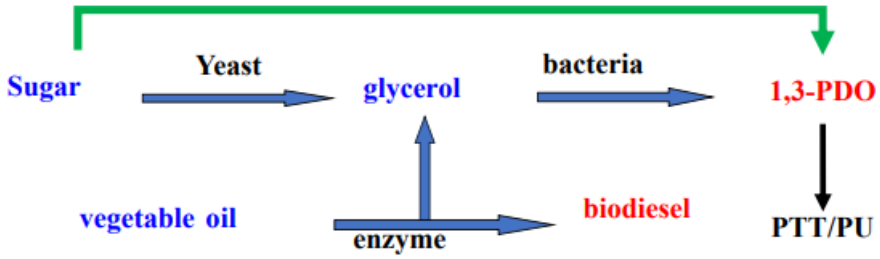
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Lipase-catalyzed transesterification and esterification from lipids for biodiesel production has obvious advantages over chemical-catalyzed process, such as environmental friendship, lower energy consumption, widely suitable for low quality vegetable oils or animal fats. However, the low stability of the lipase due to methanol has been being regarded as the main hurdle to the industrialization of lipase-catalyzed biodiesel production. Tsinghua University has developed a novel process to eliminate the inhibition of methanol on lipase, thus the operational life of the lipase could be improved into more than 300 cycles, compared with several (1-5) cycles while traditional process applied. The patented novel process was successfully demonstrated in several commercial plants with total capacities of 800 thousand ton/year.

As a by-product of biodiesel, glycerol will be produced at about 10% of biodiesel. More and more concerns were pay on how to utilize the crude glycerol. It could be a promising way to produce 1,3-propanediol (PDO) by fermentation with crude glycerol as feedstock. PDO is a valuable monomer to synthesize polytrimethylene terephthalate (PTT) or polyurethane. PTT has excellent properties for textile fibre or engineering plastics, and it was found to have some better properties than other polyesters such as PET, PBT. Tsinghua University has developed a novel flexible process for PDO production by fermentation from glycerol or sugars, and it was also successfully commercialized.



a novel biorefinery process for coproduction of biodiesel and PDO



SELF-DISPERSIBLE MDO/CROTONATE BASED DEGRADABLE POLYMERS USING MPEG MACROMONOMERS FOR STABILIZATION

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The development of degradable waterborne polymer dispersions is of growing importance in response to increasing environmental concerns associated with persistent synthetic latex materials. While waterborne vinyl polymers are widely used in coatings, adhesives, and packaging, their carbon–carbon backbones limit end-of-life degradability, creating a need for sustainable alternatives that combine aqueous processability with controlled backbone cleavage.

Cyclic ketene acetals (CKAs), such as 2-methylene-1,3-dioxepane (MDO), offer a promising route to introduce hydrolytically cleavable ester linkages into vinyl polymer backbones through radical ring-opening polymerization. However, their implementation in conventional emulsion polymerization remains challenging due to the hydrolytic instability of CKAs in aqueous media and their relatively low reactivity, which restricts efficient incorporation.

To overcome these limitations, we explore self-dispersible polymer systems as an alternative strategy that avoids the constraints of classical emulsion polymerization since performed in bulk. In this work, MDO–butyl crotonate (BCr)[1] based terpolymers were synthesized using monomethoxy poly(ethylene glycol) (mPEG) macromonomers as internal steric stabilizers, enabling the formation of surfactant-free, degradable waterborne dispersions without exposing MDO to prolonged aqueous conditions during polymerization. The influence of mPEG content, chain length, and prepolymer chemistry (crotonate, acrylate, methacrylate, or allyl functionality) on colloidal stability and degradability was systematically investigated. The resulting dispersions exhibited excellent colloidal stability, and degradation studies confirmed backbone cleavage under both chemical and biological conditions.

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DESIGN OF HYDROPHOBIC DES FOR CRITICAL METAL RECYCLING

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The recycling of critical metals from electronic waste and other secondary resources represents a major challenge for sustainable separation technologies [1]. Deep eutectic solvents (DESs) have emerged as promising alternatives to conventional organic solvents in hydrometallurgical processes due to their tuneable physicochemical properties and potential process intensification by overcoming solubility issues through liquefaction [2]. However, it is still unclear how the selection of DES precursors and the solvent non-ideality translate to macroscopic properties relevant to their application, such as viscosity and its variation under hydrometallurgical operation. The relatively high viscosity may limit mass transfer and reduce the efficiency of metal recovery processes [3].

In this work, the viscosity behaviour of several hydrophobic DES systems based on either phosphine oxide or diglycolamide ligands with different hydrogen bond donors (decanoic acid, thymol, octanol, menthol and polypropylene glycol propyl ether) was investigated over a wide composition range. The system non-ideality was determined and dynamic viscosities were measured at 55 °C and excess viscosities were calculated using the Grunberg–Nissan equation and correlated with the Redlich–Kister model [4]. Finally, the influence of metal loading on the system properties were evaluated and correlated to the emergence of long-range ion-ion correlations. Understanding these interactions is essential for designing DES with improved transport properties for efficient recovery of critical metals.

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R. Mamede

VALORIZATION OF BLACK SOLDIER FLY EXUVIAE FOR CHITOSAN PRODUCTION AND BIO-BASED FILM DEVELOPMENT

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The conventional disposal of plastics has become one of the greatest environmental challenges of this century. Food packaging is ~~a~~ major contributor to this scenario, and many alternatives to replace petroleum-based plastics have been explored. Chitosan stands out as promising candidate due to its ~~biodegradable nature~~ biodegradability and antimicrobial properties. The conventional methodology for chitosan production relies on the extraction of chitin from crustacean shells, followed by its deacetylation. This methodology is limited by seasonal availability and raises some sustainability concerns. Black Soldier Fly (*Hermetia illucens*) is a promising source of chitin, since its exuviae (BSFE) are typically discarded and can be exploited for chitin extraction and chitosan production. In this regard, this study aims to extract chitin from BSFE, convert it into chitosan, and develop bio-based films. For chitin extraction, formic acid, a greener alternative compared to the conventional hydrochloric acid, was used for the demineralization of the BSFE, yielding approximately 20% chitin after the subsequent deproteinization and bleaching steps. The deacetylation was conducted using a glyco-potassium mixture (Broussignac process), resulting in a chitosan yield of 62% relative to the extracted chitin. The resulting chitosan was then used to prepare films by the solvent casting method. The properties of these films are being analysed and compared with those of commercial crustacean-based chitosan films.

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SUPERCRITICAL CO_2-ASSISTED DEVELOPMENT OF AN AFFINITY POLYMER FOR CURCUMIN DELIVERY

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Curcumin is a naturally occurring polyphenolic compound with anti-inflammatory, antitumor, and antiviral properties [1]. Incorporating curcumin into engineered delivery systems is an effective strategy to overcome low aqueous solubility and poor systemic bioavailability limitations, improving its stability, transport, and overall pharmacological performance [2]. A broad range of carriers has been explored, from biopolymers such as starch and chitosan to lipid-based vesicles [3]. More recently, affinity-driven materials have gained attention as versatile platforms for the selective and controlled release of bioactive molecules [4-8]. In this study, a curcumin-selective molecularly imprinted polymer (MIP) was developed using supercritical carbon dioxide ($scCO_2$) technology. The MIP was synthesized using an acrylate monomer–crosslinker system at 200 bar and 65 °C. Curcumin was subsequently impregnated into both the MIP and a non-imprinted control polymer (NIP) also in $scCO_2$. The resulting dry, free-flowing polymeric particles were characterized through morphological, chemical, and physicochemical analyses and preliminary skin-therapeutic assessments were performed. This study highlights $scCO_2$ as an environmentally responsible technology for designing advanced affinity-based materials, offering an efficient and green route towards next-generation delivery systems.

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DUAL FUNCTIONAL POLYMERIZABLE DEEP EUTECTIC SOLVENTS FOR LIGNOCELLULOSE NANOFIBRILLATION AND 3D PRINTING

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The transition toward circular, low-carbon industrial systems demands materials and processes that minimize waste, valorize underutilized residues, and reduce reliance on fossil-derived resources. Lignocellulosic biomass (LCB) is an abundant, renewable feedstock for sustainable materials, yet conventional biopolymer isolation routes targeting lignin nanoparticles, cellulose nanofibers (CNFs), or cellulose nanocrystals (CNCs) individually rely on multistep processing that generates substantial waste, while direct conversion into functional end-materials remains underexplored. Here, we present a one-pot strategy that converts pineapple leaf fiber into multifunctional eutectogels using a polymerizable deep eutectic solvent (PDES) containing choline chloride: acrylic acid: citric acid. The PDES simultaneously deconstructs the biomass through cellulose nanofibrillation (12-18 nm) and surface functionalization, followed by UV-induced polymerization to directly produce biomass-derived eutectogels and 3D-printable inks, eliminating the multistep processing and waste associated with conventional synthesis. The enhanced rheological properties imparted by the nanocellulose enable direct ink writing (DIW) in both air and liquid support media, allowing fabrication of complex overhanging architectures. As a proof of concept, the 3D-printed eutectogel is applied as triboelectric nanogenerators (TENG) using various 3D-printed patterns, generating output currents up to 1.23 μA and voltages up to 91.8 V highlighting their potential as sustainable, flexible smart materials. By integrating biomass fractionation, nanocellulose formation, polymerization into a multifunctional, additively manufacturable material in a single integrated step, this work demonstrates a scalable, low-waste, one-pot green chemistry pathway supporting circular, resource-efficient industrial production.

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DESIGNABLE IONIC SYSTEMS FOR GREEN CHEMICAL ENGINEERING: FROM BIOACTIVE IONIC COMPOUNDS TO MULTIFUNCTIONAL MATERIALS AND FORMULATIONS

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Organic ionic systems, including ionic liquids (ILs), surfactant-like salts, deep eutectic solvents, zwitterionic systems, and ionic clusters, offer a versatile platform for green chemical engineering due to their tunable cation–anion structures. By integrating renewable or bioinspired motifs, structurally defined ionic systems can be designed not only as functional molecules, but also as active engineering components linking targeted performance with sustainability-oriented molecular and process design [1]. This tunability makes ionic systems particularly suitable for a design-driven green engineering approach, in which molecular structure, synthesis, processing, and targeted function are considered together. Functional cationic and anionic components are selected to provide desired properties while reducing unnecessary synthetic effort and improving technological feasibility. Particular attention is paid to substrate availability, mild reaction conditions, solvent choice, phase-based product separation, atom economy, waste minimisation, simplified process routes, and, where possible, green metrics such as E-factor and EcoScale. This approach enables ionic systems to move beyond the role of classical solvents or additives and become multifunctional components of sustainable technologies, combining bioactivity, surface activity, interfacial control, nanoparticle stabilisation, matrix formation, and biodegradable/printable hybrid materials. Moreover, their structure-dependent interactions with porous carbon architectures open additional opportunities for iontronic systems. By connecting molecular-level design with process assessment and material performance, this framework provides a practical route toward safer, lower-waste, and application-oriented ionic materials for green biotechnology and sustainable materials engineering.

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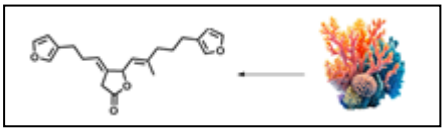
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BLUEFLOW: HARNESSING MARINE INNOVATION FOR PRODUCTION WITH CONTINUOUS FLOW

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Current treatments for chronic pain are often associated with limited efficacy and significant side effects which highlight the need for improved alternatives [1]. This gap is where Sea4Us positions itself. Marine organisms are a rich source of structurally diverse bioactive compounds with significant drug discovery potential [2-3]. In this context, molecules derived from the marine environment such as nitenin analogues identified by Sea4Us are promising candidates for the development of novel treatments (Figure 1) [1,4]. This work focuses on the synthesis of an analogue inspired by these marine compounds, to overcome limitations imposed by the supply of and scalability for natural products. As an attempt to improve the existing methodologies due to the continuous flow advantages [5,6], the objective of this study is to develop a reliable continuous flow process to produce the target compound on a kilogram scale. This presentation will highlight the integration of marine-inspired drug discovery with enabling chemical technologies to accelerate the development of promising pharmaceutical candidates.



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CFD MODELLING OF BABASSU COCONUTS IN A BUBBLING FLUIDISED BED REACTOR

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The constant use of fossil fuels has led to significant environmental problems like the increase of CO_2 levels to our atmosphere and the consequent global warming. The current study presents the CFD simulation of the experimental pyrolysis of babassu coconuts in a bubbling fluidised bed reactor for the production of bio-fuels, bio-oil, bio-gas, and bio-char as a sustainable source of energy. The 2D simulation included bed fluidisation, heat transfer, and biomass pyrolysis. The following two reactions,

$$\rho_i \phi_i \left[\frac{\partial}{\partial t}(u_i) + u_i \nabla \cdot (u_i)\right] = -\phi_i \nabla p + \phi_i \nabla \cdot \tau_i + \phi_i \rho_i g + F_{m,i} + \phi_i F_i$$

$$\rho C_p \left(\frac{\partial T}{\partial t} + (u \cdot \nabla) T\right) = -(\nabla \cdot q) + \tau : S - \frac{T}{\rho}\frac{\partial \rho}{\partial T}\Big|_p \left(\frac{\partial p}{\partial t} + (u \cdot \nabla) p\right) + Q$$

describe the heat and momentum exchange between solid and gas phases, respectively. The experimental product yields have been validated with a margin of error ±5%. The results have shown that the vigorous movement of the bed bed creates excellent transfer of heat towards sand and biomass. It is important to note that future work will include the optimisation of the pyrolysis setup taking into account the effect of temperature, gas inlet velocity and particle characteristics.

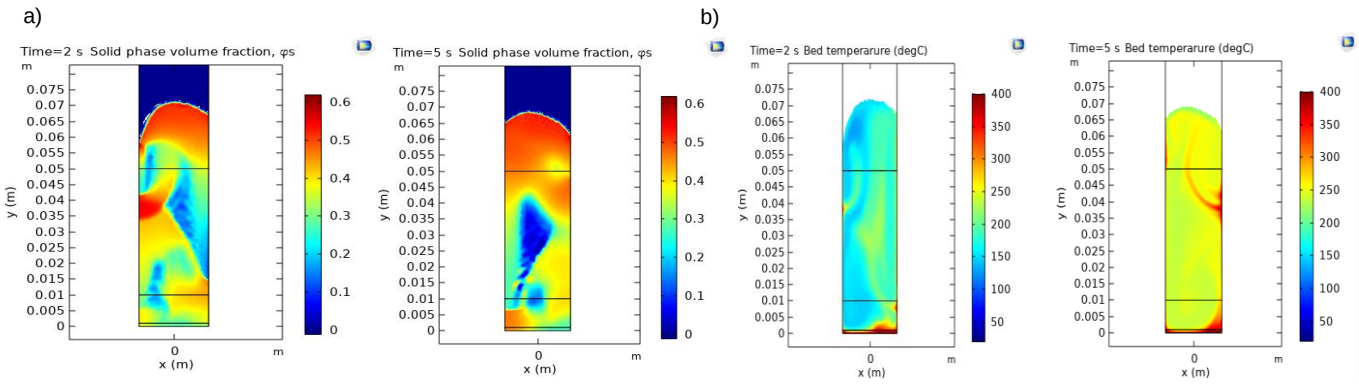


Figure 1. a) Volume fraction of sand bed at 2 and 5s, b) temperature of sand bed at 2 and 5s.



OPTIMIZATION OF NATURAL PIGMENT PRODUCTION IN MICROALGAE: AN INTEGRATED APPROACH FOR SUSTAINABLE INDUSTRIAL APPLICATIONS

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The increasing restrictions on synthetic dyes have driven interest in microalgae as sustainable sources of high-value natural pigments, with applications in food, cosmetics and pharmaceuticals [1]. This study evaluates *Arthrospira platensis*, *Chlorella vulgaris* and *Porphyridium cruentum* for the production of chlorophylls, carotenoids and phycobiliproteins. Cultures were conducted in photobioreactors under batch and fed-batch regimes, with controlled light intensity and temperature. Abiotic stress strategies, including irradiance variation and nutrient limitation, were applied to enhance pigment accumulation [2]. Pigments were characterised by UV–Vis spectrophotometry [3], and different extraction methods were assessed to improve efficiency and reduce processing time. The overall process was analysed from a techno-economic perspective, considering scalability and integration into sustainable biorefinery systems.

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GREEN IUPAC 2026
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GREEN STABILIZERS FOR NITROCELLULOSE MATRICES: EVALUATION OF THEIR STABILIZING POTENTIAL

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Developing eco-friendly stabilizers for complex polymers is an ongoing challenge in materials science. Nitrocellulose (NC) matrices, widely utilized in energetic systems, degrade over time via thermal pathways and radical scission. Although traditional stabilizers prevent this degradation, they often rely on toxic compounds that generate carcinogenic and hazardous by-products, posing environmental and health risks. In response to these limitations, the potential of sustainable green molecules to maintain thermodynamic stability and curb volatile emissions was evaluated. A screening framework combining low-cost techniques, such as gravimetric analysis, was established and validated through Nuclear Magnetic Resonance (NMR) spectroscopy (Figure 1). This approach elucidates how the chemical architecture of these molecules suppresses degradation by capturing nitrous gases, directly correlating with the stabilizer depletion rate and its stabilizing potential. The findings provide a practical pathway toward cleaner formulations that maintain high performance while minimizing degradation risks. Integrating green chemistry with materials engineering offers a safer strategy for the long-term stabilization of energetic materials.

Keywords: Green stabilizers. Energetic materials. Thermal degradation. Sustainable additives.

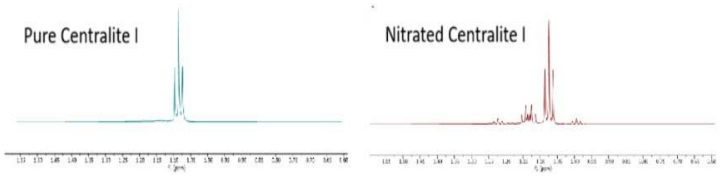


Figure1. ^{1}H NMR spectra of pure and nitrated Centralite I.

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EPR INSIGHT INTO RADICAL-MEDIATED PFAS DEGRADATION ON Ti_6O_{11} ELECTRODES

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Per- and polyfluoroalkyl substances (PFAS) are highly persistent contaminants due to the exceptional stability of C-F bonds. Electron paramagnetic resonance (EPR) spectroscopy coupled with spin trapping was employed to investigate reactive species formed during electrochemical oxidation on a Ti_6O_{11} Magnéli-phase electrode. EPR analysis confirmed the generation of sulfate ($SO_4^{\bullet-}$), hydroxyl ($OH^{\bullet}$), and superoxide ($O_2^{\bullet-}$) radicals, together with carbon-centered spin adducts associated with PFAS transformation intermediates. Time-resolved measurements suggest a sulfate radical-mediated initiation pathway followed by hydroxyl radical involvement in further oxidative transformation.

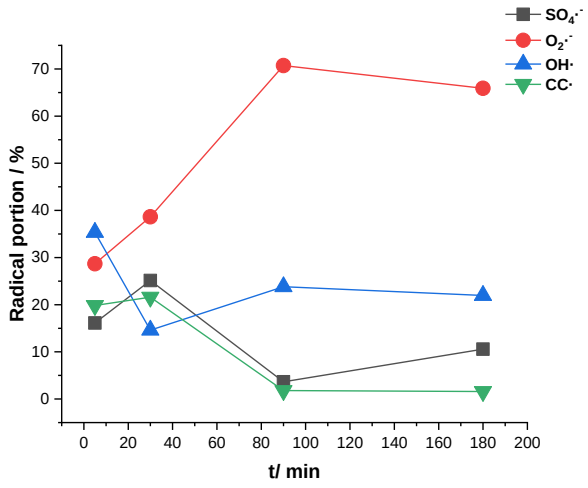


Figure 1. EPR-Detected Radical Species for the TSO Electrode

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GREEN SOLVENT-BASED RECOVERY OF BASE OILS FROM HAZARDOUS LUBRICANT WASTE STREAMS

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Waste lubricant oils (WLO) are classified as hazardous waste under European legislation and constitute a significant environmental challenge [1]. Simultaneously, they represent an important secondary resource for circular economy routes. However, conventional regeneration technologies still present major limitations, including high energy demand, generation of secondary wastes and limited selectivity towards high-quality base oil recovery [2].

This work investigates the use of supercritical carbon dioxide ($scCO_2$) as a green solvent for the regeneration of complex multisource WLO streams. The proposed process enables the selective extraction of valuable hydrocarbon fractions from heterogeneous waste oil mixtures, including saponifying residues, unsuitable for conventional re-refining routes [3]. Regeneration yields achieved 60 to 80%, depending on feedstock characteristics and operating conditions. The recovered fractions were characterized through physicochemical and compositional analyses, demonstrating quality parameters and compositional profiles approaching those of commercial base oils.

The change from conventional approaches to a process based on supercritical CO_2 contributes to waste minimization, resource recovery and circular raw material valorization. The results show the potential of $scCO_2$-based regeneration as a green and sustainable chemical engineering strategy for extending lubricant life cycles and promoting higher-value recovery pathways for hazardous waste streams.

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DEVELOPMENT OF CIRCULAR BIO-BASED ADSORBENTS FOR PHOSPHATE REMOVAL FROM WASTEWATER

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Nutrient pollution, particularly from phosphorus (P), is a critical driver of aquatic eutrophication [1]. Although a threat to ecosystems, P is a scarce, non-renewable resource whose recovery is essential [2]. This study evaluates sustainable magnesium-loaded biochars derived from two abundant biomasses, codfish bones (FB) and grapevine pruning canes (GPC), for phosphate removal from synthetic and real wastewater.

Synthesis involved biomass pre-treatment, Mg impregnation, and pyrolysis, with pyrolysis temperature and Mg-impregnation ratio optimized via a Face-Centered Composite Design. Adsorption performance was assessed through batch experiments with phosphate quantified colorimetrically, and kinetic (pseudo-first and pseudo-second order) and equilibrium (Langmuir and Freundlich) models were applied to describe the adsorption behaviour.

Optimization showed that the Mg-loading ratio governed adsorption performance, while pyrolysis temperature had no significant influence. Adsorption was highly pH-dependent, where FB exhibited optimum uptake at pH 7. Under optimized conditions, maximum adsorption capacities reached 207.75 mg P/g for FB (162.68 mg P/g after washing) and 375.50 mg P/g for GPC (276.06 mg P/g after washing). Overall, these engineered biochars represent an eco-friendly and highly efficient alternative for concurrent wastewater treatment and nutrient recycling.

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SUSTAINABLE ENZYMATIC HYDROLYSIS OF BLACK SOLDIER FLY LARVAE: A ROUTE TO BIOACTIVE HYDROLYSATES

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The continuous growth of the global population has increased the demand for sustainable food production systems and alternative protein sources. Insects have emerged as a promising solution due to their high nutritional value, low environmental footprint, and ability to valorize agricultural side streams within a circular bioeconomy framework [1]. Among them, black soldier fly (BSF, Hermetia illucens) larvae are widely studied and are already being commercialized as animal feed ingredients by EntoGreen (Ingredient Odyssey S.A.), In this work, we explored the sustainable production of value-added bioactive ingredients through the enzymatic hydrolysis of BSF larvae flour using pepsin and trypsin under different hydrolysis conditions.

The resulting hydrolysates exhibited significant antioxidant activity, as determined by FRAP and ORAC assays, highlighting their potential as natural functional ingredients [2]. Antimicrobial activity is currently being evaluated as a screening step for future food and feed applications. Overall, this work contributes to the development of sustainable insect-based biorefineries by converting insect biomass into high-value bioactive products. Beyond providing a source of bioavailable peptides and amino acids, these extracts may offer natural solutions for food and feed preservation, supporting resource efficiency, waste valorization, and the sustainability of the insect farming sector.

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ROLE OF AL-INDUCED DEPOSITION LAYER ON NANOFILTRATION MEMBRANE IN ENHANCING SELECTIVE LITHIUM RECOVERY FROM SPENT LIB LEACHATE

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The rapid growth of the electric vehicle market has intensified the demand for lithium-ion batteries (LIBs), leading to increased metal resource prices and environmental concerns associated with spent batteries. Conventional recycling methods often rely on strong acids for metal separation, causing secondary environmental issues. In this study, selective lithium (Li) separation was investigated using a commercially available nanofiltration (NF) membrane operated in a reverse osmosis (RO) system. A high-concentration spent LIB leachate was used as the feed solution, containing a total concentration of Li, Ni, Co, and Mn above 20,000 ppm, along with 12,000 ppm Al. After nanofiltration of the Al-rich feed solution, SEM-EDS analysis confirmed the formation of an Al-containing deposition layer on the feed-side surface of the NF membrane, suggesting the accumulation of Al species on the membrane during filtration. To evaluate the effect of this layer on Li separation performance, a comparative experiment was performed using an Al-removed feed solution under the same operating conditions. The Al-rich feed solution exhibited a markedly higher Li selectivity than the Al-removed feed solution, with Li selectivity reaching up to 90%. This result indicates that the Al-induced deposition layer may function as an additional selective layer, enhancing Li transport relative to other metal ions in the spent LIB leachate. This study provides insight into how in-situ formed Al-containing deposition layers can regulate ion transport through NF membranes and improve selective Li recovery from spent LIB leachates without additional membrane modification.



SELECTIVE LITHIUM RECOVERY FROM SPENT $LiFePO_4$ CATHODES USING A CO_2–H_2O_2 SYSTEM

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The rapid growth of electric vehicles has led to a significant increase in the consumption of $LiFePO_4$ (LFP) batteries. As a result, the generation of spent LFP batteries is expected to rise substantially in the coming years, creating both environmental concerns and a growing need for sustainable lithium resource recovery. Although hydrometallurgical recycling has been widely studied, most existing processes rely on strong inorganic acids, leading to high chemical consumption and secondary waste generation. To address these challenges, this study investigated a CO_2–H_2O_2 leaching system as a mild and environmentally friendly approach for selective lithium recovery from spent LFP cathode materials under ambient conditions. Leaching experiments were conducted at a solid-to-liquid ratio of 50 g/L using 4.5 vol% H_2O_2 with continuous CO_2 bubbling. A lithium extraction efficiency of 92% was achieved under the investigated conditions, while iron and phosphorus dissolution remained limited to 0.7% and 1.3%, respectively. The dissolved CO_2 maintained a near-neutral reaction environment, enabling selective lithium extraction while suppressing the dissolution of impurity elements. As a result, high lithium selectivity was achieved without the use of strong mineral acids. These findings suggest that the CO_2–H_2O_2 system can provide an effective and sustainable route for recycling spent LFP batteries. The proposed process offers a practical strategy for lithium recovery under mild operating conditions while reducing chemical usage and environmental burden compared with conventional acid-leaching methods.



ANTIFUNGAL ACTIVITY STUDY OF THE PLANT EXTRACT-BASED MICROEMULSIONS AGAINST *F. OXYSPORUM* F. SP. *LYCOPERSICI*

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Research conducted over time has shown that the plant extracts have valuable properties such as: antibacterial, antifungal, anti-inflammatory, antioxidant etc. We selected a series of plants with high antioxidant potential, such as: *Reynoutria sachalinensis* - stems (Re) and leaves (Rel), *Rheum rhabarbarum* (Ru) – roots and *Sophora flavescens* (S) – roots [1,2,3].

The extraction conditions, including alcohol concentration, temperature, and sonication time were optimized using the Minitab software. The extracts were selected taking into account their total polyphenols content and the antioxidant activity, quantified by colorimetric methods. Thus, three microemulsions were prepared from each extract by mixing the extract with rapeseed oil, resulting concentrations of 1% (R1), 3% (R3), and 8% (R8) in oil. These microemulsions were incorporated into fungal culture medium, in gradual concentrations. The potential inhibitory effect of microemulsions prepared was tested against *Fusarium oxysporum* f. sp. *lycopersici*, phytopathogenic fungus in tomato plants. The control consisted of potato dextrose agar culture medium containing the same volumes of ethanol used for extracts preparation and the vegetable oil-based surfactant corresponding to each microemulsion. For each treatment, one Petri dish was inoculated in triplicate. The addition of vegetable oil to the extracts, although it improved the stability of the formulation, did not enhance the antifungal effect of extracts, on the other hand it helps with better adherence to the leaves during application on tomato plants.

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OPTIMIZATION OF PLANT EXTRACT MICROEMULSIONS FOR PEST AND DISEASE MANAGEMENT VIA MULTI-CRITERIA ANALYSIS

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Plant extracts have emerged as promising eco-friendly alternatives to synthetic pesticides for managing agricultural pests. Their natural origin reduces environmental impact, toxicity to non-target organisms, and resistance development. Designing optimal formulations of microemulsions based on plant extracts and natural surfactants involves balancing multiple factors as surfactant concentration, stability, insecticidal activity. This complexity demands a structured approach such as multicriteria decision analysis (MCDA). Our direction of the research was optimization of preparation and characterization of *Sophora flavescens* root extract as natural insecticide and *Reynoutria sachalinensis leaves,* known for its potential as natural fungicide in greenhouses [1,2]. Research was conducted to combat greenhouse whiteflies (Trialeurodes vaporariorum) and cucumber powdery mildew. The optimization of the extracts was carried out under various conditions where the ratio of citric acid:water, temperature, pH varied. Natural surfactant was added to the prepared extracts. The total polyphenol content and antioxidant activity of the extracts were evaluated by using UV-VIS spectrophotometric methods. Performance criteria were biological efficacy (mortality or repellency rates of target pests, disease reduction) and physical stability (resistance to phase separation over time and temperature). The optimal solutions were obtained using OptimClass software, an interactive system for multi-criteria decision making and evolutionary optimization (*http://ecobionet.com/DSS.htm*). Microemulsions enhance the bioavailability, penetration, and controlled release of active compounds. Therefore, a new form of preparation was developed from the extracts of the tested plants. Data analytics using tools like OptimClass, is facilitating the transition toward sustainable and effective pest management solutions.

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POWER2VALUECHEMICALS – INTEGRATED PROCESS DEVELOPMENT FOR EVALUATING ELECTROLYTICALLY PRODUCED CO FROM CO2 FOR INDUSTRIAL APPLICATIONS

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Carbon monoxide is an essential building block in the chemical industry and is used on a large Scale. Since carbon-containing raw materials like coal, natural gas, and petroleum are to be completely eliminated from production chains as part of the defossilation of the chemical industry, new production routes are needed to provide CO in sufficient quantities as a climate-neutral feedstock. One way to achieve this while keeping the carbon cycle closed is the co-electrolysis of carbon dioxide to CO using sustainably produced electricity.

As part of the Power2ValueChemicals project, the Forschungszentrum Jülich plans the installation and continuous operation of a low-temperature CO2-to-CO electrolyzer developed by Siemens Energy in various operating modes. In the second part of the project, the continuous conversion of the electrolysis gas through a homogeneously catalyzed methoxycarbonylation reaction will be carried out to evaluate the economic and ecological potential of the electrolysis gas for the chemical industry. For this purpose, a mini-plant will be planned and built at the Max Planck Institute for Chemical Energy Conversion.

To ensure the continuous operation of the process, an efficient method for catalyst recycling is required. Therefore, various commercially available membranes were investigated regarding their catalyst retention performance. The differing retention characteristics of the active and deactivated catalyst species were examined and taken into account during the membrane selection process. Based on these findings, a process was designed, and a corresponding mini-plant was constructed to enable the continuous operation of the reaction using the selected membrane system for efficient catalyst recycling.



INVESTIGATE AND PHASE EVOLUTION OF MNO_2 UNDER ENVIRONMENTALLY REDOX CONDITIONS

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This study examines the electrochemical generation and structural evolution of manganese oxides under redox conditions representative of natural environments. Repeated oxidation–reduction cycles were simulated by cyclic voltammetry over a potential range of -1.0 to +1.0 V in neutral KCl electrolytes. During the initial 10–50 cycles, β-MnO_2 with a rigid three-dimensional tunnel structure was preferentially produced, demonstrating that this phase forms through kinetically favorable nucleation under rapid redox cycling. With continued cycling up to 300 cycles, the accumulation of lattice strain and repetitive ion intercalation/deintercalation progressively converted the tunnel framework into δ-MnO_2, a more adaptable layered structure. XRD and Raman analyses verified this transformation and identified todorokite-like phases and MnOOH as transitional intermediates. XPS results showed that the Mn^{3+} content remained consistently elevated at 35.9–43.7%, indicating that Mn^{3+} plays a central role in structural reorganization by inducing Jahn–Teller distortion and weakening the tunnel architecture [1]. These findings provide direct electrochemical evidence for the β-to-δ transformation mechanism and offer new insight into the long-term mineralogical evolution of manganese oxides in environmentally relevant systems, including soils and marine sediments.

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RECYCLING Li-ION CATHODES: FORMIC ACID LEACHING ASSISTED BY WASTE ANODE COPPER

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Traditional hydrometallurgical recycling of spent lithium-ion batteries (LIBs) relies heavily on concentrated mineral acids and external reducing agents—a setup that increases operational costs and poses clear environmental risks. To bypass these roadblocks, we developed a cleaner leaching process using formic acid, in which metallic copper recovered directly from spent anodes serves as an *in-situ* reductant to trigger cobalt dissolution [1]. Through response surface methodology (RSM), we systematically mapped and optimized the key operational variables. Leaching time proved to be the dominant factor governing metal recovery, easily outperforming formic acid concentration, whereas the Cu:Co ratio showed a much smaller effect. These optimal conditions directly reflect a complex interplay among reaction kinetics, surface passivation, and mass-transfer limitations. In the lab, our process achieved peak efficiencies of 87.9% Co, 92.3% Ni, 86.1% Mn, and 77.8% Li at a Cu:Co ratio of 0.98, a leaching time of 213 minutes, and a formic acid concentration of 2.3 mol kg^{-1}. Clearly, only a minimal amount of copper is required to sustain cobalt reduction. Looking at the mechanism, kinetic modeling and Arrhenius analysis captured a temporal shift from an initial reaction-controlled stage to a diffusion- and passivation-controlled phase [2]. Calculated activation energies confirmed mixed kinetic control for Co, Ni, and Mn, while Li and Al dissolution was strictly diffusion-controlled. Finally, a techno-economic assessment validated the commercial viability of this route, predicting minimum selling prices well within literature benchmarks and payback periods under a year. Pairing organic acid with a waste-derived internal reductant eliminates commercial reagents entirely, providing a genuinely sustainable path for LIB recycling.

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ELECTROCHEMICAL ANALYTICAL INVESTIGATION OF THE CORROSION INHIBITION EFFICIENCY OF CHOLINE-BASED GREEN IONIC LIQUIDS IN PROTECTING MILD STEEL STRUCTURES

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Corrosion of mild steel structures poses serious safety risks and leads to substantial economic losses. In this study, two biodegradable choline-based ionic liquids were synthesized, characterized and evaluated as sustainable alternatives to conventional corrosion inhibitors. Electrochemical analytical techniques–including Electrochemical Impedance Spectroscopy (EIS), Potentiodynamic Polarization (PDP) and Open Circuit Potential (OCP)–were employed to assess inhibition performance in neutral, acidic, and alkaline media. The results demonstrated improved corrosion inhibition efficiencies in acidic media exceeding 55% for choline glutamate and 40% for choline prolinate ionic liquids. Notably higher performance was observed in neutral media where both inhibitors achieved inhibition efficiencies above 76%. Similarly, in alkaline environments, [CH][GLU] and [CH][PRO] reached efficiencies of 76% and 60%, respectively. While this can be attributed to the formation of a stable protective film of the ionic liquids on the mild steel surface across neutral and acidic environments, both inhibitors appear to stabilize the passive film in alkaline conditions. This work highlights the potential of choline-based ionic liquids as eco-friendly corrosion inhibitors, offering a promising pathway toward sustainable protection of mild steel structures in industrial application.[1]

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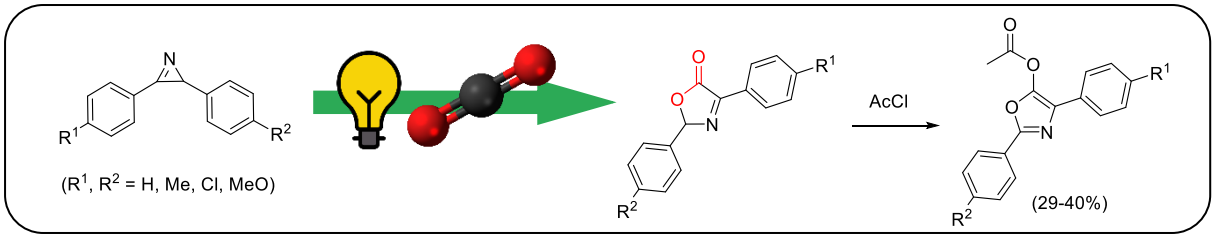
AZIRINE-BASED CO_2 FIXATION EN ROUTE TO NEW OXAZOL(ON)ES

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Up until now, the majority of carbon resources feeding the chemical industry are fossil based. Carbon dioxide represents an alternative carbon source, serving as a useful C1 building block in organic synthesis due to its abundance, non-toxicity, low cost and recyclability. Next to the traditional Lewis acid-based activation of CO_2, limitations regarding its thermodynamic stability can also be overcome by employing small-ring systems with inherent high ring-strain energy. In that respect, nitrogen-bearing rings constitute particularly attractive substrates for CO_2 capture, allowing for the preparation of azaheterocyclic scaffolds recognized as common motifs in drugs and bioactive compounds. For example, 1-azirines provide valuable building blocks for the CO_2-based construction of oxazolones and oxazoles. Apart from a few seminal studies in the 1970's [1,2], however, this transformation has been largely neglected in the literature, highlighting an overlooked opportunity regarding CO_2 valorization. In our work, the photochemical cycloaddition of non-symmetric ($R^1 \neq R^2$) 2,3-diaryl-1-azirines with CO_2 is evaluated, resulting in valuable insights in the formation and stability of the resulting oxazolones. Further reaction optimization culminated in the isolation of a set of novel 2,4-diaryloxazoles, prepared via aromatization of the corresponding oxazolone intermediates by means of acetyl chloride. Our current efforts are focused on further elaboration of this strategy using fluorinated 1-azirines as substrates for CO_2 capture.



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ROLE OF CHALCOGEN&HALOGEN BONDS IN CU(II)-CATALYZED CYCLOADDITION OF CO_2 WITH EPOXIDES

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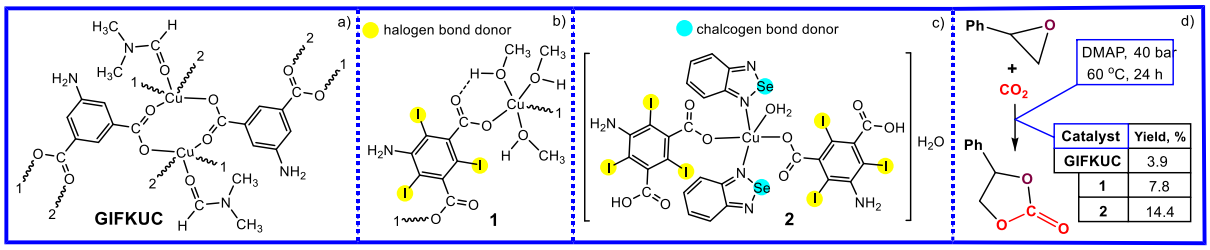
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Two new halogen and halogen/chalcogen bonded copper(II) complexes have been synthesized and characterized by conventional analyses, including single crystal X-ray diffraction (Scheme). A preliminary screening shows that the halogen/chalcogen bonded complex (**2**) is a more active catalyst in the cycloaddition of CO_2 with 2-phenyloxirane in the presence of co-catalyst - 4-dimethylaminopyridine (DMAP) in comparison to the halogen bonded complex **1** as well as known metal-organic framework (**GIFKUC**).



Scheme. Copper(II) complexes (a-c); Cu(II)-catalyzed cycloaddition of CO_2 with 2-phenyloxirane (d).

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PILOT SCALE TESTING OF CO_2 ADSORPTION CAPTURE: EXPERIMENTAL RESULTS AND IMPORTANCE OF SCALE UP TRIALS

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CO_2 capture is considered one of the key tools to decreasing hard to abate emissions in industry. The RealCapt project, funded by the Walloon region, focused on the scaling up of CO_2 capture using adsorption towards pilot scale level, using industrial-scale process parameters.

The HUGE Pilot is fixed bed pilot of the CRM Group that can reach high temperature (up to 1400°C), high pressure (45 bara) with the ability of injecting a mix of tailor-made inlet gas compositions (CO_2, N_2, O_2, CH_4, Water vapor, H_2 and possible pollutants) in a 50 L bed. This pilot has been modified to perform adsorption cycle trials on different adsorbents. Temperature swing adsorption can be done on this pilot through different means: external electrical heating, heated N2 gas and water vapour heating.



Fig 1. The HUGE Pilot used for CO_2 scale up adsorption capture

Experimental trials in the HUGE Pilot were done using benchmark adsorbents in industrial relevant conditions: flow rate (100 Nm3/h), CO_2 concentrations (ranging from 5mol% to 25mol%, with a mix of O_2, N_2) that compare to real hard to abate emissions coming from Belgian heavy industries (lime, glass and stainless steel) with which the CRM Group is working. Pressure swing adsorption (PSA), temperature swing adsorption (TSA) and mixed adsorption cycles (PTSA) were tested. CO_2 capture efficiency and capture rate were measured and compared. Laboratory scale adsorption was also performed, using the same parameters, adsorbents and concentrations as the scale up pilot

Results discrepancies between scales show how essential scale up trials are for realistic CO2 capture.



CARBON NITRIDE FRAMEWORKS HOSTING EARTH-ABUNDANT SINGLE-ATOM CATALYSTS FOR CO_2 REDUCTION TO FORMATE

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The catalytic reduction of CO_2 to formic acid/formate is a promising strategy for carbon valorization and hydrogen storage; however, most efficient catalytic systems still rely on noble metals such as Ru, Pd, and Ir. In this work, a series of non-noble single-atom catalysts supported on poly(heptazine imide) (M–PHI), including Na, Mg, Mn, Fe, Co, Cu and Zn, were synthesized through a cation-exchange strategy and evaluated for CO_2 reduction under thermal conditions. FAAS, XRD, HAADF-STEM, and XAS confirmed the stabilization of isolated metal sites within the carbon nitride framework. Catalytic reactions carried out in THF/H_2O medium under 20 bar of CO_2 and 40 bar of H_2 at 100 °C showed activity toward formate production for all catalysts, with Cu–PHI and Fe–PHI exhibiting the best performance, reaching TON values of 81 and 97, respectively.

Fe–PHI was selected for optimization and mechanistic studies. Inorganic bicarbonates and carbonates significantly enhanced the catalytic activity, with $KHCO_3$ affording the best result (0.645 mmol of formate, TON = 269 and TOF = 34 h^{-1}). The catalytic behavior depended on both the cation identity and additive solubility. Control experiments demonstrated that bicarbonate can act both as a base and as a C1 source, since reactions using $KHCO_3$ under H_2 without pressurized CO_2 still produced formate (TON = 86), while K_2CO_3 afforded TON = 32. Mechanistic investigations suggest two competing pathways involving either conventional formate intermediates or bicarbonate-derived species. Under basic conditions, Fe–OH species formed in situ may react with dissolved CO_2 to generate bicarbonate intermediates, which are subsequently hydrogenated to formate. These findings demonstrate that earth-abundant PHI-based single-atom catalysts can efficiently promote CO_2 reduction under mild conditions, opening new perspectives for sustainable carbon capture and utilization.

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ANIONIC AG4 NANOCLUSTERS FOR SUSTAINABLE ELECTROCHEMICAL CO2 REDUCTION IN PURE WATER

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Atomically precise noble metal nanoclusters (NCs) have emerged as an ideal platform for electrochemical CO_2 reduction (CO_2RR) due to their well-defined structures and tunable surface chemistry. Although steering the local microenvironment is crucial to boosting CO_2RR performance, precisely modulating this local reaction space with conventional nanomaterials remains a challenge. In particular, achieving high-performance CO_2RR under sustainable, metal-cation-free conditions is highly desirable to prevent chronic electrolyte-driven salt precipitation but is rarely achieved due to the difficulty of retaining essential driving cations at the catalyst interface without continuous external supply.[1,2] Although using anionic ionomers can induce cation retention, they suffer from poor dispersion and insufficient stability.[3]

To address this challenge, we focus on the strategic surface engineering of an atomically precise and newly synthesized anionic Ag_4(*o*-MBA)$_4$ NCs (o-MBA = 2-mercaptobenzoic acid) as a cation-retentive module. Characterized by single-crystal X-ray diffraction (SC-XRD), the newly developed Ag_4(*o*-MBA)$_4$ NC features a rigorous, rhombus-shaped core structure. Crucially, the Ag_4 core is surrounded by anionic 2-mercaptobenzoic acid (*o*-MBA) ligands. This architectural uniqueness imparts a permanent anionic charge property that effectively retains target functional cations near the active sites. Consequently, this robust interfacial cation retention allows the Ag_4(*o*-MBA)$_4$ system to achieve excellent CO_2RR performance and enhanced stability in pure-water-fed system. This result highlights the potential of charge-engineered nanoclusters for precise microenvironment regulation.

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PERFORMANCE STUDY of a PVT-HEAT PUMP DRIVEN DIRECT AIR CAPTURE SYSTEM

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Direct air capture (DAC) can remove CO_2 directly from ambient air, but adsorption, air handling, vacuum operation and sorbent regeneration require continuous electricity and heat. Coupling DAC with renewable energy is therefore important for reducing indirect emissions and operating cost[1,2]. This work is motivated by a photovoltaic-thermal (PVT) concept, in which solar panels simultaneously generate electricity and thermal energy, with heat pump used for solid-sorbent DAC regeneration.

As an initial step, an equivalent dynamic model was built in TRNSYS using a water-based PVT collector, a water-to-water heat pump, staged storage tanks and a fixed-bed DAC unit. The heat pump was used only as a temperature regulation device, and the tanks were used to decouple solar heat collection from cyclic sorbent regeneration. Because no standard DAC component is available in TRNSYS, a Python-based fixed-bed module was developed through Type163. Following Elfving and Sainio[3], the model considers the effects of temperature, relative humidity and CO_2 concentration on humid-air adsorption. Lewatit VP OC 1065 was selected as the reference sorbent based on the physicochemical and low-pressure adsorption data of Low et al.[4]. The equilibrium capacity was set from the reported value of about 1.0 mmol g^{-1} at 25 °C and around 0.04 kPa CO_2. Referring to Schellevis et al.[5], the DAC cycle includes adsorption, heating, vacuum regeneration and cooling; the sorbent heat capacity and regeneration target were set to 1.58 kJ kg^{-1} $°C^{-1}$ and 90 °C. The inlet air was set to 20 °C, 50% relative humidity and 420 ppm CO_2.

Preliminary 48 h simulations show that the model can reproduce the main operating logic of solar heat collection, temperature upgrading, thermal storage and cyclic DAC operation. The sorbent loading increases during adsorption and decreases during regeneration, while staged storage and heat-pump control provide a more stable heat supply than direct solar heating.

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COMBINATION OF ANALYTICAL SEPARATION METHODS FOR THE QUALIFICATION AND QUANTIFICATION OF HUMINS PRODUCED DURING THE DEHYDRATION OF SUGARS TO 5-HMF

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This study focuses on the characterization of "humins," by-products generated during the dehydration of fructose to produce 5-HMF **[1]**, the "sleeping giant" of sustainable chemistry **[2]**. To address the complexity of these compounds, two innovative separation techniques were coupled. The Size Exclusion Chromatography (SEC), combined with UV detection (SEC-UV), was first applied on batch samples at different reaction times to monitor the evolution of humins sizes during fructose dehydration, identifying nine subfamilies ranging from 220 to 11,440 geqPS/mol. The Centrifugal Partition Chromatography (CPC) technique, applied for the first time on humins, was then developed to decomplexify these compounds based on their polarity. A solvent system was optimized at the shake-flask scale, and CPC separation was performed on a continuous SCPC100 instrument coupled with a Spot Prep II (Gilson Purification, USA). Elution and extrusion fractions were finally collected and concentrated by evaporation, before being injected into Size Exclusion Chromatography (SEC). This two-dimensional separation (**Figure 1**) approach revealed the formation of different humins sub-families based on size (providing information on their growth process) and hydrophobicity (providing information on their degree of dehydration). Thanks to additional characterization techniques, those results are ultimately used into kinetic modelling to improve the understanding of humins formation routes during the dehydration reaction of fructose into 5-HMF. This study constitutes a solid basis to optimize the industrial process of 5-HMF production with very low by-products formation.

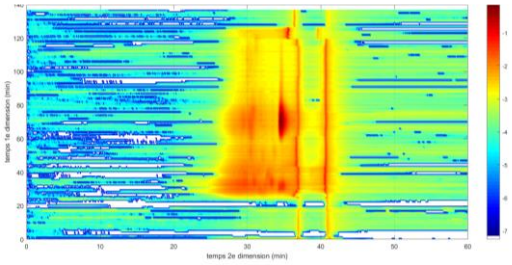


Figure 1: Identification of different families of humins via CPC x SEC

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CHEMICAL CHARACTERIZATION OF BIO-OIL OBTAINED FROM THE MICRO-PYROLYSIS OF CORN COB RESIDUES

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The European Green Deal emphasizes the necessity of improving resource circularity to achieve climate targets and promote sustainable development. The development of waste recovery technologies is vital for the energy transition, especially as rapid technological advancements and urbanization increase waste generation. Lignocellulosic biomass, commonly found in agricultural residues, represents a significant yet underutilized feedstock for renewable energy production. A prominent example of residual biomass generated in substantial volumes is corncobs, derived from both industrial processing and domestic consumption. The utilization of corncobs represents a classic example of the circular economy, transforming what was once considered a bulky agricultural waste into a high-value-added raw material. Although Brazil and Portugal operate on vastly different production scales, both countries converge in the pursuit of technological solutions for this byproduct. In a Brazilian context, Brazil is one of the world's largest maize producers, with a colossal generation of corncob, presenting significant logistical challenges. On the other hand, Portugal has a more concentrated production (notably in regions like Ribatejo), focusing on sustainability and soil integration. The main technological importance is related to energy and biofuel production. Beyond second-generation ethanol (E2G), which has been extensively explored for this biomass, thermochemical transformation (pyrolysis, liquefaction, and gasification) stands out. In both countries, corncobs can be studied for the production of bio-oil and syngas, in addition to being used directly in industrial boilers due to their favorable energy density. Pyrolysis is a thermochemical process used to decompose residual solid biomass. The process breaks down the biomass in an oxygen-free environment, producing liquid bio-oil, gases, and solid biochar, and reduces significantly the total volume of residues, which is environmentally interesting. [1,2,3]. This work represents the initial stage of a broader bilateral research project using this feedstock. The objective was to perform the micropyrolysis of corncobs in a continuous reactor and characterize the primary bio-oil products using gas chromatography coupled with mass spectrometry (GC/MS). This is a rapid process



that allows for the profiling of the bio-oil and the identification of its potential applications, beside testing pyrolytical conditions (temperature, time, heating rate, etc.). The analysis identified phenols (specifically alkylphenols), saturated hydrocarbons, ketones, and aldehydes. These results provide the necessary data for scaling up the process using a continuous-feed reactor with higher throughput, aiming for full biomass utilization, in the next steps of this research.

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ENVIRONMENTALLY CONSCIOUS ENERGY STORAGE DEVICES FROM MARINE-DERIVED MATERIALS

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In recent years, due to digital transformation and the persistence of linear economic models, the amount of waste generated by electrical and electronic equipment has increased significantly. Moreover, due to low recycling rates, this waste, usually composed of scarce and toxic materials, often ends up in uncontrolled landfills, from where it has been found to reach the marine environment. In this way, e-waste contributes to the current pollution problem in the marine environment, turning the oceans into global dumping grounds. Among this e-waste, specifically energy storage devices represent a relevant fraction due to the presence of hazardous materials and their recent increase in demand.

In this context, following the principles of responsible chemistry, this work focuses on developing energy storage devices whose complete life cycle is designed to align with the marine ecosystem, covering the selection of marine-derived materials to the application in ocean-related devices. The end-of-life stage is also considered through ecodesign strategies to ensure marine biodegradability.

With this vision in mind, this talk presents the study for the development of a supercapacitor using locally collected algae as the main material (See Fig. 1). The polysaccharide I-carrageenan extracted from algae is investigated as a replacement for the conventional polytetrafluoroethylene (PTFE) binder, achieving 98% of the specific capacitance obtained with the conventional formulation. In addition, pyrolysed algae-derived carbon is explored as an alternative to commercial activated carbon, also analysing the effect of the natural self-doping elements in algal biomass on the material's performance, achieving capacitance values within the same order of magnitude as the reference material.

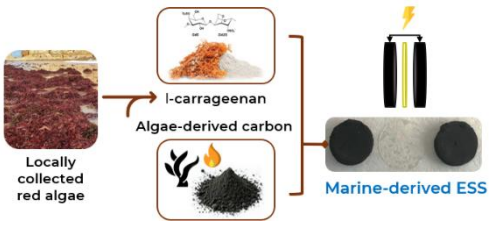


Fig. 1 | Conceptual scheme of the developed marine-derived supercapacitor

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DOPANT EFFECTS IN HYDROGEN EVOLUTION CATALYSIS BY METAL-DOPED MAG_{24} NANOCLUSTERS IN ACIDIC AND ALKALINE MEDIA

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Ligand-protected nanoclusters (NCs) serve as ideal platforms for probing structure-property relationships, owing to their atomically precise structures. In these systems, heterometal doping has emerged as a promising strategy for fine-tuning the physicochemical properties of parent NCs. [1] In this presentation, we report the synthesis and electrocatalytic applications of $M@Ag_{24}(SR)_{18}$ (SR = 2,4-dimethylbenzenethiolate) NCs doped with heterometals (M = Ag, Pd, Pt, RhH, IrH). Comprehensive experimental and theoretical studies revealed that the RhH and IrH dopants act as superatomic constructs analogous to Pd and Pt atoms, respectively. [2,3] To elucidate dopant effects on electrocatalytic hydrogen evolution reaction (HER) activity, we evaluated HER performance catalyzed by heterometal-doped Ag NCs under acid and alkaline conditions. [4] Under acidic conditions, all doped Ag NCs displayed comparable HER activities, regardless of the dopant species. In contrast, a distinct dopant-dependent trend in HER activity was observed under alkaline conditions. Further theoretical analyses indicated that alkaline HER activity is governed by differences in water dissociation capability, with the de-thiolated Ag-Ag site serving as the key active site for promoting the reaction. Notably, $RhH@Ag_{24}(SR)_{18}$ exhibited the highest alkaline HER activity among the investigated NCs, surpassing that of the Pt-doped NC. Moreover, $RhH@Ag_{24}(SR)_{18}$ exhibited stable operation after 12 h of constant potential electrolysis.

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ASSESSING THE PERFORMANCE OF DEEP EUTECTIC SOLVENTS ON BIOMASS LIQUEFACTION

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Mangifera indica L. is among the ten most consumed tropical fruits worldwide and is extensively used in the food, cosmetic and pharmaceutical industries. However, approximately 35-60% of the total fruit mass is converted into biowaste, mainly peel and seed, during industrial processing. These residues are often underutilized or discarded, representing both economic and environmental challenges. [1] Mango biowaste is rich in bioactive compounds, including polyphenols and flavonoids, and contains a lignocellulosic fraction with potential for energy recovery.[2] Hence, in this work, an integrated extraction-solvothermal liquefaction approach was investigated for the recovery of high-value phenolic compounds and production of a suitable bio-oil from mango peel, aiming to contribute to a circular biorefinery strategy. Peel was subjected separately to solvent extraction and solvothermal liquefaction (STL). STL was performed using green solvents and catalysts, such as natural deep eutectic (NADES) solvents and 2-MeTHF. Process parameters were optimised using Response Surface Methodology, achieving conversion yields of up to 60% with the L-Alanine:Citric Acid NADES catalyst. Products were characterised using Fourier Transform Infrared Spectroscopy, Gas Chromatography with a coupled mass detector, Thermogravimetric Analysis, and Elemental Analysis. The final bio-oil product was identified as a suitable precursor for fuel and platform chemicals. The same NADES system was subsequently applied to the extraction of bioactive compounds, yielding moderate extraction performance and relatively low total phenolic content, in agreement with COSMO-RS predictions. Overall, results highlighted the potential of several NADES-assisted processes for future integrated valorisation of mango biowaste within a biorefinery framework.

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INFLUENCE OF THE ALKALINE ELECTROLYTE COMPOSITION ON AMMONIA OXIDATION REACTION WITH Pt/Pt–Rh ELECTRODES

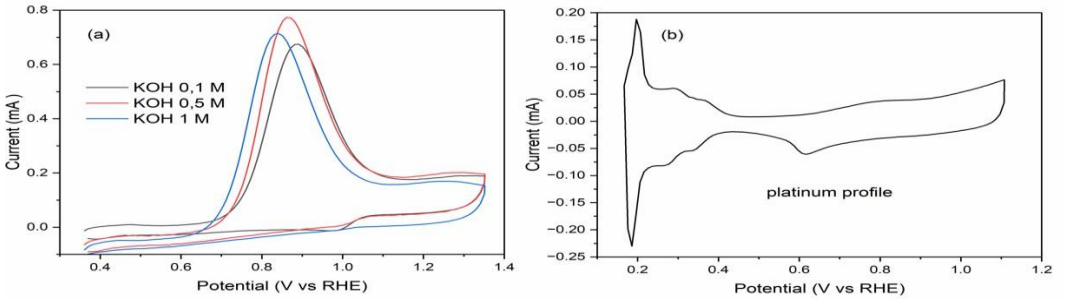
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The high emission associated with conventional power generation highlight the need for clean and sustainable alternatives [1]. Ammonia (NH_3) is a promising energy vector and hydrogen carrier, while its electrolysis enables hydrogen production without CO_2 emissions and at a lower theoretical potential than water electrolysis (0.06 V vs. 1.23 V) [2]. The electrochemically active surface area (ECSA) of the Pt-Rh electrode was determined by cyclic voltammetry in 0.5 M H_2SO_4. The influence of electrolyte composition on the ammonia oxidation reaction (AOR) was systematically investigated by varying the KOH concentration (0.1–1.0 M) at a fixed NH_4OH concentration (1.0 M), followed by varying the NH_4OH concentration (0.5–2 M) at the optimum KOH concentration. The highest anodic current density was obtained with 0.5 M KOH, while the subsequent optimization identified 0.5 M KOH + 2 NH_4OH as the most active electrolyte. These results demonstrate that electrolyte composition plays a key role in AOR performance and provide an optimized electrolyte for subsequent hydrogen production by aqueous ammonia electrolysis.

Figure 1. Cyclic voltammograms: (a) comparison of the voltametric responses as a function of KOH concentration; (b) Electrochemical profile of the electrode surface in 0.5 M H_2SO_4.



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Acknowledgments:

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GREEN SOLVENT SCREENING FOR BROCCOLI LEAF PHENOLICS AND FLAVONOIDS EXTRACTION

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Broccoli leaves are 47% of crop biomass and an underutilised agri-food side stream [1]. Their valorisation offers circular bioeconomy opportunity given their substantial bioactive potential [2]. Natural deep eutectic solvents (NADES) emerge as a green chemistry-aligned alternative for sustainable recovery of plant bioactives for their non-toxic and affordable components [3]. In this study, ten choline chloride (ChChl)- and betaine (Bet)-based NADES were synthesised (2h, 300rpm, 70°C, +20% H_2O w/w), characterised (pH, density, viscosity, polarity, toxicity) and evaluated for extracting (1h30, 400 rpm, 60°C) broccoli leaves total phenolic and flavonoid contents.

ChChl-based systems exhibited acidic to neutral pH, while Bet-based NADES were more neutral. At 22°C, ChChl:Lactic $Acid_{1:1}$ displayed the lowest pH (0.5±0.0), while Bet:$Urea_{1:2}$ the highest (8.1±0.2). Kinematic viscosity (40°C) ranged from 6.29±0.07 mm²/s (ChChl:$Glucose_{2:1}$) to 20.78±0.43 mm²/s (Bet:$Glu_{1:1}$), with sugar- and polyol-containing systems generally more viscous. Densities ranged from 1.073 g/cm³ (ChChl:Propylene $Glycol_{1:2}$) to 1.284 g/cm³ (Bet:$Glu_{1:1}$), and polarity was highest in lactic acid and glycerol containing systems and lowest in propylene glycol-based ones.

All systems showed biocompatibility for potential food and health applications, with Caco-2 EC50 values ranging from 7,485 mg/L (Bet:$LA_{1:2}$) to >190,000 mg/L (Bet:$Glu_{1:1}$). Bet:$Glu_{1:1}$ yielded the highest phenolic content (10.02±0.4 mg GAE/g DW, $p<0.0001$), while Bet:$U_{1:2}$ (1.32±0.1 mg QE/g DW) extracted the highest flavonoid content ($p<0.05$). These findings position Bet:$Glu_{1:1}$ and Bet:$U_{1:2}$ as the most promising green solvents for recovering bioactive compounds from broccoli leaves.

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SUSTAINABILITY ASSESSMENT OF ACID-BASED DEMINERALIZATION OF INSECT RESIDUES FOR CHITIN PRODUCTION USING THE PATH2GREEN FRAMEWORK

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Demineralization (DEM) of insect exuviae is a key step in chitin production; however, systematic sustainability assessments of DEM conditions are still limited. In this study, 36 acid-based DEM conditions, varying in acid type, concentration, temperature, and reaction time, were evaluated for their sustainability using experimental data in combination with the Path2Green framework [1]. The performance of the DEM approaches was first assessed based on demineralization yield (ΔDEM) and residual ash content (ΔASH). The resulting Path2Green scores (on a scale from −1 to +1) ranged from approximately −0.344 to values close to neutral, indicating that none of the investigated conditions can be considered clearly sustainable, while improvements relative to conventional approaches are achievable. The lowest score corresponded to HCl 1 N, 2 h, 80 °C, representing a highly severe processing condition. A slightly positive score (approximately +0.016) was only obtained for pure citric acid under mild conditions, indicating potential for organic acid systems, although their application may be limited by economic considerations. Process chemical use and wastewater management were identified as key limitations for improving overall sustainability.

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UPCYCLING FRUIT PROCESSING CO-PRODUCTS INTO FUNCTIONAL FOODS: A CIRCULAR BIOECONOMY APPROACH TO PRODUCT DEVELOPMENT AND STABILITY

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This work explores the valorisation of fruit processing co-products and the stability of phenolic compounds in fruit-based products within a circular bioeconomy framework.

Fruit pulp from juice production was used to develop functional snack formulations, while commercial smoothies were evaluated over four months under different storage temperatures.

Phenolic content and antioxidant capacity were assessed using HPLC, Folin–Ciocalteu, DPPH, and FRAP methods, alongside physicochemical characterization of snack products.

Results showed successful incorporation of co-products into functional foods with retention of bioactive compounds and improved formulation properties. In contrast, smoothie analysis indicated a decline in phenolic stability over time, with refrigeration better preserving antioxidant activity.

Overall, this study highlights the potential of co-product upcycling and optimized storage to support sustainable food systems and reduce food loss.

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Acknowledgments:

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SELECTING BIO-BASED POLYMERS FOR SUSTAINABLE PERSONALISED EYEWEAR: A MULTI-TECHNIQUE CHARACTERISATION STUDY

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Rising spectacle use means more discarded eyewear frames accumulating in landfills and waterways, where fossil-based plastics contribute to micro- and macro-pollution and harm marine life. The OnDemand project addresses this by developing sustainable, personalised frames produced through additive manufacturing from biomaterials, replacing conventional plastics with renewable, biodegradable alternatives aligned with circular-economy principles.

Selecting suitable biopolymers requires both reliable composition control and adequate thermal performance. We studied poly(lactic acid) (PLA), polyhydroxyalkanoate (PHA), and poly(butylene succinate) (PBS) matrices, *Luffa cylindrica*, cork and wood fillers, a plasticiser and two compatibilizers, and their composites, by ATR-FTIR, Raman microscopy, SEM, and thermal testing.

Spectral interpretation was governed by phase-dependent dominance: PBS masked PHA even at equal mass fractions, and PLA dominated the infrared response of PLA/PHA/wood composites. Raman proved decisive, resolving all three components despite lignocellulosic fluorescence. SEM linked alkaline *Luffa* treatment to improved fibre–matrix adhesion and revealed a cohesive cork interface, while wood composites showed cracking consistent with weaker adhesion. Thermal testing identified PHA/PBS as the best performer, with the highest resistance and dimensional stability after cooling.

This multi-technique approach validated formulation identities, clarified matrix–filler compatibility, and identified PHA/PBS as the leading candidate for biodegradable, made-to-order eyewear.

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STUDY OF THE CHEMICAL PROFILE OF THE ALGA *RUGULOPTERYX OKAMURAE*

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The invasive macroalga *Rugulopteryx okamurae*, native to Japan and Korea, has recently spread along southern Europe, including Portugal and the Azores, where it forms dense biomass and threatens marine biodiversity [1]. Its accumulation on beaches also harms tourism and public health, requiring costly removal. Aiming to transform this problem into an opportunity we are studying the alga chemical profile to identify bioactive secondary metabolites or potential nutraceuticals. Detected compounds include several terpenes, steroids, retinols, carbohydrates, besides fatty acids and some hydrocarbons. Amongst the terpenes, diterpenoids and sesquiterpenoids were the most common, e.g. spatanes, secospatanes, cubebanes. Their biological activity is being determined, and some neurological effects have been detected. Some of the results obtained are presented here.

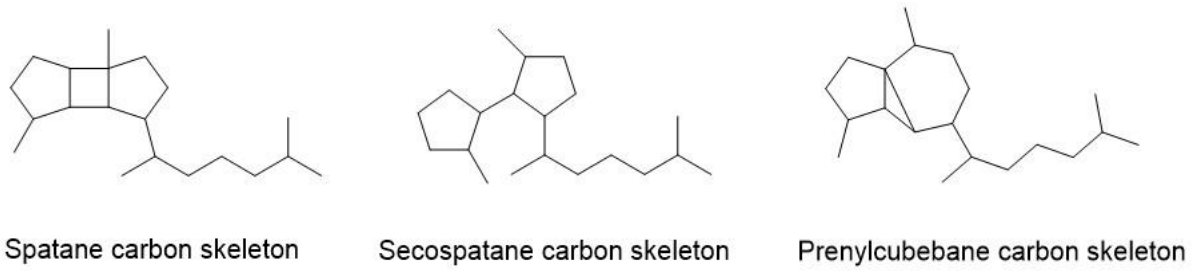


Figure 1. Some terpenoids found in *Rugulopteryx okamurae*

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MICROALGAL EXOPOLYSACCHARIDES AS RENEWABLE BUILDING BLOCKS FOR SUSTAINABLE BIOPOLYMER FILMS

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The increasing environmental impact of petroleum-based plastics has intensified the search for renewable and biodegradable materials for packaging and other short-life applications. Among emerging bio-based alternatives, exopolysaccharides (EPS) produced by microalgae have attracted growing attention due to their biodegradability, biocompatibility, and structural diversity. These EPS consist of complex carbohydrate matrices composed of multiple monosaccharides, uronic acids, and sulfate groups, conferring physicochemical properties such as high viscosity, water-binding capacity, and interfacial activity [1]. These characteristics make microalgal EPS promising candidates for biodegradable polymer films. Moreover, experimental studies demonstrate the potential of EPS as functional components in composite films. For example, EPS from the red microalga *Porphyridium cruentum* has been incorporated into chitosan-based films, significantly increasing tensile strength and Young's modulus while maintaining biodegradability [2]. Similarly, EPS-based films derived from *Graesiella* species show homogeneous structures, good oxygen barrier properties, and antioxidant activity, indicating potential for active food packaging applications [3]. In this study a review on the performance of EPS derived films is explored as a promising class of renewable biopolymers for sustainable material development.

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LIGNOCELLULOSIC NANOMATERIALS FOR SUSTAINABLE BIOCOMPOSITE FILMS: PROCESSING STRATEGIES AND FUNCTIONAL PERFORMANCE

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The transition toward sustainable materials is a key challenge for green chemistry and the emerging bioeconomy. Lignocellulosic biomass is an abundant renewable resource for producing high-value nanomaterials such as nanocellulose (NC) and nanolignin (NL) [1,2]. NC provides mechanical reinforcement, structural stability, and gas-barrier performance [1], while NL contributes UV protection, antioxidant and antimicrobial activities, and hydrophobicity [2]. This work reviews NC and NL production strategies, including chemical, mechanical, biological, and emerging green approaches, and their effects on particle morphology, surface chemistry, and dispersion. The relationship between nanomaterial characteristics and film-processing techniques, including casting and filtration, is discussed in relation to the mechanical, barrier, optical, and thermal properties of biocomposite films. NC/NL integration enables multifunctional materials for sustainable packaging, protective coatings, biomedical systems, and advanced functional applications.

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GREENCHEMAFRICA: AFRICA JOINING THE MOVE OF THE GLOBAL MISSION FOR SUSTAINABILITY

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In a world increasingly conscious of the need for sustainable practices, the field of green chemistry stands at the forefront of development, driving efforts to reduce environmental impacts and promote human health. By focusing on sustainability, renewable materials, and minimizing environmental impact, green chemistry aims to create processes and products that are efficient and environmentally benign. The essence of green chemistry lies in its commitment to sustainability and the true catalyst for this transformation is the investment in human capital by nurturing a new generation of scientists and professionals dedicated to advancing sustainable chemistry. By equipping scientists, engineers and educators with the fundamentals of green chemistry, a new generation of educators dedicated to sustainability can be developed. Moreover, investment in human capital is not only about technical skills but also about cultivating a mindset that values environmental stewardship and social responsibility. Considering this, while there is a focus on Africa's potential as a source of raw materials, the African Training School on Green Chemistry and Environmental Sustainability (GreenChemAfrica) initiative distinguishes itself by emphasizing both the investment in human capital and the rich potential of African raw materials to reimagine chemical processes, reactions, and materials in line with new concepts of sustainability. This initiative held at the University Mohammed VI Polytechnic (UM6P) in Morocco is the first-in-kind initiative in Africa dedicated to educating and training doctoral students and early career scientists from across Africa on the principles of green chemistry. And environmental sustainability. Through a collaborative learning environment, participants are provided invaluable insights into the latest educational practices in the field, fostering a sense of global community and a shared purpose. This presentation will deliver a statistical analysis, highlighting key lessons learned as well as best practices from previous editions, while also serving as a platform for open discussion and inviting constructive feedback from the community, with the aim of improving this unique initiative in the African continent.

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DEVELOPMENT OF THE EQQ FRAMEWORK: AN INTEGRATED ASSESSMENT FRAMEWORK FOR GREEN CHEMISTRY

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Since the introduction of the 12 Principles of Green Chemistry by Anastas and Warner [1], numerous green chemistry metrics have been developed to evaluate the sustainability of chemical processes [3,4]. However, no integrated framework currently combines educational, qualitative, and quantitative dimensions for Green Chemistry assessment. This study aimed to develop the Education–Quality–Quantities (EQQ) Framework. The EQQ framework was developed based on the 12 Principles of Green Chemistry [1], the 12 Principles of Green Engineering [2], and established green chemistry metrics [3,4]. Thirty indicators were refined through a three-round Delphi study and validated using the Content Validity Index (CVI). Reliability and construct validity were assessed using Cronbach's alpha, exploratory factor analysis (EFA), and confirmatory factor analysis (CFA). The developed and validated EQQ framework (Figure 1) was successfully applied to a representative green organic synthesis case study. The proposed EQQ framework provides a standardized and integrated approach for Green Chemistry assessment and supports applications in education, laboratory practice, curriculum evaluation, and future digital assessment systems.

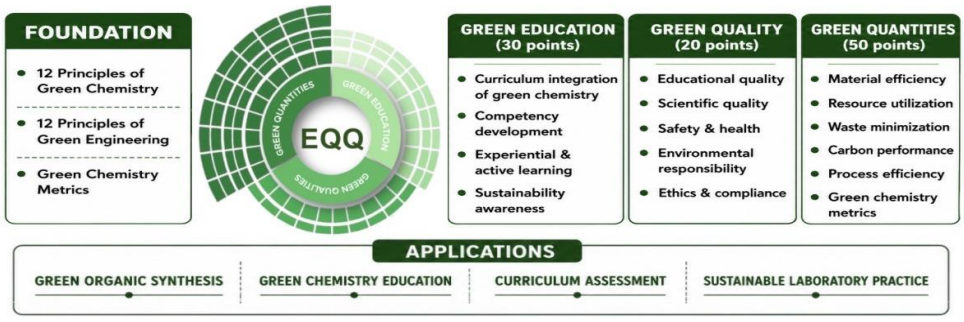


Figure 1. Overview of the EQQ framework for Green Chemistry assessment.

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A CHEMISTRY EDUCATION FOR MARINE MICROPLASTIC RESEARCH: PRELIMINARY FINDINGS FROM MOZAMBIQUE

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Marine microplastic pollution is a growing environmental challenge requiring innovative educational approaches to promote environmental literacy and sustainable practices [1,2]. However, most monitoring methods rely on sophisticated instrumentation that remains inaccessible to many educational institutions in developing countries [3]. This study presents preliminary findings from an ongoing research project aimed at strengthening environmental education in Mozambique through Green Chemistry Education and citizen science. A validated 20-item questionnaire was administered to 947 students (694 secondary and 253 university students) from eight schools and two public universities in Maputo to assess knowledge, environmental awareness and participation regarding marine microplastic pollution. A pilot field campaign engaged university students in seawater sampling and preliminary laboratory processing using low-cost protocols based on Green Chemistry principles**,** including waste prevention, safer laboratory practices and efficient resource use [4]. Results showed high environmental awareness (M = 4.19), but lower knowledge of microplastics (M = 3.81) and environmental participation (M = 3.59). These findings support a multilevel Green Chemistry Education model integrating citizen science and accessible laboratory practices to strengthen scientific literacy and contribute to SDGs 4, 12 and 14**.**

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BIOMASS-DERIVED WOOD FIBRE-IRON COMPLEX IN GREEN VISIBLE LIGHT-ASSISTED WATER POLLUTANT REMEDIATION

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Lignocellulosic biomass is a renewable resource composed of cellulose, hemicellulose and lignin with relevant functional groups for preparation of advanced materials: surface modification is possible due to cellulose's hydroxyl groups and visible light absorbing chromophores are present in lignin [1].

In this work, wood fibres were used as a renewable biomass-derived catalyst support for iron(III) salicylate/anthranilate and iron(III) salicylate complexes, yielding the hybrid materials WF-[Fe(SalAnt)] and WF-[Fe(Sal)], respectively. The synergistic interaction between the cellulosic functional groups and lignin chromophores units was explored in visible-light assisted redox/adsorption reactions for water remediation in the removal of 4-nitrophenol and of cationic and anionic organic synthetic dyes (rhodamine B, methylene blue and indigo carmine). WF-[Fe(SalAnt)] achieved 95 % conversion within 8.8 minutes in the reduction of 4-nitrophenol using $NaBH_4$. Meanwhile WF-[Fe(Sal)] showed 97 % removal of rhodamine B after 150 minutes in oxidative dye degradation using H_2O_2, with 68 % removal in spiked real wastewater treatment plant effluent. The catalyst remained active over five cycles with no detectable iron leaching. These results demonstrate the potential of wood fibre supported iron complexes as sustainable, visible-light-active materials for water pollutant remediation [2].

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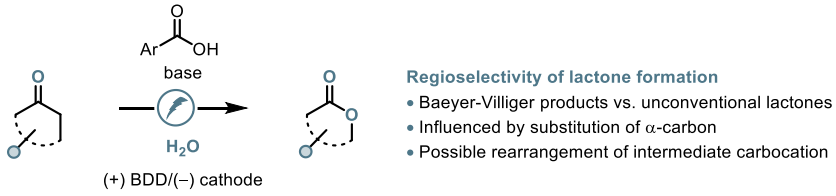
ELECTROCHEMICAL LACTONIZATION OF KETONES ENABLED BY ANODIC OXIDATION OF BENZOATES

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The Baeyer-Villiger oxidation is a key reaction in organic synthesis, involving the conversion of ketones into esters, typically using peracid oxidants [1,2]. Despite its relevance, only a limited number of electrochemical approaches to this reaction have been described. Simple, general, and stoichiometric-oxidant-free electrochemical protocols remain underdeveloped, despite their potential to provide greener and more efficient strategies [3–6]. A simple protocol for the electrochemical lactonization of cyclic ketones was developed. The method relies on the electrooxidation of benzoates to perbenzoic acids using a commercially available boron-doped diamond (BDD) anode, followed by ketone lactonization. The regioselectivity for the formation of unconventional lactones versus Baeyer-Villiger products is directly influenced by substitution on the α-carbon, suggesting that the reaction proceeds through a carbocation intermediate capable of undergoing rearrangement (**Scheme 1**).



Scheme 1. Proposed strategy for the electrochemical lactonization reaction

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EFFECT OF POLYOL-BASED BIOSOLVENTS ON LACCASE-DRIVEN DEPOLYMERIZATION OF POLY(VINYL ALCOHOL)

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Polymer-based liquid formulations (PLFs), widely used in detergents, coatings and personal care products, contribute to the release of persistent water-soluble polymers into aquatic environments. Poly(vinyl alcohol) (PVA), extensively applied in PLFs due to its film-forming properties and chemical robustness, exhibits limited biodegradability, raising environmental concerns.

Herein, a sustainable enzymatic framework for PVA oxidative transformation was established using *Trametes versicolor* laccase in bio-based polyol media under mild conditions. Polyols differing in chain length and hydroxyl density were screened as activity-modulating environments. Glycerol and xylitol enhanced catalytic performance relative to pH 4.5 buffer, with glycerol enabling measurable PVA molecular weight reduction. Process performance was optimised using a Design of Experiments (DoE) approach evaluating enzyme loading and glycerol content in the presence of ABTS or TEMPO. Response surface modelling identified operational regions maximising polymer transformation, while highlighting limitations toward complete depolymerisation.

Overall, polyol-based biosolvents act as tunable, sustainable reaction media for oxidative polymer modification, establishing a transferable biocatalytic framework to mitigate polymer persistence in polymer-based liquid formulations.

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UNDERSTANDING THE PRESENCE OF THE SURFACE COORDINATED COPPER HYDRIDES FOR THE SELECTIVE HYDROGENATION OF 5-HYDROXYMETHYLFURFURAL

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Previously, we have successfully developed the atomically dispersed hydrotalcite oxide (HTO) supported copper catalysts ($Cu_{(x)}$HTO, x was denoted the mol% of Cu) through the simple coprecipitation of in aqueous solution at tuned pH. In addition, the r-$Cu_{(5)}$HTO (r was denoted as reduced) can hydrogenate hydroxylmethylfurfural (HMF) to 2,5-bis(hydroxymethyl)furan (BHMF) selectively in a high yield under mild reaction conditions.[1] Continuing our research achievements, we aim to uncover the dynamic interface of the modified surface nanostructures for the hydrogen evolution upon adsorption, i.e. driving the adsorbed hydrogen species towards either homolytic or heterolytic pathway for selective hydrogenation is the pivotal component for the surface design in precision. Recently, the $H_2/N_2O/H_2$-TPR has revealed the dispersion (D_{Cu}) of chemically exposed copper species of $Cu_{(20)}$HTO can reach 91% high with the specific surface area (S_{Cu^o}) of 618 $m^2.g^{-1}$. It indicates that the copper adducts are atomically dispersed over the HTO surface despite the high copper loading. To understand the chemical change of copper center on HTO surface during the thermal reduction, the real-time XANES measurement at Cu K-edge was recorded in conjunction with the temperature-programmed reduction under hydrogen. The results show that the oxidation state of copper on r-$Cu_{(20)}$HTO unusually increases from Cu^0 to Cu^+ in the cooling hydrogen flow and EXAFS suggests that copper adducts might structurally present a mixture of partially oxidized species which could be attributed to the structural change derived from the formation of surface coordinated molecular copper hydrides under hydrogen.

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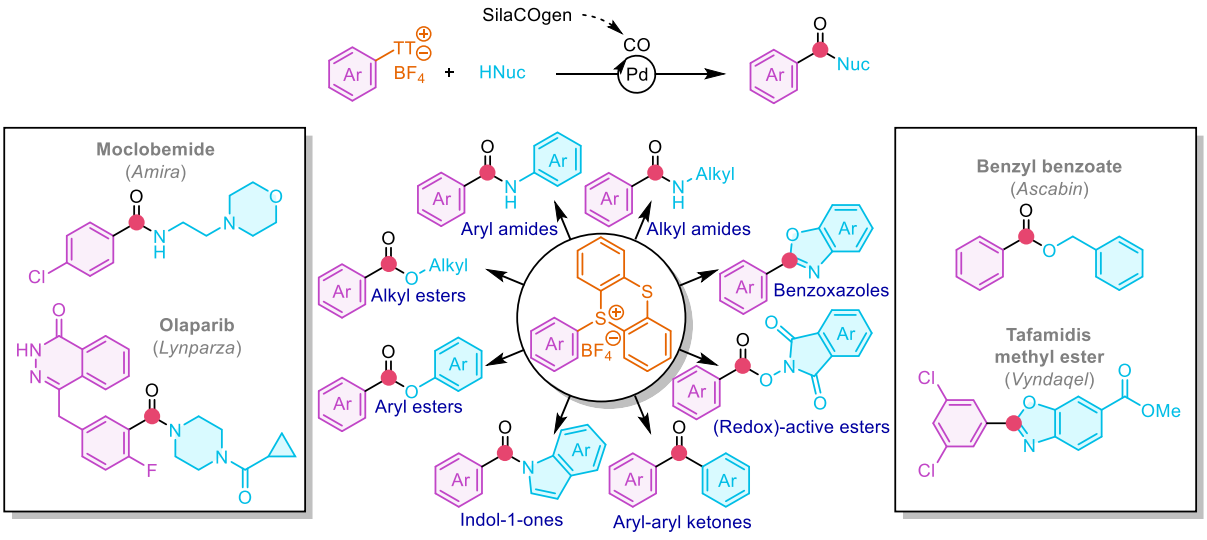
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THIANTHRENIUM SALTS ENABLE BROAD-SCOPE C–H CARBONYLATION FOR CARBON ISOTOPE LABELING

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Aryl thianthrenium salts are established as adept electrophilic coupling partners in a variety of transformations in both photoredox and transition metal-catalyzed cross-coupling reactions.[1] Though many alleys of thianthrenium reactivity have been elucidated, carbonylative cross-couplings remain underexplored. We disclose a versatile and robust method for palladium-catalyzed carbonylative transformations of aryl thianthrenium salts to afford a wide range of structurally and electronically diverse molecules. The methodology utilizes simple Pd(II) salts and phosphines and exhibits a broad substrate scope for the installation of many divergent functional groups in complex small molecules. CO generated *ex situ* from SilaCOgen,[2] facilitates carbon isotope labeling of pharmaceutically relevant compounds including aryl esters, aryl amides, and benzoxazoles.



Scheme 1. Structural motifs accessible *via* carbonylation of aryl thianthrenium salts including active pharmaceutical ingredients.

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BIOCATALYTIC PREPARATION OF ESTERS VIA HEMIACETAL OXIDATION: A NOVEL, SELF-SUFFICIENT AND INDUSTRIALLY VIABLE ESTER PRODUCTION ROUTE

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Esters are versatile organic molecules essential to numerous industrial sectors, yet their conventional chemical synthesis often relies on energy-intensive processes and corrosive catalysts [1]. While biocatalytic routes using esterases or lipases offer greener alternatives, they are frequently limited by thermodynamic equilibrium and the need for continuous water removal [1]. This study presents a novel, self-sufficient biocatalytic production route leveraging the enzymatic oxidation of hemiacetals by alcohol dehydrogenases (ADHs). We demonstrate that multiple ADHs, including Adh1 from *Saccharomyces cerevisiae* (*Sc*Adh), *Homo sapiens*, *Neurospora crassa*, and *Clostridium beijerinckii*, possess hemiacetal dehydrogenase (HADH) activity. Crucially, we discovered an intrinsic $NAD(P)^+$ regeneration pathway operated by the enzymes themselves, which utilizes the initial aldehyde substrate to re-oxidize the cofactor. This mechanism allows ester production to significantly exceed traditional stoichiometric limits, without external cofactor regeneration systems or sacrificial substrates. In batch experiments, *Sc*Adh achieved methyl formate titers 4.5 times higher than the stoichiometric threshold. Through process optimization and iterative aldehyde feeding, methyl formate titers were further increased to 11787 mg L^{-1}, approximately 65 times the expected maximum. Furthermore, the versatility of this route was confirmed by the successful synthesis of ethyl formate, methyl acetate, and ethyl acetate using various ADHs. These findings establish hemiacetal oxidation as a robust and industrially viable platform for the sustainable synthesis of high-value esters.

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PHOTOCATALYTIC HYDROGELS DERIVED FROM FOOD WASTE FOR THE REMOVAL OF ORGANIC CONTAMINANTS

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The increasing demand for clean water, driven by population growth, climate change, and the progressive depletion of freshwater resources, highlights the urgent need for sustainable and efficient water treatment technologies. In particular, emerging and persistent organic contaminants such as pharmaceuticals and dyes represent a significant environmental challenge, as they are often poorly removed by conventional wastewater treatment processes.

In this presentation, we report the development of sustainable multifunctional materials obtained through the valorization of food waste for environmental remediation, with a specific focus on water purification. This approach exploits the synergistic integration of functional components capable of capturing and degrading different classes of organic pollutants, including dyes and pharmaceutical residues. In particular, we describe a multifunctional system based on chitosan-derived hydrogels incorporating photocatalytic units within the polymeric network. Chitosan, a biopolymer obtained from food-processing waste such as shrimp shells, represents an environmentally benign platform that promotes circular use of biomass while providing intrinsic adsorption capability. The resulting hybrid material combines the adsorption properties of the chitosan matrix with photocatalytic activity, enabling the simultaneous capture and catalytic degradation of organic pollutants under mild conditions. The performance of the system is evaluated in aqueous solutions containing dyes and pharmaceutical compounds, also in the presence of inorganic ions to simulate realistic water matrices. Degradation pathways and by-products are carefully investigated to assess environmental safety and to explore routes toward enhanced pollutant mineralization.

Overall, this work demonstrates a sustainable strategy for water remediation that integrates waste-derived materials, green catalytic processes, and advanced treatment technologies.



POLYMER FILM / NANOMATERIAL MODIFIED ELECTRODES BY ELECTROPOLYMERIZATION IN TERNARY DEEP EUTECTIC SOLVENTS AND APPLICATION

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The electropolymerization of the redox-active brilliant cresyl green (BCG) and brilliant cresyl purple (BCP) on glassy carbon electrodes (GCE) modified with gold nanoparticles (AuNP) and graphene quantum dots (GQD) [1] dispersed in chitosan has been explored by potential cycling in ternary DES, composed of choline chloride (ChCl) as hydrogen bond acceptor plus acetic acid (AcA) and ethylene glycol (EG) as hydrogen bond donors and $HClO_4$ as acid dopant. Deep eutectic solvents (DES) are easy to prepare and exhibit lower toxicity, and are more environmentally-friendly, than ionic liquids and non-aqueous solvents, with sufficient conductivity to act as electrolytes, due to strong hydrogen-bond interactions [2]. $GQD_{chitosan}$ was synthesized by a simple procedure using citric acid as carbon source in a chitosan solution containing 1% v/v acetic acid [1]. AuNP were mixed with $GQD_{chitosan}$ in a 70/30% (v/v) ratio. The polymer-modified electrode platform was characterized by cyclic voltammetry and electrochemical impedance spectroscopy, and the morphology by scanning electron microscopy, with better characteristics than the equivalent polymer film modified electrodes formed in aqueous media. Biosensors prepared by immobilization of glucose oxidase (GOx), were employed for glucose determination by amperometry at -0.2 V vs. Ag/AgCl, up to 200 µM for GOx/PBCG/$(AuNP+GQD)_{chitosan}$/GCE and 140 µM for GOx/PBCP/$(AuNP+GQD)_{chitosan}$/GCE. Limits of detection were 2.3 µM and 3.1 µM, respectively, with high selectivity. The biosensors were successfully applied to wine samples with good recoveries which augurs well for their application as GOx enzyme inhibition biosensors for diagnosis of environmental toxicity, as in [3].

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FOOD-INSPIRED OXIDATIVE COUPLING OF CAFFEATES: A NEW TOOL FOR THE GREEN SYNTHESIS OF BENZACRIDINES

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Benzacridines are nitrogen-based heterocyclic compounds derived from acridines, a class long recognized for its pharmacological and photophysical properties. [1] A distinct subclass, benz[kl]acridines, was unexpectedly identified as green byproducts of food processing through oxidative coupling of caffeic acid derivatives with primary amines from proteins and amino acids. [1]

This biomimetic one-step synthesis is highly innovative, since it is conducted in water with inexpensive basic catalysts, representing a greener alternative to conventional multicomponent reactions. Yet, its potential as a green synthesis tool for producing new benzacridines has never been explored. This research is focused on developing and optimizing the scope of this synthetic protocol and assessing the core photophysical properties of these derivatives.

Herein, we report the synthesis of new benzacridine derivatives from caffeic acid derivatives and butylamine, including optimization data and full characterization. Photophysical properties, like UV-Vis spectra, pKa values, molar absorptivity, and fluorescence data, are also reported. These findings demonstrate successful manipulation of this food-inspired process towards novel chromophores and pharmacophores via green chemistry.

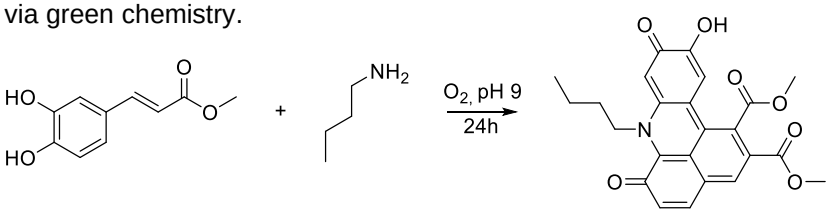


Figure 1: Synthesis of benzacridine with methyl caffeate and butyl amine

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LAYER STRUCTURE IN AN AIR-STABLE HYDRATED EUTECTIC ELECTROLYTE FOR ALUMINUM-ION ENERGY STORAGE

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The *α*-MoO_3 material with a two-dimensional (2D) layer structure is proposed as a promising cathode material for aluminum-ion (Al-ion) energy storage in the air-stable $Al(ClO_4)_3 \cdot 9H_2O$/succinonitrile hydrated eutectic electrolyte (ASHEE) system. The electrochemical measurements reveal that the *α*-MoO_3 electrode material exhibits a high capacity of approximately 285 mA h g^{-1}, a wide potential window of 2 V, and the capacity retention of approximately 86 % after 40 charge/discharge cycles at a current density of 0.4 A g^{-1}. The correlation between the electrochemical performance and the crystal structure of the α-MoO_3 electrode material is investigated using in situ X-ray absorption spectroscopy (XAS) and X-ray diffraction (XRD). The results highlight the favorable attributes of *α*-MoO_3 as a cathode material in the ASHEE system for Al-ion energy storage, including high safety, air-stability, exceptional electrochemical performance, and low cost. This study provides detailed insight into the electrochemical performance and ion-storage mechanism of the 2D α-MoO_3 cathode material, paving the way for its application in promising electrolyte systems for Al-ion energy storage. The findings contribute to advancing Al-ion energy storage technology by providing a comprehensive understanding of the electrochemical performance and storage mechanism of 2D α-MoO_3 as a cathode material in the ASHEE system, facilitating the development of an efficient, safe, and cost-effective Aluminum-ion battery.

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ULTRAFAST BROMIDE-FREE MECHANOCHEMICAL TEMPO OXIDATION OF CELLULOSE

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The selective oxidation of cellulose primary hydroxyl groups (C6–OH) using 2,2,6,6-tetramethylpiperidine-1-oxyl (TEMPO) radical is among the most effective routes to produce carboxylated cellulose nanocrystal (CNC) and cellulose nanofiber (CNF) with high surface charge density. [1] However, the conventional TEMPO/NaBr/NaOCl system introduces bromide into the waste stream, raising significant environmental and corrosion concerns, while established bromide-free alternatives require up to 48 hours to reach comparable carboxylate yields. [2] Therefore, we explored mechanochemistry as an alternative approach for TEMPO oxidation. Mechanochemistry can significantly accelerate chemical reactions due to the high concentration of reactants and their intimate mixing, and has proven particularly promising for the chemical modification of cellulose and cellulose nanomaterials. [3] In this presentation, we show how mechanochemistry leads to an ultrafast, bromide-free oxidation of cellulose, reaching a surface carboxylate content of 0.9 mmol/g with only 5 minutes and the concurrent production of nanocellulose measured by AFM (fig.1). The developed approach offers a substantially greener process profile, with a particularly high impact on the space-time-yield, as the reaction rate is enhanced one to two orders of magnitude over existing bromide-free aqueous systems, and eliminates the need for conventional steps of acid pre-hydrolysis.

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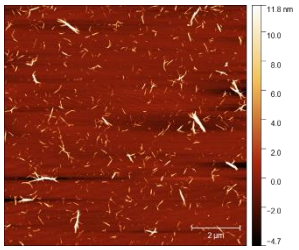


Fig.1 AFM image of nanocellulose produced by mechanochemistry.



PHOTOCHEMICAL VALORIZATION OF LIGNIN

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Lignin is a potential sustainable source of carbon-based materials and chemicals, yet, its recalcitrancy and heterogeneity hinder its depolymerization and chemical modification. Light-driven methods often provide milder reaction conditions and higher selectivity than thermochemical routes, which could facilitate tailoring of lignin into applications. Direct irradiation of lignin with UV-light can indeed promote its fragmentation. Our group has previously shown that UV-light can be used to produce small molecules from lignin without the use of photocatalysts,[1] which allows milder and metal-free conditions to be used. However, the direct irradiation of lignin with UV-light often leads to oxidation of the aromatic rings and repolymerization reactions, which motivated us to explore the use of a photosensitizer.[2] Lignin can also act as a photocatalyst itself, and some studies have shown its use in aqueous solutions to catalyse the formation of hydrogen peroxide,[3,4] which can be used for further in-situ oxidation reactions. However, aqueous systems limit the use of a wide range of lignin types due to their low solubility.

In this presentation, we will discuss the use of different photocatalysts to achieve more controlled reactions to modify both the functional groups and size of lignin under near UV-light and visible light irradiation. It will also address the use of lignin in the light-driven production of hydrogen peroxide in non-aqueous solvents, which allows a wider range of lignin types to be used due to its higher solubility in organic solvents.

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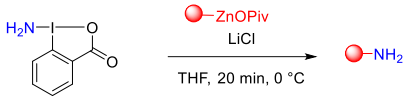
DIRECT ACCESS TO PRIMARY AMINES VIA ELECTROPHILIC AMINATION MEDIATED BY HYPERVALENT IODINE REAGENTS

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Primary amines are central motifs in organic synthesis, yet their preparation often relies on multistep strategies or amination methods with limited scope. Our group has been investigating the reactivity of hypervalent iodine (III) reagents,[1] and their application to secondary amine synthesis.[2] Herein, we will present an efficient electrophilic amination of air-stable and functional-group-tolerant organozinc pivalates using NH_2-benziodoxolone, a primary amino–λ³-iodane[3] that enables direct installation of the NH_2 group under mild conditions.[4] This study establishes a practical and versatile electrophilic amination platform that expands synthetic access to diverse primary amine building blocks from readily prepared organozinc reagents.



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SUSTAINABLE DESIGN OF PHOTOACTIVE METAL COMPLEXES FOR LOW-TOXICITY THERAPEUTIC APPLICATIONS

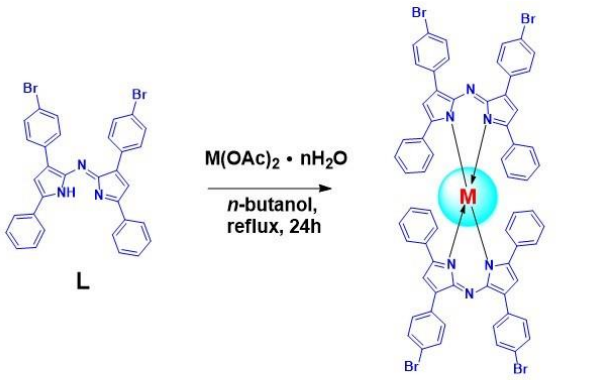
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The development of therapeutic strategies that minimize environmental impact and reduce systemic toxicity remains a key challenge in modern chemistry. Photodynamic therapy (PDT) is considered a promising approach due to its spatiotemporal control and reduced invasiveness, relying on the activation of photosensitizers to generate reactive oxygen species [1-3].

This contribution presents a general overview of recent advances in the design of dipyromethene-derived coordination systems as potential photoactive agents. Particular attention is given to strategies that align with green chemistry principles, including the use of efficient synthetic pathways, reduced energy input, and the potential for selective activation.

The results highlight the broader potential of such systems in developing safer and more sustainable photoresponsive materials for biomedical and related applications [4].



Scheme 1. Synthesis of ADPM complexes.

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EXTRACTION OF NITROSOAMINES BY STIR BAR SORPTIVE EXTRACTION WITH NATURAL DEEP EUTECTIC SOLVENT

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In recent years, deep eutectic solvents (DESs) have been widely used in the treatment of various samples prior to analysis [1,2]. Among the increasingly common DESs are natural deep eutectic solvents (NADESs), which, unlike DESs, consist of natural substances. Natural substances used to form NADES include organic acids and bases, amino acids, sugars, sugar alcohols, and polyols. NADES can be used in various microextraction techniques, such as liquid-liquid dispersion microextraction (DLLME) or liquid-phase microextraction (LPME).

In our work, we used NADES in stir bar sorptive extraction (SBSE) [3]. A stable ferromagnetic NADES was prepared from thymol and benzyl alcohol in a 1:1 molar ratio with the addition of Fe_3O_4 in the form of nanoparticles as the magnetic component. The NADES prepared in this manner was used in SBSE to extract four *N*-nitrosamines with varying polarities: *N*-nitrosodiethylamine (NDEA), *N*-nitrosodiphenylamine (NDPhA), *N*-nitrosodibutylamine (NDBA), and *N*-nitrosopiperidine (NPIP). The extraction yield reached up to 50% for the more polar analytes NPIP and NDEA and around 70% for the less polar analytes NDPhA and NDBA.

Separation and detection of *N*-nitrosamines was performance by HPLC with UV at 230 nm. The chromatographic separation was performed on analytical column Intersil C18 (250 × 4.6 mm I.D, 5 µm) at 40 °C under the gradient elution using water and acetonitrile as a mobile phase at flow rate of 1.2 mL/min. The sample injection volume was 20 µL.

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IN-SYRINGE RAPID SYNERGISTIC MIXED MICELLE CLOUD POINT EXTRACTION AS "SMART" EXTRACTION FOR DETERMINATION OF COPPER IN PHARMACEUTICAL PREPARATIVE

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Smart analytical chemistry represents a modern approach to analytical measurements, which combines classical analytical methods with advanced digital technologies, miniaturization and automation [1]. Our research focuses on the modification of traditional procedures in the "smart" concept into sustainable procedures in modern analytical chemistry. We aim to highlight their transformative potential in increasing efficiency, reducing environmental impact and supporting innovation in analytical methodologies, as well as their successful applications on real samples [2]. In this work, we present the implementation of a smart element into Cloud Point Extraction (CPE). This is an efficient and sustainable preconcentration technique that uses phase separation of surfactants as a more environmentally friendly alternative to organic solvents. Although CPE is an effective and relatively simple technique in itself, its applicability and performance can be limited by various factors. Our proposed procedure represents a new "smart" approach for simultaneous CPE and detection performed in a syringe. An optical probe immersed directly into the syringe tip was used to detect the surfactant-enriched phase in pharmaceutical preparative. Green and white analytical chemistry principles evaluation tools confirmed that this procedure is not only environmentally friendly but also suitable in terms of practical efficiency. It represents a smart, cost-effective and easy-to-apply solution that replaces conventional cuvette-based spectrophotometric measurements.

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THE INFLUENCE OF DES ON THE ESTERIFICATION OF LEVULINIC ACID CATALYSED BY BIOMASS POROUS CARBON

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Biomass-derived platform molecules play a crucial role in the transition to a more sustainable and circular chemical industry, as they offer renewable alternatives to fossil-based raw materials. These molecules, obtained from lignocellulosic biomass such as agricultural and forestry residues, serve as versatile building blocks for the production of fuels, chemicals, and materials with a lower environmental impact. Among these, levulinic acid (LA) esters are particularly important due to their wide range of applications and favorable properties. Derived from levulinic acid, a key platform molecule, these esters exhibit excellent solvency power, low toxicity, and biodegradability, making them attractive for use as green solvents, fuel additives, and intermediates in fine chemicals.

In this work, we combine a sustainable heterogeneous carbon catalyst derived from biomass with the use of deep eutectic solvents (DES) for the catalytic synthesis of ethyl levulinate. Esterification reactions in conventional systems often do not reach completion due to equilibrium limitations. Continuous removal of water can enhance conversion by shifting the equilibrium toward the products. In the system investigated here, we evaluate the feasibility of DES to induce phase split during the esterification reaction, thereby promoting the direct reaction and improving overall efficiency.[1]

The results show that at 70°C, using EtOH:LA mass ratio of 5, 100 mg of carbon catalyst (CAT) and 50%wt of DES, the presence of both CAT & DES improves the conversion of the reaction significantly with time comparing to the autocatalytic process (no DES, and no CAT), from 36% to 72% after 24h reaction. Various operational parameters were studied and optimized, namely, temperature, alcohol-to-acid ratio, catalyst loading and the amount of DES.

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Acknowledgments:

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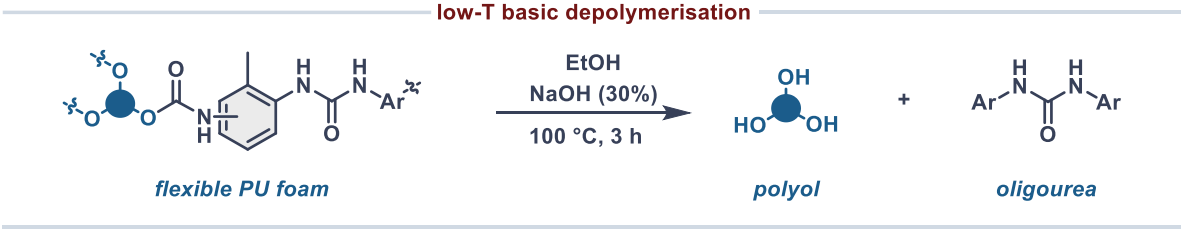
LOW TEMPERATURE PHASE-SEPARATING HYDRO-ALCOHOLYTIC DEPOLYMERISATION OF POLYURETHANES

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Polyurethane (PU), a non-biodegradable thermoset plastic produced at over 26 million tonnes annually, constitutes a growing environmental challenge due to inefficient disposal and energy-intensive recycling methods. Current chemical recycling strategies often require harsh conditions and extensive purification, thus limiting their practical implementation.[1] Here, we present a low-temperature, base-mediated hydrolysis approach for efficient PU depolymerisation into high-purity polyols and oligoureas. Using model flexible foam, complete depolymerisation is achieved within one hour at 100 °C, accompanied by spontaneous phase separation that enables straightforward product recovery. The method is applicable to a range of PU materials, including rigid foams, elastomers, and mixed waste streams. Scale-up to 100 g affords polyol recoveries exceeding 85%, with OH values comparable to virgin materials, while downstream conversion of oligoureas to anilines enables full monomer recovery. This approach offers a practical and scalable pathway for PU recycling under mild conditions.



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BIOPOLYMERS FROM DIFFERENT SPECIES OF BORAGINACEAE FAMILY AND THEIR SYNTHETIC ANALOGUE

M. Merlani, L. Amiranashvili, L. Gogilashvili, V. Barbakadze, N. Sukhishvili, K. Mulkijanyan

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High molecular (>1000 kDa) water soluble polymer - poly-[3-(3,4-dihydroxyphenyl)glycerine acid] (PDHPGA) 1 (Fig.1,1) diverse biological properties [1] was isolated from various species of plants of Boraginaceae family: *Symphytum asperum* (SA), *S. caucasicum* (SC), *S. grandiflorum* (SG), *S. officinale* (SO), *Anchusa italica* (AI), *Cynoglossum officinale* (CO), *Borago officinalis* (BO), *Paracynoglossum imeretinum* (PI) and *Trachistemon orientalis* (TO). Distinguished from PDHPGA-SA, PDHPGA-SC, PDHPGA–SO, and PDHPGA–CO most of the carboxylic groups of PDHPGA-SG, PDHPGA-AI, and PDHPGA-BO are methylated (Fig.1,2).

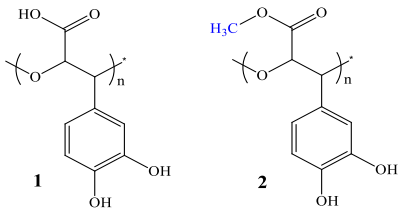


Figure 1. Poly[3-(3,4-dihydroxyphenyl)glyceric acid] (PDHPGA) (1) and poly[2-methoxycarbonyl-3-(3,4-dihydroxyphenyl)oxirane] (PMDHPO) (2)

For the first time, synthetic analogue of PMDHPO was successfully synthesized by enzymatic polymerization of 2-methoxycarbonyl-3-(3,4-dibenzyloxyphenyl)-oxirane using lipase *Candida rugosa,* under mild and environmentally-friendly conditions. Catalytic debenzylation of obtained oligomer with H_2 on Pd/C yielded the synthetic analogue of PMDHPO at ~80% yield and without loss in molecular mass.

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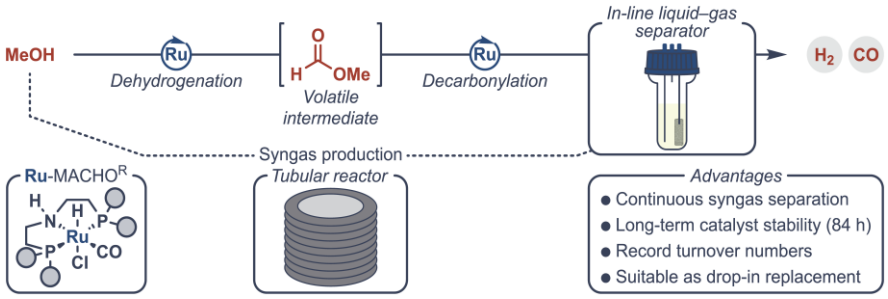
ENABLING HIGH-TURNOVER METHANOL-TO-SYNGAS REFORMING

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The transition towards a carbon-neutral chemical industry necessitates the integration of renewable carbon feedstocks into established industrial infrastructures. Yet, the sector remains fundamentally dependent on fossil-derived, standardised intermediates such as syngas, making large-scale process redesign both technically and economically prohibitive. Strategies that enable renewable inputs to serve as drop-in replacements are therefore particularly attractive. In this context, renewable methanol has emerged as a promising C1 platform molecule due to its increasing availability from biomass and CO_2, favourable handling properties, and central role in chemical manufacturing.

Here, we report a continuous flow strategy for methanol-to-syngas reforming based on homogeneous Ru-MACHO catalysts. By combining deliberate reactor engineering with ligand-controlled catalyst design, the intrinsic limitations of batch operation are overcome, enabling sustained syngas production over 84 hours. Furthermore, kinetic and selectivity studies further elucidate the parameters governing efficient syngas formation. This approach establishes methanol as a viable entry point for introducing renewable carbon into existing chemical value chains, offering a practical pathway towards defossilised chemical manufacturing.



Acknowledgments:

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MULTICOMPONENT REACTIONS FOR SUSTAINABLE CHEMISTRY

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Multicomponent reactions (MCRs) provide efficient and sustainable routes to complex molecules by combining several reactants in a single operation with excellent atom economy and minimal waste [1,2]. Their use under heterogeneous catalysis further improves sustainability, enabling simple catalyst recovery, reuse, and reduced environmental impact [3,4]. Our group has developed solvent-free MCRs promoted by inexpensive, recyclable heterogeneous catalysts operating without co-catalysts or additives.

To expand the structural diversity accessible through MCRs, we apply the union of MCRs, where orthogonal functional groups or in situ-generated intermediates trigger sequential or tandem pathways in one pot [5,6]. This complements the single-reactant-replacement (SRR) strategy, which broadens MCR reactivity and allows access to densely functionalised scaffolds with potential biological relevance.

Overall, our results show that heterogeneous, solvent-free MCRs—together with SRR and union-MCR strategies—offer efficient, scalable, and environmentally responsible synthetic routes.

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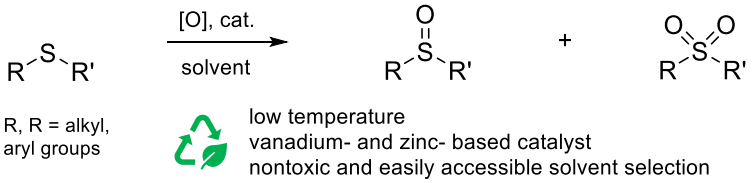
EVALUATION OF CATALYTIC SULFOXIDATION REACTIONS FOR OBTAINING SULFONYL AND SULFINYL CONTAINING COMPOUNDS

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Sulfinyl and sulfonyl moieties are important components in a variety of compounds, for example in biologically relevant derivatives, fine chemicals, pharmaceuticals, ligands in catalyst structures, material chemistry, etc.[1] Thus, the synthesis of such derivatives presents an interest in the scientific community.[1]

Our research group has previously demonstrated the utility of compounds containing sulfoxide and/or sulfone groups in the design of pincer type ligands as well.[2] In the last few years, pincer type ligands that contained such moieties were used to obtain p block element containing derivatives.[2] Building on this work, we focused on developing an easy, cheap and more sustainable process for the synthesis of sulfoxides and sulfones.



Scheme 1. General reaction scheme for sulfoxidation of thioethers

This study details the evaluation of vanadium- and zinc-based catalytic systems for the sulfoxidation of mono- and bisthioethers.[3] In optimizing the reaction parameters (solvent choice, temperature) we prioritized the principles of green and sustainable chemistry.

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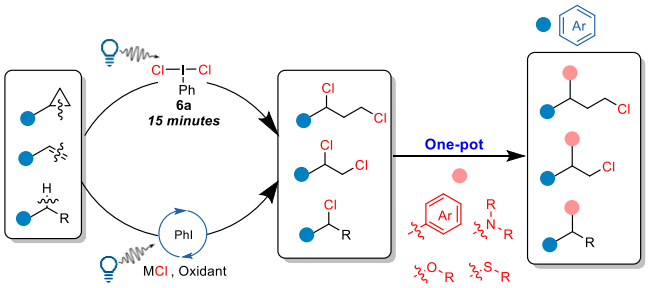
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UNIFIED PHOTOCHEMICAL APPROACH TO C(SP³) CHLORINATED COMPOUNDS FROM CYCLOPROPANES, OLEFINS, AND C–H BONDS USING WILLGERODT-TYPE REAGENTS

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C(sp³)–Cl bonds are essential intermediates in organic synthesis as versatile diversification handles, and are widely found in natural products and biologically active molecules.[1] Herein, we report a practical protocol for the selective formation of C(*sp³*)–Cl bonds from aryl cyclopropanes, olefins, and activated C–H bonds.[2] This transformation relies on the direct photoexcitation of Willgerodt-type reagents as chlorine radical precursors, enabling functionalization of π- and σ-bonds as well as activated C–H bonds. The method shows broad substrate scope, and compatibility with drug molecules, highlighting its potential for late-stage chlorination. We also introduced a iodine(I/III)-mediated catalytic system using inexpensive chloride salts, together with a one-pot telescoped protocol to expand this work. Overall, this work provides a versatile photochemical platform for C(*sp³*) chlorination and enables rapid access to 1,1-diaryl motifs commonly found in bioactive compounds.

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SUSTAINABLE MICROWAVE-ASSISTED HYDROTHERMAL CONVERSION OF BIOMASS RESIDUES INTO BIO-OIL AND HIGH-PERFORMANCE CARBON MATERIALS

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The growing demand for sustainable alternatives to fossil resources has driven the development of efficient thermochemical conversion processes for biomass valorisation. This study explores microwave-assisted hydrothermal technologies as eco-friendly and energy-efficient methods for converting lignocellulosic waste into valuable products. The main aim was to optimise operating conditions for maximising bio-oil and hydrochar yields from different biomass residues and to assess their potential downstream uses. Microwave-assisted hydrothermal liquefaction (MW-HTL) of spent coffee grounds (SCG) and microwave-assisted hydrothermal carbonisation (MW-HTC) of nutshell biomass (walnut and almond shells) were optimised using response surface methodology, considering temperature, reaction time, and biomass-to-water ratio. The resulting hydrochars obtained from MW-HTC were further converted into activated carbons using KOH and H_3PO_4 activation. A range of zeolitic catalysts, including NiO- and Ce-modified systems and magnetic composites, were evaluated to enhance bio-oil yields from MW-HTL. Products were extensively characterised using elemental, thermal, spectroscopic, and textural analyses.

Optimal MW-HTL conditions yielded 12.2 wt.% bio-oil without catalysts, increasing significantly up to 52.0 wt.% with NiO-ZSM-5. In MW-HTC, hydrochar yields reached 83 wt.% under optimised conditions. Activated carbons derived from hydrochars exhibited excellent textural properties, achieving surface areas up to 1200.8 m^2/g and pore volumes of 0.5271 cm^3/g. Overall, microwave-assisted hydrothermal processes are promising for biomass valorisation, offering rapid, energy-efficient, and sustainable methods that align with green chemistry principles by using waste feedstocks, reducing energy demand, and enabling the production of renewable fuels and high-value carbon materials.

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MODULATING NUCLEIC ACIDS SOLUBILIZATION AND STABILIZATION WITH TAILORED NON-CONVENTIONAL SOLVENTS

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Ionic Liquids (ILs) and Deep Eutectic Solvents (DES) are non-conventional solvents which, due to their biocompatibility and tunable properties, have attracted attention as alternative media for biomolecular applications [1]. Compared with aqueous systems, these solvents have demonstrated to the ability to dissolve DNA while enhancing its stability [2]. Due to the potential use of DNA as catalyst [1], we have designed and synthesized ILs and DES as potential reaction media for DNA-based asymmetric catalysis (**Figure 1**), exploiting the intrinsic chirality of DNA. The capacity of these solvents to solubilize and stabilize salmon testes DNA (st-DNA) was evaluated. Our findings show that several of these non-conventional solvents can effectively solubilize st-DNA, reaching concentrations of up to 16.5% w/w while preserving and, in certain circumstances, improving its stability.

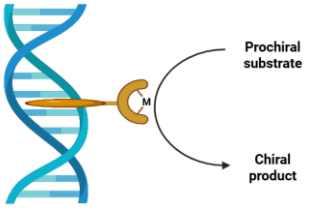


Figure 1. Schematic representation of DNA-based asymmetric catalysis, created in BioRender.com.

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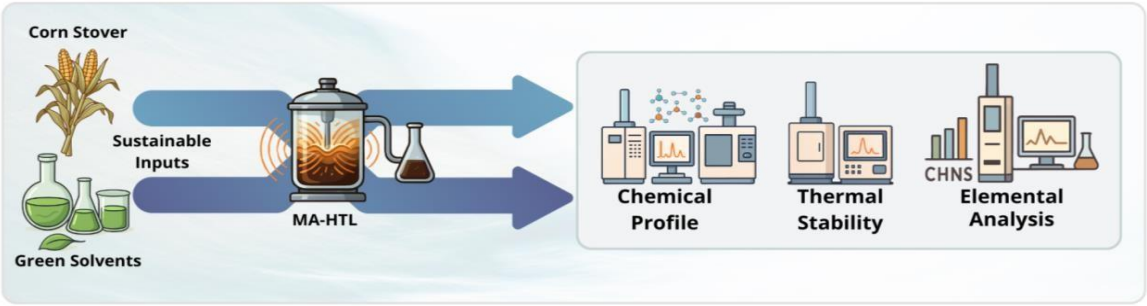
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BIO-OILS FROM FOOD WASTE: TURNING WASTE INTO SUSTAINABLE SOLUTIONS

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The transition toward a circular and green economy depends on efficient strategies to convert agricultural residues into high-value chemicals and fuels. Corn stover, one of the most abundant by-products of global cereal cultivation, offers a promising yet underutilised source of lignocellulosic biomass for sustainable valorisation. This study investigates the conversion of corn stover into bio-oil via microwave-assisted hydrothermal liquefaction (MA-HTL), an energy-efficient thermochemical process that enables rapid, uniform heating. The influence of various solvent systems, particularly those employing environmentally benign and sustainable solvents, is examined with respect to conversion efficiency and the chemical characteristics of the resulting bio-oils. Comprehensive product characterization is conducted using gas chromatography–mass spectrometry (GC–MS), thermogravimetric analysis (TGA), Fourier-transform infrared spectroscopy (FTIR), and proximate and ultimate analyses. The study advances understanding of the influence of solvents on MA-HTL and contributes to the development of cleaner, more selective thermochemical routes. Ultimately, these insights support the design of greener biorefineries and the integration of sustainable chemical processes into the circular bioeconomy.



Acknowledgments:
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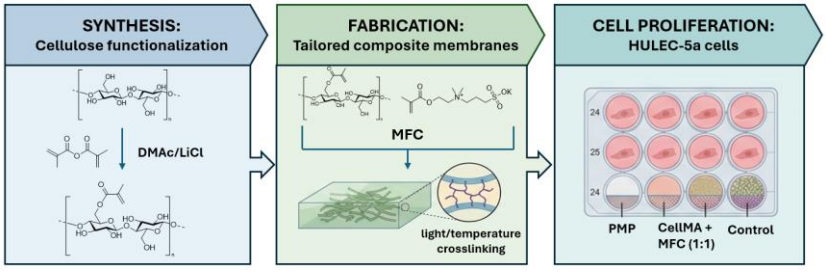
SYNTHESIS OF CELLULOSE METHACRYLATE AND ITS USE FOR ARTIFICIAL LUNG APPLICATIONS

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Chronic respiratory diseases can progress to end-stage lung failure and are the third leading cause of death worldwide, highlighting the need for improved lung-support strategies. Current ECMO devices use PMP/PP membranes that, when uncoated, may promote platelet aggregation and thrombosis, limiting device lifetime. Here, we developed sustainable, cytocompatible cellulose-based alternatives. Cellulose methacrylate (CellMA) was synthesised in DMAc/LiCl and crosslinked using LAP or AIBN. Composite membranes containing CellMA, and microfibrillated or microcrystalline cellulose, and sulfobetaine methacrylate (SBMA) were compared with PMP using HULEC-5a cells over one week. CellMA + 50% MCC showed the highest proliferation at day 7, exceeding PMP and supporting its potential for ECMO applications.



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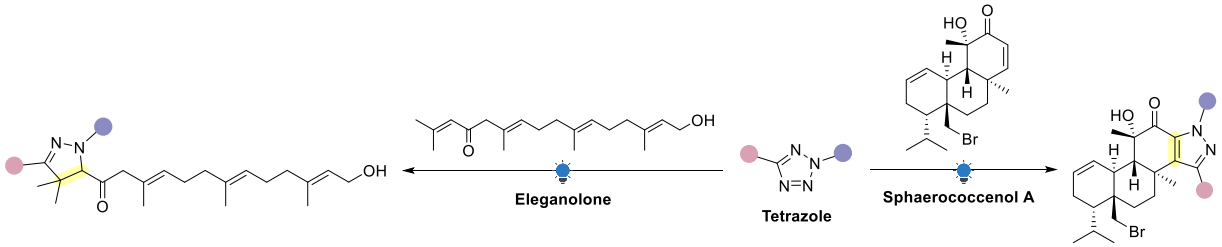
NATURAL PRODUCTS DERIVATIVES FOR THE TREATMENT OF PARKINSON'S DISEASE

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Parkinson's disease (PD) remains, nowadays, an incurable chronic condition, with available treatments only mitigating symptoms [1]. Marine Natural Products produce secondary metabolites with unique and highly complex chemical structures, representing a valuable source for Drug Discovery and Development. Among them, sphaerococcenol A (SA) and eleganolone, diterpenes isolated from the algae *Sphaerococcus coronopifolius* and *Bifurcaria bifurcata*, respectively, have shown diverse biological activities [2,3]. Five-membered heterocycles like pyrazoles and pyrazolines often appear in compounds implicated in PD [4]. Therefore, our research focuses on the synthesis of novel hemi-synthetic SA and eleganolone derivatives containing pyrazole and pyrazoline functionalities through photoinduced 1,3-dipolar cycloadditions with tetrazoles (Scheme 1).



Scheme 1. Synthesis of SA and eleganolone derivatives containing pyrazole and pyrazoline functionalities.

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GREEN ACCESS TO TRANS-2,4,5-TRIAMINO-CYCLOPENT-2-ENONES FROM BIOMASS-DERIVED FURANS

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Cyclopentenones are valuable scaffolds in organic synthesis. Particularly, diaminocyclopentenones, derived from furfural, serve as versatile intermediates despite typically requiring catalytic and non-sustainable conditions [1]. In the context of Green Chemistry, more sustainable methodologies are needed. Herein, ultra-high pressure (UHP) is explored as an alternative activation tool, promoting reactions with negative activation volumes while enhancing reactivity and selectivity under milder conditions [2]. Building on previous reports, this work employs 3-acetamido-5-furan (3A5F), a less reactive nitrogen-rich building block derived from chitin biomass [3, 4]. The transformation proceeds via a Nazarov-like electrocyclization through a Stenhouse salt intermediate to afford the cyclopentenone framework, enabling the formation of trans-3,4,5-triamino-cyclopent-2-enones under catalyst-free conditions. Overall, this approach provides a more sustainable route to nitrogen-rich cyclopentenones, combining biomass-derived substrates with pressure as a green activation methodology. [2, 3, 4]

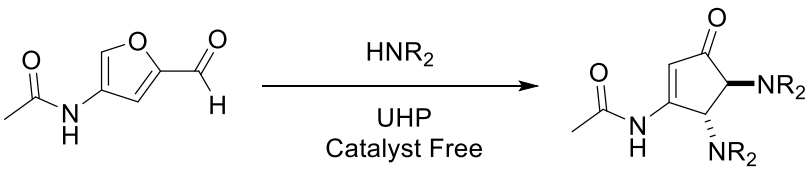


Figure 1. Preparation of trans-3,4,5-triamino-cyclopent-2-enones from furfural derivative 3A5F

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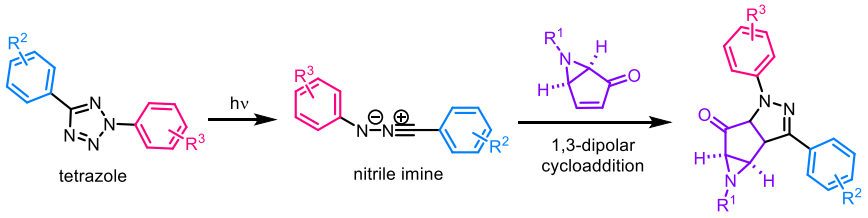
PHOTOINDUCED 1,3-DIPOLAR CYCLOADDITION ON BICYCLIC AZIRIDINES TOWARDS THE SYNTHESIS OF NEW PYRAZOLINES

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In the search for more environmentally friendly synthetic methods, the use of light as energy source has become more prominent [1]. In previous works, we have developed the photoreaction of pyridinium salts into the corresponding hydroxyl bicyclic aziridines, under continuous-flow conditions [2,3]. In this work, we report the use of α,β-unsaturated carbonyl bicyclic aziridines for the obtention of new pyrazoline derivatives, a nitrogen-containing heterocycle known for its biological activities, such as anti-inflammatory, antibacterial and anticancer activities [4]. This pyrazoline scaffold is synthesized *via* 1,3-dipolar cycloaddition of unsaturated systems with nitrile imines generated photochemically from tetrazoles [5]. Moreover, this transformation was also implemented in substrates derived from marine biorenewable sources.



Scheme 1 Synthesis of pyrazolines *via* photoinduced 1,3-dipolar cycloaddition

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STRUCTURAL AND SURFACE ENGINEERING OF PTCO NANOWIRES FOR ENHANCED DURABILITY IN OXYGEN REDUCTION REACTION

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Grain boundaries (GBs) are typical crystal defects widely recognized for providing highly active sites in various electrocatalytic reactions. However, this study reveals the adverse effects of GBs in bimetallic platinum-cobalt (Pt-Co) nano catalysts during the oxygen reduction reaction (ORR). Using a magnetic field-assisted synthesis, we precisely controlled the GB populations to prepare GB-rich Pt-Co nanowires (GB-NWs) and single-crystalline Pt-Co nanowires (SC-NWs) as model catalysts. Both nanowires share highly similar diameters, overall Pt-to-Co ratios, and Pt-rich surface structures, differing primarily in their GB density. Our electrochemical investigations reveal that the presence of GBs in Pt-Co NWs significantly accelerates Co leaching under applied electrochemical potentials, leading to drastic alterations in the surface Pt-to-Co ratio. Consequently, the resulting Pt-Co GB-NWs exhibited only half the ORR mass activity compared to their SC-NW counterparts. These findings demonstrate that surface GB sites in Pt-Co nanowire catalysts undergo deactivation through elemental leaching, functioning as structural degradation centers rather than ORR promoters. This provides crucial insights into the necessity of crystal engineering for highly durable electrocatalysts.



BOOSTING ACIDIC HYDROGEN EVOLUTION KINETICS THROUGH TENSILE STRAIN ON PT(111)

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Hydrogen adsorption free energy (ΔGH) is a well-known descriptor for the hydrogen evolution reaction (HER) in acidic media. However, relying solely on ΔGH has limitations in fully explaining the facet- and strain-dependent HER kinetics. In this study, we highlight the often-overlooked competitive adsorption of hydrogen and water during the acidic HER and elucidate the role of tensile strain on the Pt(111) surface in determining reaction kinetics. To systematically investigate this, we designed model catalysts through shape-controlled synthesis: Pt octahedra, which possess strain-free Pt(111) surfaces, and Pt icosahedra, which exhibit naturally induced tensile strain due to lattice expansion to bridge an angular gap of 1.54 sr. Experimental analyses combined with density functional theory (DFT) calculations reveal that tensile strain on the Pt(111) surface strengthens the adsorption of not only hydrogen but also water. Interestingly, the tensile-strained Pt icosahedra exhibited superior HER activity, demonstrating an exchange current density approximately 1.3 times higher than that of the strain-free Pt octahedra. Our findings suggest that for catalyst surfaces accompanied by structural strain, a simple thermodynamic approach based on ΔGH is insufficient to capture the full impact of interfacial factors. Furthermore, we propose a new perspective that the surface adsorption of water molecules—previously considered irrelevant in acidic HER—plays a crucial role in regulating proton accessibility and ultimately determining the overall reaction kinetics.



DYNAMIC SURFACE TRANSFORMATION OF RUTHENIUM CARBIDE DURING HYDROGEN EVOLUTION REACTION PROMOTES ACTIVITY AND STABILITY IN ACIDIC MEDIA

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For the commercialization of polymer electrolyte membrane water electrolysis (PEMWE), developing low-cost hydrogen evolution reaction (HER) catalysts that simultaneously satisfy both high activity and durability in harsh acidic environments is imperative. This study presents a novel self-optimizing catalyst design strategy based on *in situ* electrochemical phase derivation, where the catalyst autonomously constructs optimal active sites and a protective barrier during operation. The metastable Ru@RuC/C precursor, designed based on our previous findings, undergoes spontaneous carbon exsolution under a reductive operating environment, dynamically evolving into a Ru@C/C architecture where a conformal graphitic carbon shell entirely encapsulates the metallic Ru core.

Spectroscopic analyses reveal that this dynamically formed carbon shell acts as an active chemical modulator, inducing spontaneous interfacial electron transfer from the carbon shell to the inner Ru core, thereby rendering the Ru active sites electron rich. This electronic rearrangement optimizes the d-band center and fundamentally prevents the corrosion and poisoning of the catalyst. Consequently, the derived Ru@C/C catalyst achieves an overpotential of 23 mV at 10 mA cm^{-2} in an acidic medium, rivaling commercial Pt/C. Most notably, it demonstrates unprecedented ultra-long-term durability with negligible voltage degradation (-0.01 mV h^{-1}) over 600 h under a harsh practical PEMWE device operation at 80 °C and 1.0 A cm^{-2}. This dynamic surface transformation mechanism provides a new paradigm for designing robust electrocatalysts for practical, high-performance green hydrogen production systems.



VERTICAL-ß-NIOOH ON FE-DOPED (111)-FACETED NI NANOPLATES FOR HIGHLY DURABLE OXYGEN EVOLUTION

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Ensuring the long-term durability of nickel-based anode catalysts in anion exchange membrane water electrolyzers (AEMWEs) remains a critical hurdle. To address this, we introduce a straightforward and highly effective electrochemical anodization method to grow vertically aligned β-NiOOH atomic sheets on Fe-doped Ni nanoplates. This structurally optimized electrocatalyst demonstrates outstanding stability, sustaining a stable current density for more than 120 days of continuous oxygen evolution reaction. Furthermore, when integrated into a zero-gap AEMWE cell, these anodized nanoplates deliver an impressive current density of 2.26 A cm^{-2} at 1.80 V, alongside a high energy efficiency of 85.1%. Our results underscore the immense potential of facet-engineered, nickel-based nanostructures to push the boundaries of AEMWE performance.

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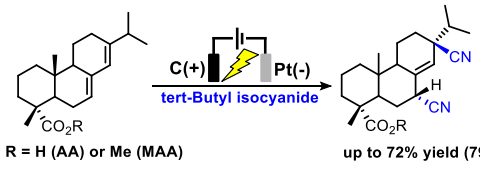
STEREOSELECTIVE ELECTROCHEMICAL 1,4-DICYANATION OF ABIETANES

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Colophony, a natural pine resin, is composed largely of diterpenes known as abietanes, which along with their derivatives display a wide range of relevant biological activities [1]. The cyano group is a versatile, widely used synthetic handle that can be converted into diverse functionalities [2]. Electrochemistry offers a sustainable alternative to traditional cyanation methods, which often require hazardous reagents or harsh conditions [2,3]. Herein, we report an electrochemical 1,4-dicyanation of abietanes, optimized by screening electrode material, charge density, supporting electrolyte, cyano source, and solvent, with DFT calculations providing mechanistic insight. This work establishes a novel electrochemical transformation of conjugated olefinic systems and grants access to previously unexplored derivatives functionalized at two underexplored olefinic positions of abietanes (**Scheme 1**).



Scheme 1: Electrochemical double cyanation of abietic acid (AA) and methyl abietate (MAA).

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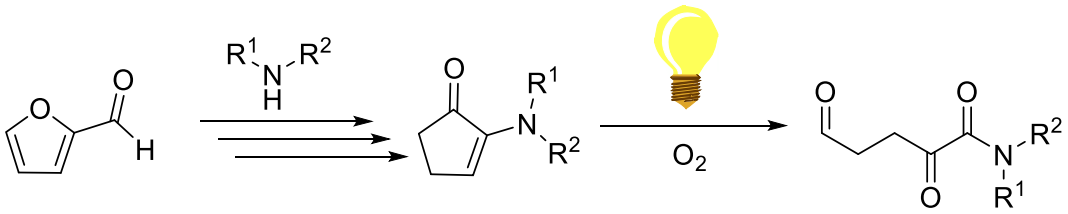
PHOTOCHEMICAL OXIDATION OF ENAMINONES

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The valorisation of biomass-derived platform molecules into structurally complex and functional building blocks represents a key challenge in sustainable organic synthesis. Furfural, a renewable feedstock derived from lignocellulosic biomass, is a particularly interesting synthon and has been used in many useful transformations.[1] In previous works, our group synthesized α-enaminones starting from furfural and through a sequence of a Nazarov-type electrocyclization, catalytic hydrogenation and β-amine elimination.[2] In this work have developed a green photochemical method to oxidise and cleave α-enaminones using only O_2 and a photosensitiser, producing α-ketoamides (Scheme 1). These products are relevant molecules as they possess a moiety that is present in different biological active compounds, like some FDA approved antivirals and snake venom inhibitors. [3]



Scheme 1. Synthetic pathway for enaminones and their photochemical oxidation.

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SELECTIVE ALLYLIC OXIDATION OF CYCLOHEXENE AND IONONE FOR THE PRODUCTION OF FINE CHEMICALS

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Allylic oxidation of hydrocarbons is of great industrial interest for the production of high-value chemicals. This work focuses on the selective allylic oxidation of (a) cyclohexene and (b) ionone using heterogeneous catalysts. Selective oxidation of cyclohexene enables the direct synthesis of adipic acid, a key building block in polymer chemistry [1], while the ketone products of ionone are valuable intermediates used in the fragrance industry [2].

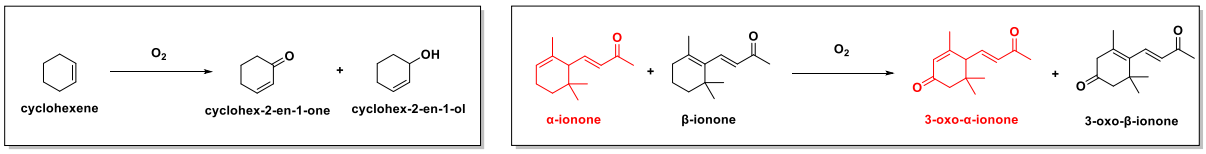


Figure 1: Target oxidation reaction scheme for (a) Cvclohexene and (b) Ionone

The objective of this study is to promote the catalytic selectivity towards the corresponding alcohol and ketone products from both of these substrates under mild reaction conditions, with molecular oxygen as the oxidant and, whenever possible, in the absence of any solvents. Several catalysts and radical mediators have been investigated, in this way targeting towards a higher selectivity of the alcohol and ketone products, at very high conversions ($X_{substrate}$ >80%). This approach aims to advance a more sustainable and greener industrial production of such fine chemicals.

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BILE ACID VALORIZATION THROUGH BACTERIAL BIOTRANSFORMATION: A CIRCULAR ECONOMY APPROACH

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Biotransformations represent a sustainable approach to obtaining novel derivatives by employing biological systems under mild conditions. This methodology enables clean, efficient, and selective processes with reduced toxicity and energy demand compared to traditional chemical synthesis. In this context, the valorization of agro-industrial by-products through biotransformation serves as a sustainable alternative across various sectors. Bile acids, which are easily recovered as by-products from cattle or pig slaughterhouses, represent a low-cost raw material for these processes [1].

In this work, we propose a biotechnological and sustainable alternative: the use of bacterial biotransformation to obtain high-value compounds from bile acids, focusing on 9,10-secosteroids.

These compounds are a group of steroids obtained through the cleavage of the B-ring between carbons C9 and C10 of the steroidal nucleus. Traditionally, 9,10-secosteroids have been isolated from scarce natural sources, such as marine gorgonian corals [2,3]. Many of these molecules have demonstrated significant biological activities [2-4].

We present the results of biotransformations using whole-cell biocatalysts (including *Tsukamurella* sp., *Streptomyces* sp. and *Acinetobacter* sp.). These strains were isolated from wool-washing effluent treatment samples [5]. These bacteria were capable of biotransforming cholic acid, lithocholic acid, and deoxycholic acid. To enhance the bioavailability of these substrates in the aqueous medium, ethoxylated castor oil was utilized as an effective dispersing agent. The products are currently being characterized by mass spectrometry, HPLC-DAD, and NMR to elucidate their structures.

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SYNTHESIS OF SUSTAINABLE BINDERS FOR AGGLOMERATION IN CORK FROM RENEWABLE RAW MATERIALS.

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In recent years, the use of renewable materials has grown due to concerns regarding environmental sustainability, the preservation of natural resources, and the consequent decrease in the use of petroleum-based polymers. In this context, the use of green chemistry has intensified and has become an important differentiator in the search for alternatives to materials derived from fossil resources. Currently, in the synthesis of binders for cork agglomeration, some alternatives to petrochemical-derived prepolymers have emerged. However, current binders for cork agglomeration are not able to meet the real needs of the industry, mainly due to their limitations regarding scalability at the industrial level. In this context, binders derived from vegetable oils continue to be a promising sustainable alternative, as the use of bio-isocyanates with 70% carbon content derived from biomass is foreseen, as well as the use of greener solvents and reduced amounts of catalysts, acids, and other compounds necessary for the binder synthesis process, making the new binders sustainable and widely promising materials for agglomeration in cork. In this sense, the present research aims at the synthesis of new binders for agglomeration in cork from sustainably sourced raw materials such as castor and sunflower oils. It is anticipated that the results of this investigation will have a high impact on the industry regarding the development of cork-derived products, as it will allow for the production of more sustainable and eco-friendly products.

Acknowledgments:

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UPCYCLING COFFEE WASTE: SUPERCRITICAL CO_2 EXTRACTION

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Spent coffee grounds (SCG) are an abundant agro-industrial waste and a promising source of high-value bioactive lipids for cosmetic, nutraceutical, and food applications. [1] Supercritical CO_2 ($scCO_2$), above its critical point (31.8 °C, 73.8 MPa), exhibits unique solvent properties enabling efficient extraction of low-polarity and heat-sensitive compounds while minimizing organic solvents use. [2]
Here, we present a novel integrative approach combining green extraction techniques with advanced multi-omics profiling to sustainably recover and characterize high-value extracts from SCG. Conventional and alternative methods, including Soxhlet, ethanol maceration, and ultrasound-assisted extraction (UAE), were evaluated, with particular focus on $scCO_2$ extraction performed at 25 MPa and 50 °C using 0-10% (*v/v*) EtOH as co-solvent. Lipidomic profiling (LC-QTOF-MS) showed that $scCO_2$, particularly with 10% EtOH, enhanced preservation of key bioactive lipids (e.g., ceramides and FAHFAs), while significantly reducing oxidized phosphatidylcholines (OxPCs).



Figure: From coffee waste to high value lipidic extracts by $scCO_2$.

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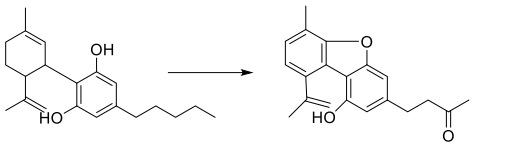
CANNABIDIOL BIOTRANSFORMATION AS A GREEN STRATEGY FOR DEVELOPING ANTIBIOFILM AGENTS

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In the context of the fight against antimicrobial resistance to antibiotics, natural products have been widely investigated for their potential antibacterial activity. Among them, cannabinoids have attracted attention due to their biological properties. In this context, biotransformations are a sustainable way to obtain novel derivatives, using biological systems under mild conditions to achieve clean, efficient, and selective processes with low toxicity and energy demand.[1] Here, we present the biotransformation of cannabidiol (CBD), a non-psychodysleptic compound, using *Trichoderma scalesiae* Y4B, a fungal biocatalyst isolated from a CBD-rich *Cannabis sativa* strain. Key process variables—including substrate concentration, biotransformation time, enzymatic system induction, and culture medium—were evaluated. The best conditions were achieved using Yeast Nitrogen Base (YNB) mineral medium supplemented with 0.05% CBD in a pre-induced system, reaching the maximum concentration of the target compound at 168 hours. Furthermore, efficient methodologies for the extraction, quantification, and purification of the biotransformation product were established. The compound was tentatively characterized by mass spectrometry, HPLC-DAD, and NMR, and its structure was proposed (Figure 1). Finally, antibiofilm assays revealed that the compound inhibits *Staphylococcus aureus* and *Candida albicans* biofilm formation.



Cannabidiol (CBD) Proposed structure of the product

Figure 1. CBD biotransformation by *Trichoderma scalesiae* Y4B.

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VALORIZATION OF RICE HUSKS THROUGH FUNCTIONALIZATION WITH EUTECTIC MIXTURE

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Conventional functionalized material often demands high energy and generates toxic waste. In this context, lignocellulosic biomass, such as rice husk, emerges as an abundant but underutilized resource for material development [1]. Although eutectic mixtures (EM) are established extraction solvents, their functional groups suggest potential as active agents for biomass functionalization [1]. This study proposes a choline chloride and malic acid EM for rice husk modification. The EM was prepared by stirring and heating [2] at 60 °C for 90 min and applied to the biomass through two methods: conventional stirring and heating (SH: 120 °C for 30-120 min) and microwave radiation in leaching mode with 10-minute warm-up ramp (MW: 120 °C for 10-30 min). Raw rice husks were characterized by ICP-MS and ICP OES showed trace contaminants (As: 21.9 µg g^{-1}; Pb: 25.0 µg g^{-1}) and macronutrients (K: 2.4 mg g^{-1}; Ca: 1.1 mg g^{-1}). FTIR analysis of the biomass showed a scarcity of active sites, with only Si-O-Si stretching (1142-967 cm^{-1}). Post-functionalization, FTIR confirmed the incorporation of new functional groups. SH for 120 min and MW for 30 min incorporated O-H and C=O groups (3358 and 1725 cm^{-1}, respectively). Overall, MW at 120 °C for 30 min was most efficient (intensities up to 25% higher compared to 120 min of SH), scoring 0.90 on the AGREE metric, with low toxicity and energy efficiency for environmental remediation.

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SYSTEMATIC FUNCTIONALIZATION OF SILK SERICIN VIA ACETYLATION: A DESIGN OF EXPERIMENTS APPROACH TOWARD SUSTAINABLE BIOMATERIALS

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Silk sericin, the adhesive protein surrounding fibroin fibres, is generated as a byproduct of silk processing but remains largely underutilized despite its rich chemical functionality. Owing to its intrinsic properties, it is a promising renewable building block for sustainable biomaterials. However, its effective valorisation requires a quantitative understanding of the relationship between chemical functionalization and protein structure. In this work [1], acetylation was employed as a model reaction to establish a quantitative framework for sericin functionalization. A Design of Experiments (DoE) approach systematically evaluated the effects of reagent amounts, reagent ratios, and reaction medium composition. Quantitative Fourier-transform infrared (FTIR) spectroscopy combined with Amide I band deconvolution enabled the definition of two complementary descriptors: the functionalization index (FI) and β-sheet index (BI), derived from band areas and intensities. The developed models revealed distinct responses, with β-sheet organization exhibiting robust predictive behaviour driven by significant quadratic and interaction effects, while FI provided complementary information on the extent of chemical modification. Overall, this work establishes a reproducible quantitative framework linking reaction parameters with chemical functionalization and protein structural organization, providing a basis for the rational design of functionalized sericin-based biomaterials.

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IONIC AND NON-IONIC POROUS ORGANIC MATERIALS FOR ADVANCED WATER PURIFICATION

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Water contamination by emerging pollutants, including pharmaceutical residues, toxic metal ions, and electronic waste-derived species, remains a major global environmental challenge. Covalent Organic Frameworks (COFs) have emerged as promising adsorbents due to their permanent porosity, high chemical stability, and tunable functionalities. Herein, we report a family of ionic and non-ionic COFs with distinct microporous and mesoporous architectures (RIO-12, RIO-23, RIO-55, and RIO-70) for the efficient removal of antibiotics, heavy metal ions, and e-waste-derived contaminants [1]. While ionic COFs enhance the adsorption of charged species through electrostatic interactions, the combination of micro- and mesoporosity promotes efficient mass transport and broadens the adsorption of structurally diverse pollutants.

The adsorption performance of the COFs was evaluated by UV–Vis, LC–MS/MS, and ICP–MS, depending on the target contaminant, and further validated using real water samples. The results demonstrate the versatility and effectiveness of these materials under environmentally relevant conditions, highlighting the synergistic advantages of combining ionic and non-ionic frameworks with hierarchical porosity. This work establishes these COFs as multifunctional adsorbents with strong potential for sustainable water remediation technologies [2].

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INTENSIFICATION OF SUPERCRITICAL CO_2 EXTRACTION OF LIPIDS FROM INSECT MEAL: EXTRACTION PERFORMANCE AND PROCESS EFFICIENCY

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The valorisation of edible insects as sustainable sources of lipids requires efficient extraction technologies with reduced environmental impact [1,2]. In this work, supercritical CO_2 (SC-CO_2) extraction was investigated for lipid recovery from *Tenebrio molitor*, *Acheta domesticus* and *Hermetia Illucens* meals. Extractions were performed at 40°C and 200 bar, using laboratory-scale extraction vessels, with extraction kinetics monitored over 6h. For *T. molitor*, experimetns were additionally conducted at 10, 150 and 1500 ml extractor scales to assess process performance upon scale-up. Maximum oil recoveries of 27.6% and 22.5% (w/w) were obtained at the 10 and 1500 ml scales, respectively. Under comparable laboratory-scale conditions, maximum recoveries of 18.5%, 18.3% and 17.3% (w/w) were obtained for *T. molitor*, *A. domesticus*, and *H. Illucens*, respectively. Overall, the results demonstrate the potential of SC-CO_2 as a solvent-efficient technology for insect lipid recovery and provide insights into the relationship between extraction kinetics, feedstock characteristics, and process efficiency.

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MW IRRADIATION AND FLOW CHEMISTRY APPROACHES FOR A MORE EFFICIENT SYNTHESIS OF 2*H*-AMINOCHROMENES

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The chromane scaffold is a common oxygen-containing heterocyclic core found in many bioactive natural products, metabolites, and pharmaceuticals.[1] Our group is interested in using the zwitterionic intermediate generated from electron-deficient allenes, such as allenic esters, in the presence of Lewis base (LB) catalysts (figure 1a) as reactive species for obtaining diverse chromane scaffolds. After exploring the reaction of allenic esters with nitrochromenes, which affords either cyclopenta[*c*]chromenes or chromeno[3,4-*b*]pyridines depending on the catalyst choice,[2] we shifted our focus to 4-iminochromanes. Unexpectedly, this study revealed an umpolung γ-addition of 4-iminochromanes to allenic esters that enabled the synthesis of 4-amino-2H-chromenes (figure 1b). Implementing greener synthetic techniques, such as microwave (MW) irradiation and flow chemistry can lead to a more efficient and less wasteful synthesis. In this communication, we compare the results obtained using batch, MW-assisted, and flow protocols.

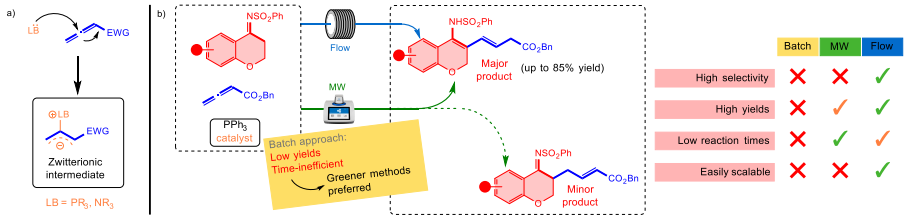


Figure 1: a) Zwitterionic intermediate; b) Umpolung γ-addition of 4-iminochromanes to allenoates.

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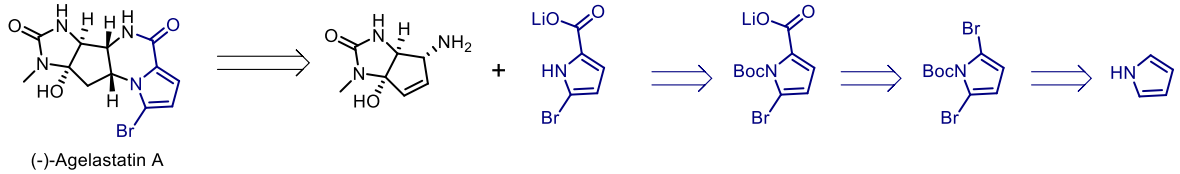
SYNTHESIS OF 5-BROMOPYRROLE-2-CARBOXYLATE TOWARDS THE TOTAL SYNTHESIS OF (-)-AGELASTATIN A

João Jorge*[1], João R. Vale[1], Carlos. A. M. Afonso[1]

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Agelastatin alkaloids have attracted scientific interest since the isolation of (-)-agelastatin A (AglA) from the sponge Agelas dendromorpha by Pietra et al. in 1993[1] and the discovery of its remarkable cytotoxicity against a variety of tumour cells.[2] Asymmetric synthesis is very challenging and requires laborious steps and protecting groups to construct the four contiguous nitrogen-bound stereocenters of the cyclopentane C-ring.[3]We have developed a strategy (Scheme 1) that involves the early-stage photochemical transformation of pyridinium salts to bicyclic vinyl aziridines that originate, in one step, the AglA's C-ring with the desired functionality and relative configuration. A sequence of nitrogen-carbon bond forming reactions culminated in the total synthesis of (-)-agelastatin A in 12 steps with 4% overall yield, using a single protective group.[4] Nevertheless, key problematic steps of this total synthesis were hindering scale up and reproducibility due to a challenging late-stage bromination reaction. We have recently improved the total yield and decreased the number of operations of the total synthesis by installing the bromine atom in early stage in a convergent approach.



Scheme 1. Retrosynthetic analysis of (-)-agelastatin A focused on the pyrrole ring.

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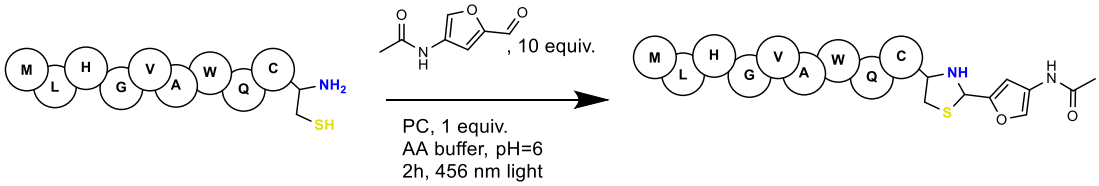
EXPLORATION OF N-TERMINAL FUNCTIONALIZATION OF PEPTIDES THROUGH PHOTOCATALYTIC PROCESSES

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Peptide functionalization is a valuable strategy for expanding the therapeutic potential of peptide-based molecules. This work explored a photocatalytic approach for N-terminal peptide modification using 3-acetamido-5-formylfuran (**3A5FF**), a renewable heterocycle derived from chitin biomass. [1,2] While N-terminal serine-containing peptides showed negligible oxazoline formation due to oxazolidine instability and rapid Schiff base formation, [3,4] N-terminal cysteine-containing peptides underwent efficient conversion to thiazoline derivatives, reaching up to 98.7% conversion depending on the photocatalyst used. Additionally, singlet oxygen-mediated oxidation of the furan moiety generated potentially useful bio-orthogonal intermediates. [5,6] These findings highlight the potential of chitin-derived building blocks and photocatalysis for sustainable peptide bioconjugation strategies.



Scheme 1- Preparation of N-terminal thiazolidines in Peptides via photocatalysis.

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A HYBRID ELECTROLYTE STRATEGY ENABLING WATER-DERIVED PROTONS IN LI-MEDIATED AMMONIA SYNTHESIS

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Ammonia has attracted increasing attention as a carbon-free energy carrier owing to its high hydrogen density and favorable liquefaction characteristics compared to molecular hydrogen. Despite its industrial maturity, the Haber–Bosch process remains intrinsically energy-intensive due to its reliance on high temperature and pressure operation, motivating the development of alternative ammonia synthesis pathways under ambient conditions. Among them, Li-mediated electrochemical nitrogen reduction has emerged as a promising route, yet its practical implementation is fundamentally constrained by the incompatibility between lithium-mediated nitrogen activation and aqueous proton sources.

Here, we demonstrate a reaction architecture that decouples lithium-mediated nitrogen activation from proton delivery, enabling the use of water-derived protons without destabilizing the Li–N_2 chemistry. This is achieved through a biphasic electrolyte configuration comprising an organic-phase catholyte and an aqueous-phase anolyte, separated by a cross-linked anion exchange membrane that selectively facilitates proton transport while suppressing water permeation. The resulting system sustains stable ammonia generation for 50 h with a Faradaic efficiency of approximately 60%.

By mitigating the long-standing incompatibility between lithium reactivity and water-based proton sources, this work demonstrates the feasibility of integrating aqueous chemistry into Li-mediated nitrogen reduction systems, while highlighting remaining challenges in long-term stability.

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SUPERCRITICAL WATER LIQUEFACTION OF MIXED PLASTIC WASTE CONTAMINATED WITH PET: INFLUENCE ON YIELDS AND PRODUCT COMPOSITION

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Mixed plastic waste streams invariably contain polyethylene terephthalate (PET) alongside polyolefins and polystyrene. Unlike polyolefins, PET degrades under supercritical water conditions via hydrolysis rather than radical chain scission, generating solid terephthalic acid (TPA) and oxygenated aromatic intermediates that suppress oil formation and cause operational equipment fouling and valve blockage. Supercritical water liquefaction (400–460 °C, ~25 MPa, 30–210 min) of mixed LDPE/PP/PS feedstocks was conducted in a 75 mL Hastelloy-C batch autoclave at controlled PET loadings of 10, 30 and 50 wt%. The four product phases (oil, gas, aqueous and solid) were characterised by GC-FID, GC-TCD/FID, HPLC and FTIR respectively. Oil yield fell from 64.3 wt% at 10 wt% PET to 24.5 wt% at 50 wt% PET, with carbon increasingly diverted to solid TPA and aqueous aromatic acids. The oil phase remained dominated by BTEX aromatics from polystyrene depolymerisation, with additional benzene arising from decarboxylation of PET-derived benzoic acid. Gas production (2–6.4 wt%) was primarily governed by experimental conditions, with CO2 becoming the dominant gas species at high PET loadings due to progressive decarboxylation of TPA intermediates. HPLC analysis of the aqueous phase revealed isophthalic acid accumulation up to ~32 mg mL−1 and persistent benzoic acid concentrations of 10–18 mg mL−1 at 30–50 wt% PET, both indicators of incomplete carbon recovery into the oil phase. Feedstock composition proved that the dominant control variable is the reaction conditions that primarily influenced gas formation rather than oil yield. A practical upper limit of 30 wt% PET is recommended for efficient supercritical water liquefaction of mixed plastic waste. Selective recovery of high-purity TPA from the solid phase offers an additional valorisation pathway compatible with circular economy objectives [1,2].

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VALORISATION OF COFFEE SILVERSKIN USING SUBCRITICAL WATER EXTRACTION

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Coffee silverskin (CS) is the main by-product of coffee roasting and is mainly composed of dietary fiber (cellulose, hemicellulose, and lignin) and proteins [1,3]. Its valorization can contribute to reducing agro-industrial waste and recovering valuable compounds. Subcritical water (SBW) is a promising sustainable approach, as it can act as an extraction and reaction medium without added chemicals. Moreover, its decreasing dielectric constant at higher temperatures enhances the solubilisation of less polar compounds, making the process fast and environmentally friendly [4,5].

The focus of this work is the extraction of bioactive compounds from CS using subcritical water at various conditions and the assessment of the viability of using subcritical water as an environmentally friendly solvent to hydrolyse the lignocellulosic fraction of CS. Extractions were carried in a batch apparatus at temperatures between 120-250°C, biomass-to-water rations from 1:10 to 1:50. The results showed that the yield increased between the temperatures of 120 and 180°C, reaching a yield of 35.1 g solids/ 100g initial CS. At temperatures between 220°C and 250°C, extraction yield decreases due to degradation reactions that result in the formation of products like furfural e 5-hydroxymethilfurfural.

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GC-MS BASED CHEMICAL PROFILING OF PORTUGUESE *CISTUS* SPP. AND ASSESSMENT OF BIOACTIVITY

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In the present study, the chemical profile of a Portuguese bioresource from a *Cistus* species was characterized by Gas Chromatography–Mass Spectrometry (GC-MS). A range of extraction methods (hot/cold maceration, Soxhlet extraction, microwave-assisted extraction, and ultrasound-assisted extraction) were applied using solvents of varying polarity (ethanol, hexane, water, methanol, butanol, propanol, diethyl ether, and ethyl acetate). These approaches were systematically evaluated and compared to obtain a comprehensive chemical profile to assess the potential for high-value bioeconomy applications. *Cistus* are widely recognized for their richness in polyphenolic compounds which are closely associated with strong antioxidant properties. Previous studies have demonstrated variability in both phenolic content and antioxidant activity, highlighting the importance of reliable analytical approaches to characterize their bioactive profiles. [1], [2] In light of these findings, the extracts were further assessed using DPPH radical scavenging and Folin–Ciocalteu assays to determine antioxidant capacity and total phenolic content, providing a preliminary evaluation of their bioactive potential.

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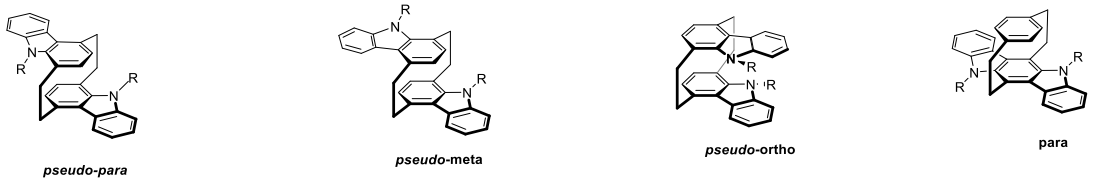


MOLECULAR ENGINEERING OF CARBAZOLOPHANE DONORS DERIVED FROM PCP SCAFFOLDS FOR TADF APPLICATIONS

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Compounds based on [2.2]paracyclophane (PCP) scaffolds have attracted considerable attention as versatile platforms for studying planar chirality, as well as through-space charge transport and electronic communication in π-stacked molecular systems.[1] The configurational rigidity of the PCP framework and its excellent chemical stability make it a robust molecular building block for organic electronic applications. In this work, we report the molecular design and ongoing synthesis of carbazolophane donors aimed at the construction of carbazole-functionalized PCP scaffolds, which integrate the structural features of both PCP and carbazole units.[2,3] These donor systems are envisioned as promising building blocks for thermally activated delayed fluorescence (TADF) materials. TADF materials are of particular interest for next-generation organic light-emitting devices due to their potential for high energy efficiency and reduced power consumption, contributing to more sustainable optoelectronic technologies.



Scheme 1: Synthesis plan

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CONJUGATION TUNING OF PORPHYRIN LINKERS FOR GREEN PHOTOACTIVE MOFS

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Metal-organic frameworks (MOFs) incorporating porphyrin linkers represent a versatile platform for sustainable optoelectronic materials, combining visible light absorption with structural tunability [1]. In this work, we explore a molecular design strategy to control the optoelectronic properties of porphyrin-based MOFs by tuning linker conjugation and peripheral substitution. Two classes of linkers including monomeric porphyrins and meso-meso coupled diporphyrins, each with and without methoxy substituents are employed to systematically extend π-conjugation and adjust electronic delocalization. Meso-meso coupling introduces a characteristic split Soret band and red-shifted Q-band absorption, consistent with enhanced charge delocalization across the coupled macrocycles. Furthermore, methoxy substitution modulates the exciton coupling geometry between the two porphyrin units, shifting the dominant electronic transition and suggesting distinct photophysical behaviours across the four linkers. The integration of these linkers into MOF structure is currently underway, targeting materials with tunable electronic structure and accessible porosity.

The target applications are solid-state chemical sensing and photoconductive response under visible light irradiation. As solid-state reusable materials requiring no solvent or consumable reagents, these MOFs offer a waste-free sensing platform aligned with Green Chemistry principles [2, 3], particularly the goals of real time environmental monitoring and energy efficient operation driven by sunlight. This work establishes a conjugation and substitution driven approach to the rational design of next generation photoactive porous materials.

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DESIGN AND OPTIMIZATION OF AQUEOUS TWO-PHASE SYSTEMS FOR BIOTECHNOLOGICAL APPLICATIONS AND WASTE VALORIZATION

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A wide range of separation techniques has been developed for processing vapor, liquid, solid, and multiphase mixtures, encompassing nearly 100 operations based on thermal, chemical, mechanical, and membrane-driven principles. Among these, Aqueous Two-Phase Systems (ATPS) have gained increasing attention due to their environmental sustainability, operational simplicity, scalability, and cost-effectiveness. In this context, the present work focuses on the design and optimization of ATPS based on ionic liquids (ILs) for applications in waste valorisation and biotechnological processes. Specifically, the ability of selected ionic liquids to induce phase separation in aqueous systems containing non-ionic surfactants was investigated. This approach is proposed as a platform technology for the recovery of valuable compounds from waste streams and as a pretreatment or integration step in bioprocesses, including oil-containing waste remediation and potential lipase production. Phase diagrams were determined at different temperatures and correlated using established thermodynamic models. The influence of operational variables on phase behaviour was systematically evaluated. Tie-lines were determined, and relevant parameters such as tie-line length and slope were calculated to characterize phase equilibrium. The experimental data were modelled through different empirical equations [1, 2]. The proposed IL-based ATPS demonstrated excellent performance in the extraction of model contaminants and metabolites from aqueous waste streams, highlighting the potential of IL-based ATPS not only as efficient separation platforms but also as enabling technologies for integrated bioprocesses. In particular, their application as downstream or auxiliary stages could significantly enhance biological treatments and facilitate the recovery of value-added products from complex waste matrices.

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IMPREGNATING IONIC LIQUIDS INTO A MOF: CATIONIC AND ANIONIC EFFECTS AND IMPACT ON SORBENT PROPERTIES

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Carbon dioxide (CO_2) is the main greenhouse gas driving global warming, making its mitigation fundamental. Among available technologies, gas adsorption and absorption are environmentally friendly approaches for CO_2 capture/separation. Both Metal-Organic Frameworks (MOFs) and ionic liquids (ILs) exhibit high CO_2 sorption capacity [1], and their combination into IL@MOF composites can enhance performance through synergistic effects [2-4].

In this work, different IL@MOF materials were produced. ILs with different structures were carefully chosen and impregnated into ZIF-8, at a constant IL molar loading, to study the anion and cation effects. Using a standard static gravimetric method, gas sorption-desorption measurements were performed at 303 K, between 0-10 bar. The tailoring of the cationic/anionic structures promoted synergistic effects that improved sorbent properties such as gas sorption capacity and selectivity performance between 0-1 bar.

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PVDF DISSOLUTION BY BIO-BASED SOLVENTS FOR IMPROVED LITHIUM-ION BATTERY RECYCLING

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In the recycling of spent lithium-ion batteries (LIBs), the separation of cathode materials from the aluminum current collector is a critical step to simplify downstream metal recovery processes.[1] This involves the removal of the polyvinylidene fluoride (PVDF) binder, which is typically achieved via its thermal degradation due to its lower economic values. However, this approach neglects not only potential environmental impacts from the release of fluorinated compounds such as hydrofluoric acid (HF), but also significant process gains during leaching (improved mass transfer) and separation. Solvent-based approaches for the removal of PVDF were proposed, but the strong adhesion of the PVDF binder hinders this separation for most solvents, relying instead on environmentally problematic options such as n-methyl-2-pyrrolidone (NMP).[2]

In this work, bio-based solvents are proposed as an alternative to N-methyl-2-pyrrolidone (NMP), aiming to enable efficient cathode material separation and the sustainable recovery of PVDF and the electrolyte. A computational methodology based on COSMO-RS was developed for the rapid in-silico screening of over 100 potential solvent alternatives, with the most promising substitutes experimentally validated. The influence of solvent polarity and solvent–polymer interactions on process efficiency was evaluated, and a full process including solvent reuse and PDVF recovery developed and validated on real LIB cathode.

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TAILORING IRON OXIDES BY SURFACTANT-ASSISTED PECHINI ROUTE WITH APPLICATION IN POLLUTANTS DETECTION

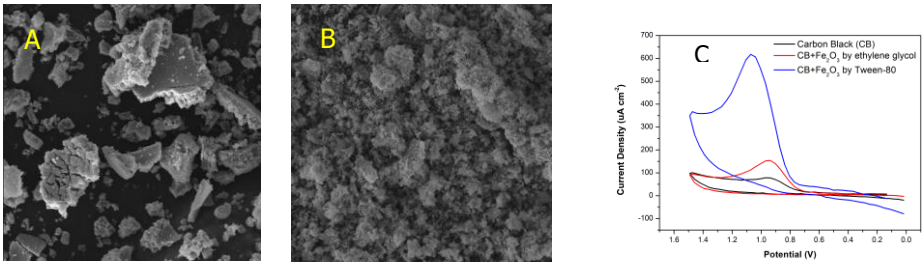
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Fe_2O_3 based materials are widely applied in photocatalysis and water pollutant remediation within green energy technologies [1]. However, the conventional Pechini method, widely used to synthesize materials, uses ethylene glycol, resulting in particle agglomeration [1,2]. In this work, Fe_2O_3 particles were synthesized by Pechini method using ethylene glycol and surfactant-assisted with Tween-80. Particles were characterized by SEM images (Figure 1A–B) and cyclic voltammetry by carbon-based paste electrode, for phenol detection (5.7 mmol L^{-1}) (Figure 1C).

Figure 1. SEM images of Fe_2O_3 particles produced with ethylene glycol in A, Tween-80 in B and phenol detection by cyclic voltammetry (500mV s^{-1} in 0.1M Na_2SO_4 as supporting electrolyte) in C.



SEM images showed Tween-80 produced smaller and less agglomerated particles, comparing with ethylene glycol use, indicating a higher surface area. XRD indicated an increased in maghemite (γ-Fe_2O_3) fraction for the Tween-80 route. Consequently, electrodes prepared with surfactant material exhibited enhanced electrochemical response for phenol detection.

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SUSTAINABLE APPROACHES TO TEAR BIOFLUID ANALYSIS BY LC-MS/MS

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The convergence of non-invasive tear analysis, preventive medicine, and advanced analytical techniques offers a promising path toward sustainable, personalized healthcare [1]. Tears are an accessible biofluid that contains molecular information relevant to disease diagnostics, and their collection generates minimal environmental impact compared to conventional blood sampling [1,2].

This study focuses on the green analytical chemistry for tear biomarker selection, employing liquid chromatography coupled to tandem mass spectrometry (LC-MS/MS) with electrospray ionization (ESI). Emphasis is placed on optimizing sample preparation for analysis methodologies to reduce solvent consumption, minimizing sample volumes, and validate analytical conditions with lower chemical waste, thereby aligning chemical analysis with environmentally responsible practices.

By integrating sustainability principles into advanced LC–MS/MS workflows, this approach enhances the analytical potential of tear fluid while demonstrating the effective implementation of green chemistry strategies in high-performance chemical analysis. Tear samples from healthy volunteers will contribute to a deeper understanding of tear biochemical composition while advancing greener analytical methodologies.



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PH-RESPONSIVE DELIVERY OF TYROSOL USING MOLECULARLY IMPRINTED POLYMERS PREPARED IN SUPERCRITICAL CO_2

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Tyrosol (TY) is a bioactive phenolic compound with antioxidant and anti-inflammatory properties, with potential nutraceutical and therapeutic applications [1]. However, its effective delivery requires systems capable of controlling its release under physiological conditions. In this work, molecularly imprinted polymers (MIPs) were designed as selective carriers for TY, using functional monomers with pH-responsive behaviour [2]. The materials were synthesized using supercritical carbon dioxide ($scCO_2$) as a green processing medium, enabling the production of solvent-free polymers while preserving their porous structure and functional integrity [3]. Further, TY loading was achieved through $scCO_2$-assisted impregnation, followed by *in vitro* release studies under simulated gastrointestinal conditions. The results showed that MIPs exhibited enhanced release compared with NIPs, while pH-responsive functionalities enabled distinct release profiles under the simulated gastric and intestinal environments. These results demonstrate the potential of combining molecular imprinting and green processing to develop tunable oral delivery systems for phenolic compounds.

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SUSTAINABLE XYLANASE PRODUCTION THROUGH VALORIZATION OF OLIVE OIL BY-PRODUCT

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The olive oil industry in Uruguay generates increasing amounts of *alperujo* (olive mill pomace), a semi-solid residue with high moisture and phenolic content, posing environmental challenges. Developing sustainable alternatives for its utilization is therefore of growing interest [1,2].

Within a biorefinery-oriented framework, this study focuses on xylanase production using alperujo derived from *Olea europaea* cv. *Coratina* as substrate. Two microbial strains, *Bacillus* sp. 12-22 and *Moesziomyces bullatus* 97-87, previously identified as endo-xylanase producers, were evaluated [3]. The bacterial strain produces xylanase without β-xylosidase co-expression, while the yeast-derived enzymatic extract lacks cellulase activity, features relevant for selective industrial applications.

Cultivation was performed using raw and pretreated alperujo, including lipid removal by hexane extraction and autohydrolysis. Process variables such as substrate concentration, inoculum size, fermentation time, and the presence or absence of olive pits were assessed. Both pretreatments enhanced xylanolytic activity, showing a synergistic effect. Olive pits positively influenced enzyme production in *M.* bullatus, whereas acid hydrolysis was detrimental under the conditions tested. Enzyme production reached up to 130 EU g^{-1} dry substrate for the yeast and 215 EU g^{-1} for *Bacillus* sp, highlighting the potential of alperujo as a low-cost substrate.

The use of the residue obtained after supercritical fluid extraction is currently under study for enzyme production, as part of a broader sequential valorization strategy.

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BALANCING ADSORPTION EFFICIENCY AND SUSTAINABILITY: A GREEN METRICS APPROACH TO SELECTING BIOCHAR FOR DEFERIPRONE REMOVAL

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Emerging pharmaceutical contaminants in aquatic systems require treatment strategies that are both effective and sustainable. This study evaluates agricultural waste-derived biochars from sugarcane bagasse, coffee grounds, and coconut processing waste as low-cost adsorbents for the removal of deferiprone (DFP), a widely used drug in Thailand. Surface modifications (iron, acid, and base treatments) were applied to enhance adsorption performance. Batch experiments showed that Fe-modified biochars achieved complete removal (100%); however, improved performance did not consistently align with sustainability. Notably, coconut biomass residues-derived biochar showed high removal even with minimal modification, highlighting the importance of feedstock selection. To assess sustainability, green chemistry metrics (Path2Green[1] and AGREEprep[2]) were integrated with adsorption performance. Results showed that additional processing steps and chemical inputs reduced overall greenness despite improving efficiency. By balancing performance with green metrics, acid-treated coconut waste biochar (ACWB) was identified as the optimal adsorbent. Kinetic and equilibrium analyses showed that adsorption using ACWB followed a nonlinear pseudo-second-order model and a Freundlich isotherm, indicating chemisorption on a heterogeneous surface. Characterization further supported a combined physisorption–chemisorption adsorption mechanism. When applied to real pharmaceutical wastewater, ASBB achieved an adsorption capacity of 263 mg/g (27% removal). Overall, integrating green chemistry metrics with adsorption performance enables a more informed, sustainable selection of adsorbents for water treatment applications.

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BIOOXIDATION OF GRAPHITE FOIL WITH WHITE-ROT FUNGI

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Graphite is widely used in advanced materials due to its excellent electrical and mechanical properties However, its intrinsic hydrophobicity limits surface interactions and functional applications. In this study, a biological approach based on the white-rot fungus *Phanerochaete chrysosporium* was explored as a mild method for modifying graphite surfaces under aqueous conditions.

Structural changes were monitored using Raman spectroscopy, while surface wettability was evaluated through water contact angle measurements. The results indicate a progressive increase in structural disorder accompanied by a significant enhancement in surface hydrophilicity.

The observed relationship between defect formation and wettability suggests that fungal treatment induces surface modification of graphite, leading to improved interfacial properties. This approach offers a simple and environmentally friendly route for modifying carbon materials for advanced applications.



WASTE TIRE PYROLYSIS AS AN INTEGRATED CARBON RECOVERY ROUTE: DIRECT CO_2 EMISSIONS FROM ENERGY FRACTIONS AND CARBON RETENTION IN RECOVERED CARBON BLACK

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Waste tire pyrolysis offers an alternative to conventional disposal by converting a high-carbon-content residue into recovered carbon black (rCB), tire pyrolysis oil (TPO) and non-condensable gases1,2. In this work, the pyrolysis process is assessed as a carbon recovery route, mainly through direct CO_2 emissions from the combustible fractions and carbon retention in the solid product. To this end, the mass balance of the products obtained from the pyrolysis of waste tire samples at 300, 400 and 500 °C, with particle sizes smaller than 0.50 mm (16 mesh), will be determined, and the solid, oil and gas fractions will be characterized by elemental analysis (CHN) to quantify the carbon distribution in each by-product. Direct CO_2 emissions from rCB will be estimated based on mass and elemental composition, while TPO and non-condensable gasses will be evaluated using fuel composition obtained by gas chromatography (GC-TCD-FID). The higher and lower heating values (HHV/LHV) will be obtained by differential scanning calorimetry (DSC) to assess the energy potential of each by-product. The results will support the interpretation of waste tire pyrolysis as a promising route for the valorization of solid waste within a lower-carbon circular economy.

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POROUS CARBON MATERIALS DERIVED FROM INVASIVE SEAWEEDS AS EFFICIENT RECOVERY AGENTS FOR NEODYMIUM

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The growing demand for rare earth elements, such as neodymium (Nd), combined with increasing environmental contamination in aquatic systems, highlights the need for sustainable and efficient removal technologies. This study explores the valorisation of the invasive brown seaweed *Sargassum muticum*, collected from the Portuguese marine coast, as a precursor to produce carbonaceous bio-adsorbents capable of removing Nd from aqueous solutions. Biochar and activated carbons were produced through pyrolysis followed by physical and chemical activation, generating BC, BC-W, SM-CO_2-30min, SM-H_3PO_4 and SM-K_2CO_3 materials. The adsorbents were characterized using CHNS analysis, SEM-EDS, thermal analysis, N_2 adsorption–desorption, and FTIR. Batch adsorption experiments were conducted using Nd solutions of known concentration, with metal quantification performed by ICP-AES. Among the produced materials, SM-CO_2-30min showed the best performance for Nd removal, achieving 63.61% removal under batch conditions (10 mg adsorbent, 20 mL of 200 mg L^{-1} solution). Its high efficiency is attributed to the elevated mineral content derived from the algal precursor, with an ash content of 66.24%, which enhances ion-exchange interactions with Nd ions. Biochar also exhibited notable performance due to its significant mineral fraction. The equilibrium uptake capacity of SM-CO_2-30min was more than 16 times higher than that of the commercial activated carbon used for comparison. Freundlich isotherm modelling suggested multilayer adsorption on heterogeneous surfaces.

These results demonstrate the potential of converting invasive marine biomass into sustainable materials for rare-earth metal recovery from water streams.

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GREEN FABRICATION OF CHITOSAN-BASED MICROCAPSULE STRUCTURES FOR SUSTAINABLE MATERIAL APPLICATIONS

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Microencapsulation has attracted significant attention as an effective strategy for developing functional materials such as self-healing systems and controlled-release platforms. However, conventional microcapsule fabrication often relies on synthetic polymers and environmentally harmful chemicals, which raises concerns regarding sustainability. In this study, an eco-friendly approach for fabricating microcapsule structures using chitosan, a biodegradable and bio-based polymer derived from natural resources, was investigated.

Chitosan was employed as a shell-forming material to develop environmentally benign microcapsule architectures through a green fabrication process. The influence of synthesis conditions on capsule formation was investigated, and the resulting structures were systematically characterized. Fourier transform infrared spectroscopy (FT-IR) was used to confirm the chemical structure of the chitosan-based capsules. Morphological characteristics were analysed using scanning electron microscopy (SEM), while particle size distribution was evaluated through particle size analysis (PSA).

The results confirmed the successful formation of stable and nearly spherical capsule structures. In addition, the capsule size could be controlled by adjusting the synthesis conditions, indicating the feasibility of tailoring capsule dimensions depending on the type of encapsulated materials and the intended application. These findings highlight the potential of bio-based polymers for sustainable microencapsulation systems and provide a green platform for future development of functional capsule systems applicable to smart materials, including self-healing textile systems.

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LIGNIN UPCYCLING ON BIODEGRADABLE COMPOSITES FOR FOOD PACKAGING

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Lignin is the most abundant aromatic biopolymer, but is regarded as waste within the paper and pulp industry, responsible for producing 150 million tons of chemical pulp annually, from which 70 million tons are estimated to be lignin [1, 2]. As the process byproduct, 98% of technical lignin is incinerated for internal energy production, and 2% is commercialized [1]. This project aimed to valorise technical lignin, a renewable resource, as filler in bio-based PLA/lignin composites to apply to the food packaging market, which has been searching for biobased materials with adequate mechanical resistance, stability and low cost [3]. Kraft lignin was isolated from the industrial liquors through acidification and precipitation. The isolated lignin was characterised through 13C NMR, Folin-Ciocalteu's colorimetric method, FTIR, and determination of its inorganic content. Lignin was chemically modified to better blend with PLA via acetylation. The efficiency of the modification was evaluated through 13C NMR, Folin-Ciocalteu's colorimetric method, FTIR, and their inorganic content. PLA/lignin composites were produced by melt blending followed by injection moulding, with kraft lignin, before and after their chemical modification, whose content varied from 5 to 20%. The mechanical properties of the different blends were studied, to evaluate whether lignin improves PLA's properties, and which formulation best suits the food packaging industry's demands.

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DEVELOPMENT OF SUSTAINABLE BIO-BASED MICROCAPSULES FOR TEXTILE FUNCTIONALIZATION

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Textile functionalization converts fabrics beyond their traditional role, with essential oils (EOs) as key active ingredients for their potential antimicrobial, anti-inflammatory, and antioxidant effects [1,2]. Since EOs are prone to degradation, microencapsulation is used to enhance their stability and control their release [2]. However, conventional commercial shell materials are toxic or plastic-based, raising environmental and health concerns [1]. This project studied the sustainable microencapsulation of an EO via complex coacervation, a scalable, solvent-free method [3], using biodegradable, bio-based shells – chitosan and an innovative protein. Key parameters were systematically optimized through optical microscopy (OM) and laser diffraction (LD). Chemical structure and encapsulation efficiency (EE) were studied by FTIR and GC-MS. Health and wellness-oriented fabrics were produced through capsule impregnation using the pad–dry method and characterized by scanning electron microscopy (SEM). Promising formulations showed spherical microcapsules with low aggregation, achieving an EE of (91.7 ± 0.9) % and a mean particle size of (19.71 ± 0.16) µm, with confirmed stability after 21 days. SEM revealed partial capsule adhesion to textiles. Padding roller pressure led to capsule rupture, highlighting the need to improve shell resistance and fabric adhesion. A stable, sustainable formulation was successfully developed with preliminary textile evaluations showing promising performance pending further optimization.

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SHAPING ZIF-8 IN CHITOSAN – IN-SITU GROWTH AND POWDER DISPERSION FOR ENHANCED CO_2 CAPTURE

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Global temperatures have consistently risen in the 21st century, with the 23 warmest years occurring in this period out of 174 recorded years [1]. Climate change is primarily driven by greenhouse gas (GHG) emissions, particularly CO_2, making emission mitigation essential [2]. Metal–organic frameworks (MOFs) are promising for gas separation due to their high surface area and tunable porosity [3], but their powder form limits industrial application. Integration into polymeric matrices offers an effective solution. Here, ZIF-8 was structured into chitosan-based macroscopic fibers via particle dispersion and in-situ growth. The latter improved MOF distribution, loading, and porosity preservation, enhancing adsorption performance. Supercritical CO_2 drying and covalent crosslinking further textural properties. The composites showed a synergistic effect at sub-atmospheric pressure, achieving higher CO_2 uptake than pristine ZIF-8 and chitosan aerogels. The best material reached 65% higher uptake than ZIF-8 at low pressure. Ideal selectivity for CO_2/N_2 and CO_2/CH_4 mixtures was calculated, showing enhanced selectivity, ranging from ~4–8.5× for CO_2/N_2 and ~3.8–8.5× for CO_2/CH_4 compared to pristine ZIF-8. All materials were obtained as macroscopic fibers, overcoming powder limitations and exhibiting enhanced CO_2 selectivity, highlighting in-situ MOF growth in biopolymers as a scalable and sustainable strategy.

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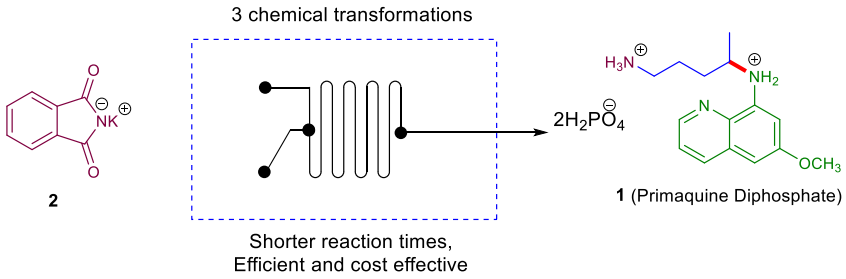
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CONTINUOUS FLOW SYNTHESIS OF PRIMAQUINE DIPHOSPHATE AN ANTI-MALARIAL DRUG

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Malaria is one of the world's most infectious diseases. It is present in over 80 countries with the most affected population being children under 5 years of age, pregnant women and HIV-AIDS patients.[1] According to the WHO's 2019 World Malaria Report, there were 229 million cases and an estimated 409,000 deaths worldwide while in 2018, 228 million cases and 411,000 deaths were recorded. The African region was reported to have accounted for 94% of all global cases and deaths; 67% of deaths worldwide were of children under the age of 5 years.[2] It is therefore paramount that access and availability to potent anti-malarials be improved especially in low developing economies. This can potentially be achieved through local drug manufacture and capacity development using cost efficient and effective technologies such as continuous flow technology. Herein, we present, the continuous flow synthesis of Primaquine Diphosphate **1**, an antihypnozoite 8-aminoquinoline compound which was furnished from readily available potassium phthalimide **2** *via* three chemical transformations; phase transfer catalyzed *n*-alkylation, reductive amination and phthalimido deprotection all in good yields and in shorter reaction times compared to the batch processes disclosed in literature.[3]



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ZERO-CARBON SEAWATER DESALINATION WITH ELECTRICITY COGENERATION VIA PROCESS INTENSIFICATION AND GENETIC ALGORITHM OPTIMISATION

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Potable water is fundamental to sustaining human life. However, its accessibility remains a critical global challenge. This is paradoxical because 71% f the Earth's surface is covered with water, yet nearly 97% of it is saline and unsuitable for direct human consumption [1]. At the same time, approximately 44.6% of the world's population lives within 150 kilometres of a coastline, which highlights the strategic potential of desalination technologies [2]. This makes seawater desalination a strategically vital solution. We propose a zero-carbon desalination system that co-generates electricity. To decouple the energy-water nexus of multi-effect distillation (MED), a solar collector is integrated with vapour compression components. An organic Rankine cycle (ORC) is coupled with the solar field and steam boiler to minimise external energy demand; the ORC-generated electricity powers the solar system, reducing both energy requirements and the MED unit's equipment load. A theoretical framework of the proposed system is developed and validated using data from three operational plants (Tripoli, Kish Island, Umm Al-Nar). A genetic algorithm identifies globally optimal parameters, yielding substantially higher productivity and lower cost than the reference plant. This sustainable approach offers strong potential to mitigate global potable water scarcity.

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Keywords: *Multi-effect desalinator; solar system; organic Rankine cycle; process integration; multi-objective optimisation; cost and productivity*



HOMOGENEOUS CO(II) CRYPTATES FOR LIGHT-DRIVEN CO2 TRANSFORMATION: OPTIMISATION AND SCALE-UP

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In recent decades, population growth and industrialisation have increased atmospheric CO2 levels thought fossil fuel combustion and other human activities, disrupting the natural carbon cycle and intensifying climate change. To mitigate these effects, research have focused on carbon capture and storage (CCS) and carbon capture and utilisation (CCU). Within CCU, photoreduction of CO2 has offer a promising strategy to convert CO2 into value-added chemicals and liquid fuel precursors, using catalytic systems capable of driving this transformation under light irradiation. In homogeneous media, CO2 photoreduction typically relies on three key components: the catalyst (which in the active form, converts CO2), the sacrificial donor (donates electrons and is consumed) and the photosensitizer (absorbs light and mediates the electronic transfer between the catalyst and the sacrificial donor).

We present the synthesis and characterization of Co(II)/Co(II)[1] and Co(II)/Zn(II)[2] dinuclear cryptates bearing a bromo substituent in the aromatic ring, together with their application in CO2 photoreduction and optimisation. System optimisation led to TONCO values exceeding those previously reported for this catalyst family.[3] We also present preliminary scale-up studies were performed at laboratory scale.

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CO_2 HYDROGENATION TO FORMIC ACID ASSISTED BY MN CATALYSTS

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The unprecedented rise in atmospheric CO_2 levels is driving severe and unpredictable consequences on Earth's climate. Hence, the development of efficient strategies to reduce atmospheric CO_2 while simultaneously converting it into valuable products is crucial. In this context, the transformation of CO_2 into formic acid (FA) represents a promising carbon recycling pathway, important in the energy and chemical sectors [1]. Particularly, the chemical reduction of CO_2 to FA through homogeneous hydrogenation has been extensively investigated. Typically, this reaction is catalyzed by transition metal complexes, with manganese (Mn)-based systems in acetonitrile reported as effective catalysts [2]. In this work, we investigate the superbase DBU-assisted hydrogenation of CO_2 to FA catalyzed by a series of bromo tricarbonyl Mn complexes, coordinated by bidentate bis N-heterocyclic carbene (bNHC), bis triazole (btrz) or pyridine (py) ligands, and were previously synthesized and characterized [3,4]. Reaction parameters—including temperature, pressure, DBU and catalyst loading—were fully optimized, aiming to develop a sustainable CO_2 conversion system with high yield toward FA.

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Fe_3O_4 ENHANCES CHAIN ELONGATION FROM CO_2 AND H_2

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Utilizing CO_2 through microbial fermentation offers an environmentally friendly solution to mitigate global climate change while simultaneously reducing our reliance on fossil fuels for chemical synthesis (1).Nanomaterials such as Fe_3O_4 and MnO_2 accelerate CO_2 bioconversion by acting as electrical conduits that could enhance extracellular electron transfer (EET) and lowering the activation energy of key Wood-Ljungdahl-Pathway steps (1).Most CO_2 fermentation results in acetate as the primary product but Medium-chain carboxylic acids (MCCAs) are a better choice because their longer carbon chains provide higher energy density, greater commercial value, and lower water solubility, making them significantly easier to extract from the fermentation broth (1).In our study, an anaerobic semi-batch experiments were conducted using enriched mixed microbial cultures (MMC) under H_2/CO_2 (80:20) as the primary electron and carbon source respectively, with ethanol (6500mg/L) as a co-substrate for chain elongation. In the absence of ethanol, acetate was the primary product (2468mg/L). Ethanol added reactor accumulated acetic acid, butyric acid, and caproic acid at 1346, 603, and 841mg/L, respectively. Fe_3O_4 supplementation resulted in an enhanced product synthesis of longer-chain products, with caproate becoming dominant (3128mg/L), accompanied by butyrate (1467mg/L) and a reduced acetate accumulation (881mg/L). Concentration of Fe_3O_4 plays a role in product selectivity and activity of the biocatalysts. Concentrations in range 100-300mg/L performed well for caproate synthesis and productivity decreased considerably at 500mg/L addition with highest caproate observed at 200mg/L supplementation, reaching >4000mg/L. It was also observed that gas feeding interval was a major contributor to product selectivity with frequent replenishment selecting for acetate as primary product and 48-72 Hr interval of gas feeding attributed to chain elongation products mainly as caproate. SEM imaging showed the NPs jacketing the biocatalysts surface which could be aiding the increased tolerance of caproate within the reactor microenvironment. Preliminary TEA and LCA suggest improved process feasibility and reduced environmental impact for Fe_3O_4-assisted CO_2 conversion. These findings highlight Fe_3O_4-mediated chain elongation as a viable strategy for enhancing CO_2-to-MCFA bioconversion, supporting scalable and sustainable carbon utilization.

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FERRIHYDRITE-BASED CATALYSTS FOR SYNTHETIC WAX PRODUCTION VIA FISCHER-TROPSCH SYNTHESIS

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Fischer-Tropsch synthesis (FTS) is an attractive technology for producing synthetic wax from syngas (CO + H2). The resulting synthetic wax serves as an important intermediate for fuels, lubricants, and specialty chemicals and has emerged as a promising precursor for sustainable aviation fuel (SAF) production. Iron-based catalysts are widely used in FTS due to their high activity, low cost, and intrinsic water-gas shift (WGS) activity. These catalysts are typically present as hematite (α-Fe2O3) and require reduction and carburization to form the active iron carbide phases prior to reaction [1-2]. Ferrihydrite is a poorly crystalline iron oxyhydroxide (FeOOH·nH2O) that commonly forms in iron-containing aqueous environments. Owing to its high surface area, large pore volume, and small crystallite size, ferrihydrite has attracted considerable interest as a promising precursor for iron-based catalysts in FTS [3]. However, the reduction and carburization behavior of ferrihydrite-based catalysts and its impact on catalytic performance in Fischer-Tropsch synthesis remain poorly understood.

In this study, ferrihydrite-based catalysts were synthesized and systematically compared with conventional hematite-based catalysts under various syngas activation pressures. The ferrihydrite-based catalysts exhibited enhanced reducibility and carburizability, enabling the formation of active iron carbide phases even under high-pressure conditions and leading to significantly improved C5+ selectivity compared with conventional hematite-based catalysts.

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INTERFACIAL MECHANISM OF CO_2 ELECTROREDUCTION ON Cu/Zn-MODIFIED ELECTRODES INVESTIGATED BY EIS–DRT ANALYSIS

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Fossil fuels remain the dominant energy source for most industrial and human activities, significantly contributing to environmental degradation and the global energy crisis. Their continued use has led to unprecedented CO_2 emissions, with atmospheric concentrations reaching 422.8 ppm in 2024, well above the widely accepted safe limit of 350 ppm [1]. This increase has intensified environmental issues such as global warming, climate change, and ocean acidification. Among the proposed mitigation strategies, the conversion of CO_2 into value-added products has gained considerable attention. In this context, the electrocatalytic CO_2 reduction reaction (CO_2RR) represents a promising approach due to its mild operating conditions and compatibility with renewable electricity sources. Despite significant progress in the development of electrocatalysts and catalyst supports, a deeper understanding of the interactions between CO_2, the electrical double layer, and the electrode surface remains essential for improving catalytic performance. In this work, Zn-modified Cu electrodes were investigated as model systems for CO_2RR. The electrodes were prepared through a simple and cost-effective procedure, where Zn deposition was performed using an ammonium-containing electrolyte. The electrode/electrolyte interface was analyzed by electrochemical impedance spectroscopy (EIS) coupled with distribution of relaxation times (DRT) [2], enabling the separation of the different physicochemical processes occurring at the interface. The results reveal that the synergistic interaction between Zn species and NH_4^+ ions influences the interfacial kinetics in the presence of CO_2, contributing to the stabilization of the electrode surface and modifying charge transfer processes and double-layer structure. These findings were further validated on Cu/Zn-modified nickel foam electrodes, representing a first step toward the development of scalable catalytic architectures for practical CO_2 electroreduction systems.

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STUDY AND DEVELOPMENT OF INNOVATIVE PROCESSES AND MATERIALS FOR THE SYNTHESIS OF HYDROGEN CARRIERS FROM CO_2

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Sustainable Aviation Fuels (SAFs) production can be pursued through a multi-step circular economy pathway: targeting acetic acid from CO_2 electroreduction (CO_2-ER), upgrading it to acetone, and reaching jet fuel precursors. While CO_2-ER in solid-state electrolyte flow-cells effectively produces aqueous solutions of C_1-C_2 carboxylic acids (15–30 wt%) [1], synthesizing longer-chain compounds remains a challenge. A primary obstacle is the downstream upgrading of these intermediates, as high-water content typically poisons bulk catalysts during ketonization.

In this work, novel hybrid catalysts (MnO, Al_2O_3, ZrO_2, Na-ZrO_2, Ga-ZrO_2, Zn-ZrO_2, CeO_2, Na-CeO_2, $CeZrO_2$, Na-$CeZrO_2$) supported on high surface area carbon were investigated to bridge the gap between CO_2-ER outputs and fuel synthesis. The catalysts were prepared by incipient wetness impregnation and characterized by XPS, XRD, SEM-EDS, N_2-porosimetry, H_2-TPR, CO_2 and NH_3-TPD. This study examines the gas-phase ketonization of 15 wt.% aqueous acetic acid over these materials. Several catalysts showed higher activity than the benchmark [1]. This improvement is attributed to Na^+ ions in the most active systems (Na-ZrO_2/C and Na-$CeZrO_2$/C), which achieved acetone productivities of 4.02 and 4.16 $g_{KETONES} \cdot g_{A.P.}^{-1} \cdot h^{-1}$ respectively, versus 3.56 $g_{KETONES} \cdot g_{A.P.}^{-1} \cdot h^{-1}$ for the benchmark.

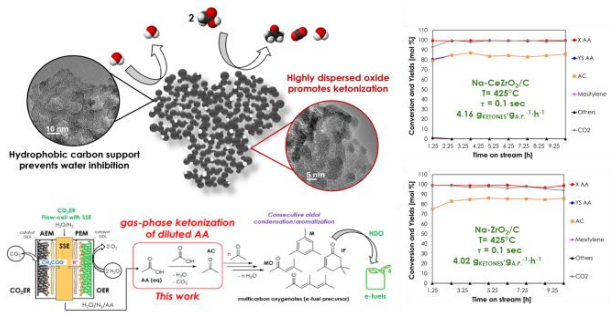


Figure 1. Proposed cascade approach towards multi-carbon e-chemicals and e-fuels and main results of this study. Symbols: acetic acid conversion (X AA), sum of yields (YS AA), acetone yield (AC), CO_2 yield, mesitylene yield (M), unknown compounds (Others).

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MESOPOROUS TiO_2 AS SUPPORT FOR Co-Ce PROX CATALYSTS

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It is well known that H_2-polymer electrolyte membrane fuel cells (PEMFCs) are operated at relatively low temperatures (80°C) and their Pt-anode catalyst is extremely sensitive to CO (1%) in reformed gases, which poisons the catalyst. CO concentration has to be reduced to below 10 ppm. PROX reaction is a simple, efficient, and economic method for CO removal from hydrogen rich streams in comparison with other methods. Co-based catalysts have shown promising performance for the CO PROX reaction. Different studies indicate that a highly oxidized form of cobalt that exhibits strong interaction with a support allows CO activation that could lead to high activity for the preferential oxidation of CO in excess H_2. Mesoporous materials have attracted much attention because of their large specific surface area, uniform pore-size distribution, and large pore size. A mesoporous TiO_2 support is scarily investigated as a support in PROX reaction although TiO_2 is an active reducible oxide, low-cost, widely available and environmentally friendly material.

This work is focused on the investigation of the structural and catalytic properties of series of mono component Co and bi-component Co-Ce catalysts supported on mesoporous TiO_2. The obtained materials were characterized by SAXS, N_2 adsorption-desorption, X-ray diffraction, SEM and HRTEM microscopy, XPS, XAS, diffuse reflectance infrared spectroscopy (DRIRS).

Catalytic tests showed that cerium modified the catalytic behavior of cobalt in PROX process. Because of close interaction and good contact between Co_3O_4 and CeO_2 in the bi-component Co-Ce samples, more surface oxygen species are provided to the cobalt oxide. Another factor controlling the activity of the catalysts is most likely the part of oxide phases reducing at lower temperatures. These phases prevail at 1Co2Ce (1:2 mol ratio) catalyst according TPR data.

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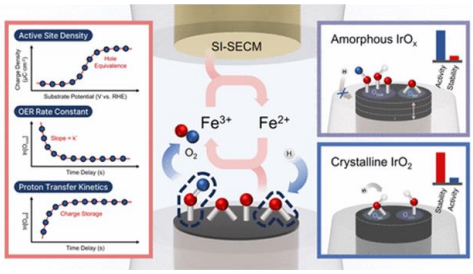
SCANNING ELECTROCHEMICAL MICROSCOPY: IN OPERANDO ANALYSIS OF ELECTROCATALYTIC, BIO-INTERFACIAL, AND GAS-EVOLVING SURFACES

Hyun S. Ahn*

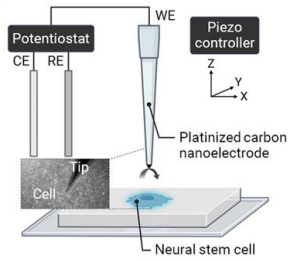
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This communication will introduce advancements in operando scanning electrochemical microscopy (SECM) technologies involving three key area: 1) transient analysis of the reactive catalytic surfaces capturing reaction intermediates and key kinetic parameters[1], 2) analysis of the bio-interfacial surfaces and boundaries for the detection of signaling cascade processes and understanding of the cellular language[2], and 3) gas-phase SECM for the microscopic spatiotemporally-resolved analysis of various gas-evolving surfaces for the deeper understanding of the chemical processes involving gaseous reactants and products[3,4].

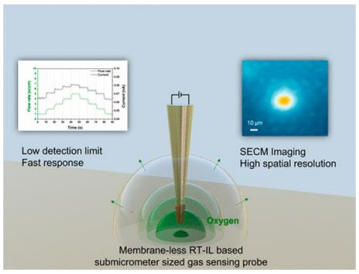
1) Electrocatalysis



2) Bio-interface



3) Gas-evolving surface



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SELECTIVE LEACHING OF LI-ION BATTERY METAL SCRAP WITHOUT EXTERNAL REDUCING AGENTS

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In lithium-ion battery (LIB) pretreatment, black mass can be lost together with metal scraps, a level comparable to the material loss occurring during subsequent metal extraction. Despite this considerable loss, relatively few studies have focused on recovering valuable metals from metal scraps. Here, we demonstrate selective leaching of approximately 95% of transition metals from metal scraps using 2 M sulfuric acid (H_2SO_4) at a high solid-to-liquid ratio of 250 g/L, without external reducing agents and with negligible copper loss. Rapid dissolution of aluminium inherently present in the scraps facilitates galvanic leaching by supplying reducing power while simultaneously lowering the redox potential of the leachate, thereby suppressing copper dissolution. Any dissolved copper is further recovered as metallic copper through cementation. Unlike conventional H_2O_2-assisted leaching, which can promote copper dissolution, the use of intrinsic aluminium eliminates the need for an external reducing agent while minimizing copper loss and the subsequent separation burden. Furthermore, operation at high solid-to-liquid ratios of 250–300 g/L results in relatively high leachate pH, lowering the alkali demand and salt generation associated with downstream neutralization. Overall, this selective leaching approach reduces resource loss while lowering chemical consumption and downstream processing requirements, providing a more sustainable route for LIB recycling.

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FOUR-COMPONENT NICKEL-BASED CATALYST FOR EFFICIENT HYDROLYSIS OF SODIUM BOROHYDRIDE

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One of the most important properties of hydrogen storage materials is their high gravimetric hydrogen capacity. Gravimetric hydrogen capacity is a measure of how much hydrogen mass can be stored per unit mass of the entire system or material. Some of those materials could be liquid ammonia, various organic compounds, or solid materials such as metal hydrides, complex hydrides, organic hydrides, carbon-containing materials, zeolites, and metal-organic frameworks. Sodium borohydride is considered one of the most suitable materials for hydrogen storage. It is characterized by a high hydrogen content (10.8 wt.%), it is cheap, environmentally friendly, stable in alkaline solutions, non-flammable, non-toxic, and works under mild conditions [1,2].

This work aimed to form four-component NiCoMoW/Cu catalysts, to characterize them, and to evaluate their catalytic properties for the hydrolysis reaction of sodium borohydride. Ni-based coatings were deposited on a Cu substrate by a simple chemical deposition method using morpholine borane as a reducing agent. The surface morphology, structure, and chemical composition of the catalysts were investigated using SEM, EDS, ICP-OES. The catalytic activity of the sodium borohydride hydrolysis reaction was evaluated by measuring the amount of hydrogen released from the catalysed sodium borohydride hydrolysis reaction.

Nickel alloy catalysts were formed during the work. Their morphology and structure were studied. It was found that the prepared coatings consist of particles of various sizes, which combine into oval-shaped agglomerates. It was found that the four-component NiCoMoW coating exhibited high catalytic activity. It was found that the H_2 evolution rate of this catalyst at 70 °C was 13.0 ml/min, and the calculated activation energy is equal to 38.22 kJ/mol. A similar nickel coating, which was obtained by chemical deposition using the same amounts of materials except for the cobalt salt, NiMoW, was characterized by slightly lower catalytic activity. The H_2 evolution rate of this catalyst at 70 °C was found to be 11.36 ml/min, and the calculated activation energy is equal to 52.01 kJ/mol.

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GREEN SURFACE-ENGINEERED NANOCELLULOSE FROM *RAPHIA FARINIFERA* INFLORESCENCE FOR MECHANISTIC CONTROL OF INTERFACIAL CHEMISTRY IN SUSTAINABLE WATER TREATMENT

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Performance in green water treatment is usually reported as removal efficiency, while the surface chemistry controlling selectivity and reversibility remains underexamined [1]. Nanocellulose from *Raphia farinifera* inflorescence was produced by aqueous delignification and low-toxicity fibrillation, yielding nanocrystalline spheres with high hydroxyl density and tunable charge.

Structural refinement altered surface electron distribution and pH-dependent electrokinetic response, while surface area increased only marginally, so interfacial charge modulation dictated performance. Spectroscopy indicates atrazine interaction is governed by hydrogen bonding and charge-assisted association with surface oxygen functionalities [2,3]. Controlled xanthation further modified interfacial electron density, strengthening surface–molecule interactions, and temperature-dependent analysis supports a chemically mediated rather than diffusion-controlled pathway.

Surface functionality remained intact after repeated mild alkaline regeneration, confirming reversible binding governed by interfacial chemistry rather than structural collapse. In agricultural wastewater under seasonal variation, contaminant reduction remained consistent, indicating that surface control translates beyond ideal conditions.

These observations show that *Raphia farinifera* inflorescence can be transformed into a renewable nanocellulose system in which interfacial chemistry, not empirical adsorption metrics, dictates performance, providing a basis for designing green nanocellulose from lignocellulosic feedstocks.

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SEQUENCIAL AND SIMULTANEOS EXTRACTION OF PHENOLIC COMPOUNDS AND BIOPOLYMERS FROM *SARGASSUM MUTICUM* USING ALTERNATIVE SOLVENTS

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Sargassum muticum is an invasive brown seaweed still underexplored. Promoting its exploitation not only generates economical value but also helps mitigate its environmental burden [1]. In line with the EU strategy for biomass valorisation through a cascade process [2], this work explores the recovery of value-added compounds from *S. muticum*. This seaweed is known to be rich in phenolic compounds (PCs) exhibiting beneficial properties [1]. *S. muticum* is also rich in structural biopolymers, namely alginates and fucoidans, widely recognized for their functional and bioactive properties [3].

This work studied sequential extractions of PCs and biopolymers (alginates and fucoidans) using biocompatible solvents. It was possible to observe improvements in yields and purities. This sequence was compared with a simultaneous extraction of PCs and biopolymers using biphasic systems, which also produced good yields and enabled compound partitioning in a single step. These results will contribute to the development of sustainable and efficient extraction strategies, supporting the implementation of integrated biorefinery approaches for invasive seaweeds.

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GREEN ADSORBENTS FOR SUSTAINABLE WATER REMEDIATION: MOF-DERIVED POROUS CARBONS AND WASTE-DERIVED CHARS

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The increasing discharge of inorganic pollutants and organic dyes into water systems poses significant environmental and health risks. The development of sustainable and efficient remediation strategies is therefore essential, in line with Green Chemistry principles and the United Nations Sustainable Development Goals.[1]

In this work, two distinct classes of adsorbent materials were explored and compared: (i) porous carbons derived from Metal–Organic Frameworks (MOFs), obtained via controlled pyrolysis, (ii) low-cost biochars derived from (agro)industrial wastes, including cork residues and shrimp shells (SS); and (iii) chitin/chitosan obtained from SS. This approach combines advanced functional materials with waste valorisation strategies within a circular economy framework.[2,3] The adsorptive performance of both types of materials was evaluated for the removal of toxic metal ions and organic dyes from aqueous media. MOF-derived carbons exhibit high surface areas and tunable porosity, while biochars offer abundant surface functional groups and low-cost sustainable production. The comparative analysis highlights the advantages and limitations of each system in terms of adsorption efficiency, selectivity, and reusability. Comprehensive characterization (FTIR, SEM/EDS, PXRD, N_2 adsorption-desorption, and zeta potential analysis) confirmed the structural and surface properties of the materials. Reusability studies demonstrated the stability of the adsorbents over multiple adsorption–desorption cycles. This work provides insight into the complementary roles of advanced and bio-based materials, contributing to the design of sustainable and cost-effective water remediation technologies.

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SUSTAINABLE EXTRACTION AND PHYTOCHEMICAL CHARACTERIZATION OF BIOACTIVE COMPOUNDS FROM *MARRUBIUM DESERTI* FOR PHARMACEUTICAL APPLICATIONS

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The present study focuses on the sustainable extraction and phytochemical characterization of bioactive compounds from *Marrubium deserti*, a medicinal plant native to the Algerian desert, with the aim of evaluating its pharmaceutical potential in accordance with green chemistry principles. Essential oils were analyzed using GC–MS, revealing a rich chemical profile with 63 identified compounds, where Germacrene D was the major constituent. Bioactive compounds were extracted from leaves and stems using environmentally friendly polar solvents (50% ethanol and distilled water) through Soxhlet and ultrasound-assisted extraction methods. Phytochemical screening demonstrated the presence of several secondary metabolites, while quantitative analyses confirmed a high content of total phenols and flavonoids, highlighting the antioxidant potential of the plant. Antioxidant activity assessed by DPPH and ABTS assays showed a significant free radical scavenging capacity of the extracts. Anti-inflammatory activity evaluation indicated that the ethanolic extract of *Marrubium deserti* effectively inhibited bovine serum albumin denaturation at higher concentrations. These findings support the valorization of *Marrubium deserti* as a promising natural source of bioactive compounds, while emphasizing the relevance of sustainable extraction strategies aligned with the objectives of green chemistry.

Key Words — *Marrubium deserti*, Bioactive compounds, Antioxidant activity, GC-MS, Phytochemical characterization, Anti-inflammatory activity, Pharmaceutical applications*.*

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SUSTAINABLE SYNTHESIS OF ARTIFICIAL HUMIC SUBSTANCES FROM BIOMASS FOR ENVIRONMENTAL REMEDIATION

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Humic substances (HS) are key components of soil organic matter that regulate carbon cycling, soil fertility, and pollutant attenuation. However, most commercial HS are derived from non-renewable coal and lignite, while natural humification occurs over centuries [1]. Therefore, sustainable methods to rapidly produce humic-like materials from renewable biomass are essential for advancing green chemistry and circular bioeconomy strategies.

In this study, poplar bark, an abundant lignocellulosic residue, was converted into artificial humic substances (AHS) via hydrothermal treatment. This water-based process mimics natural humification and enables rapid formation of oxygen-rich aromatic structures containing carboxyl, phenolic, and quinone functional groups. The synthesized AHS were characterized using complementary spectroscopic techniques to understand their structural features and reactivity. The environmental performance of AHS was evaluated through adsorption of emerging organic contaminants, including antibiotics and herbicides, demonstrating strong sorption affinity in soil and water systems. Interactions between AHS and microplastics were also investigated to better understand their influence on pollutant transport. Furthermore, the interaction of AHS with clay minerals such as montmorillonite was explored to assess their potential to promote soil aggregation and enhance carbon stabilization.

Overall, hydrothermal conversion of biomass waste provides a green pathway for producing functional humic-like materials with promising applications in pollutant immobilization, soil improvement, and carbon sequestration.

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SMART AND SUSTAINABLE AZETIDINE SYNTHESIS: INTEGRATING FLOW CHEMISTRY WITH MACHINE LEARNING

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Azetidines are important nitrogen-containing motifs in medicinal chemistry and industrial synthesis [1,2] but are often prepared by conventional batch methods. Continuous-flow chemistry and data-driven optimization offer a promising route to greener and more robust synthetic processes [3,4].

This work is part of an ongoing project on sustainable azetidine synthesis under continuous-flow conditions. Experimental work has focused on selected synthetic routes to target compounds, while a preliminary reaction database was assembled from literature and related synthetic examples to support future model development, validation, and external evaluation.

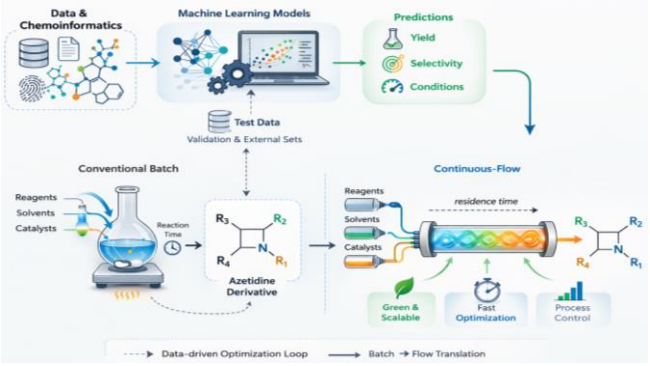


Figure1. Conceptual overview of the data-driven workflow for sustainable azetidine synthesis under continuous-flow

Preliminary kinetic and optimization studies were performed to identify relevant parameters and define an experimental space for implementation in flow. These efforts establish the basis for future machine learning-assisted optimization of azetidine synthesis.

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GREEN CHEMISTRY AND TEACHING ABOUT MICROPLASTICS TO PROMOTE OCEAN LITERACY: POTENTIAL THROUGH THE STEAM APPROACH

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This study, situated within the field of Science Education, is guided by the following research question: how does Green Chemistry, articulated with the theme of Ocean Literacy, contribute to the learning of scientific concepts related to microplastics among basic education students? The target audience consisted of second-year high school students from a state public school located in Vitória, Espírito Santo, Brazil. The activities were carried out through a didactic sequence grounded in the STEAM approach (Science, Technology, Engineering, Art and Mathematics) [1]. The choice of this theme is justified by the ongoing “United Nations Decade of Ocean Science for Sustainable Development” (2021–2030), established by the United Nations (UN), which aims to foster actions for the preservation and sustainable use of the oceans. Experimental activities, such as analyzing the density of different types of plastics, enabled students to understand the mechanisms underlying the dispersion of microplastics in aquatic environments, while also critically examining the impacts of these materials on marine ecosystems and human health. By incorporating Green Chemistry principles, such as pollution prevention and the development of more sustainable materials, the teaching process encouraged critical reflection on alternatives to the linear model of production and consumption, contributing to the development of students who are more aware of and engaged with sustainability. The construction of solutions to mitigate microplastic pollution, such as the prototypes developed by the students, demonstrated the translation of scientific knowledge into action, a central feature of Education for Sustainability.

Thus, by guiding the teaching of microplastics, Green Chemistry contributed significantly to promoting Ocean Literacy in high school, aligning with contemporary demands for science education committed to social and environmental transformation.

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ADVANCING GREEN CHEMISTRY THROUGH AI-DRIVEN SYNTHESIS PLANNING AND DATA-ENABLED INSIGHTS

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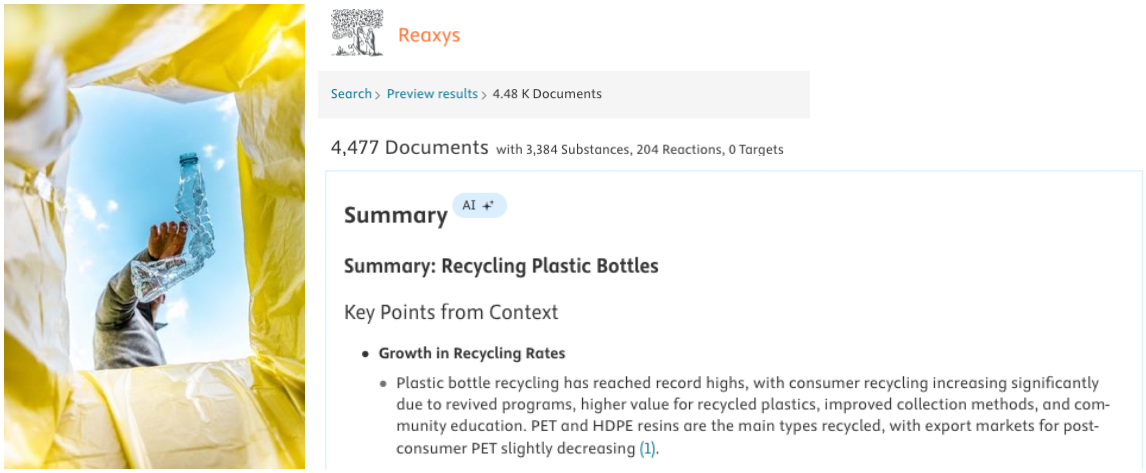
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The transition toward sustainable chemistry requires new approaches to the design of synthetic routes and chemical processes. At the same time, global analyses of chemistry research show steady growth and increasing focus on sustainability-driven topics such as CO_2 utilization, photocatalysis, and advanced materials.

In this context, AI-driven synthesis planning combined with large-scale chemical data enables researchers to explore alternative synthetic pathways under defined constraints, including reduced step count, safer reagents, and the use of renewable feedstocks. These tools support faster identification of feasible routes and facilitate more informed trade-offs between efficiency and sustainability.

Beyond synthesis design, data-driven approaches contribute to a broader research workflow by supporting reaction feasibility assessment, impurity prediction, and integration with biological and materials data. This enables more holistic decision-making across different areas of chemistry.

This work highlights how the integration of chemical data, predictive modelling, and research landscape insights can support the adoption of green chemistry principles and accelerate the development of more sustainable chemical processes.





EDUCATING GREEN CHEMISTRY LEADERS: INTEGRATING EDUCATION, RESEARCH, AND INNOVATION FOR GLOBAL IMPACT

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Green chemistry constitutes a foundational paradigm for addressing complex global environmental challenges through the design of inherently safer, resource-efficient, and sustainable chemical processes. The Green Chemistry Nexus advances this paradigm by establishing a tightly integrated academic–research ecosystem built upon three synergistic pillars: a specialized Green Chemistry Master's program, an innovation-oriented TechHub supporting doctoral research, and the Education Campus Hainburg as a hub for interdisciplinary learning and scientific exchange.

The Master's program delivers a rigorous curriculum grounded in the principles of sustainable chemistry, emphasizing systems thinking, lifecycle assessment, and the rational design of benign chemical transformations. It equips students with both conceptual frameworks and applied competencies required to operate effectively across industry, academia, and regulatory environments. Extending this foundation, the TechHub provides a collaborative, research-intensive setting in which PhD candidates engage in frontier projects spanning green synthesis, circular material flows, and process intensification, fostering translational research with tangible societal and industrial relevance.

The Education Campus Hainburg complements these efforts by cultivating an intellectually vibrant environment that promotes interdisciplinary dialogue, mentorship, and advanced skills development. It serves as a catalyst for integrating scientific inquiry with pedagogical innovation, enabling learners and researchers to critically engage with sustainability challenges across disciplinary boundaries.

By systematically interlinking education, research, and technological development, the Green Chemistry Nexus functions as a model for capacity building in sustainable chemistry. It not only advances scientific knowledge but also shapes a new generation of leaders capable of driving systemic change toward a resilient, circular, and environmentally responsible chemical enterprise.

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SUSTAINABLE ETHYLBENZENE SYNTHESIS VIA IN SITU HYDROGEN-DRIVEN STYRENE HYDROGENATION

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Metal/support nanocatalysts composed of different metal oxides not only retain the intrinsic acidity characteristics of each component but also exhibit enhanced catalytic activity due to synergistic kinetic interactions. The catalysts were designed to promote a reaction process in which hydrogen produced in situ dehydrogenation of ethanol and directly utilized for the styrene hydrogenation to form ethylbenzene. Strong interactions between Ga, Cu and the SiO_2 support to contribute to enhanced dispersion and superior catalytic performance. In this study, bimetallic Ga–Cu catalysts supported on silica were synthesized via an impregnation method, with varying Ga/Cu loadings to optimize catalytic performance for the indirect hydrogenation of styrene to ethylbenzene. The ethanol dehydrogenation to carbonyl compounds without an oxidant as hydrogen acceptor is an economic and important synthetic approach for the production of valuable chemicals. The results indicate that the Ga/Cu weight ratios significantly affects the catalytic activity. The optimized Ga-Cu support on SiO_2 based catalyst exhibits high stability and reusability. Our finding provides a robust and effective catalytic system with significant potential for tandem hydrogenation and related applications, which would be applied to wide catalytic reactions.

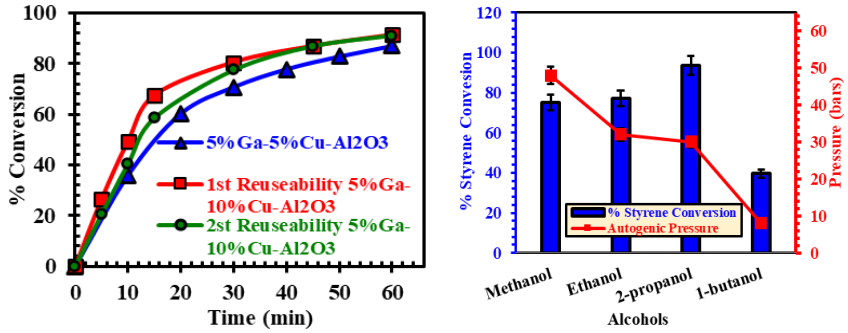


Fig. 1. (a): Catalytic Performance of Ga/Cu-SiO2 catalysts; (b): Influence of different alcohol.

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CYCLOHEXANONE OXIDATION WITH ACID-FUNCTIONALISED SBA-15 CATALYSTS FOR SUSTAINABLE ADIPIC ACID OBTENTION

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Adipic acid (AA) is one of the most demanded compounds in the chemical industry owing to its role in the production of nylon 6,6 [1]. It is typically obtained from the oxidation of fossil-derived mixtures of cyclohexanol and cyclohexanone (C-ONE) with HNO_3, releasing large amounts of N_2O linked to ozone depletion and global warming [1]. This work aims to explore the use of SBA-15 functionalised with Brønsted acid sites of different strength and number, in the fashion of other oxidation reactions [2], as catalysts for the oxidation of C-ONE with air as a greener AA obtention alternative.

SBA-15 was functionalised with 0.2, 0.4 and 0.7 g of 2-(4-chlorosulphonylphenyl)ethyltrimethoxysilane by microwave-assisted reflux at 40 ºC for 2 h (C1-SBA-15, C2-SBA-15 and C3-SBA-15 respectively), with H_3PO_4 by impregnation followed by calcination at 400 ºC for 3 h (P-SBA-15) and with $ClSO_3H$ by addition at 0 ºC (S-SBA-15). X-Ray Diffraction showed that acid functionalisation did not alter the lattice structure of any SBA-15 catalyst. C-ONE conversion gradually rose in S-SBA-15 and C-SBA-15 catalysts with increasing acidity while AA selectivity held steady between 26 % and 33 % (Figure 1), comparable to the 35 % achieved by Dandapat et al [1]. Moreover, P-SBA-15 led to the lowest C-ONE conversion and AA selectivity despite its higher acidity, showing that acid site strength has a greater effect on AA selectivity than acid site number.

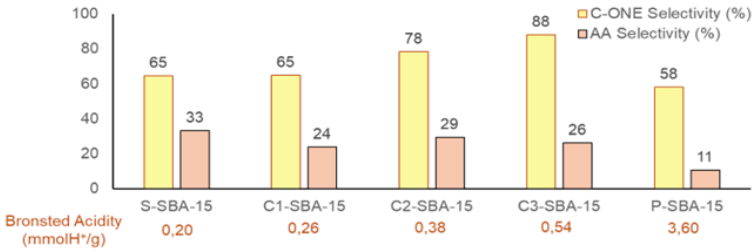


Figure 1. C-ONE oxidation results of functionalised SBA-15 catalysts vs Brønsted acidity measured by titration. Reactions run with 110 µL of C-ONE and 0,1 g of catalyst, at 120 ºC and 30 bar of air for 6 h

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MAKING THE ELUSIVE TANGIBLE: LONG-LIVED BENZYL CATIONS STABILIZED IN ZEOLITES

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The benzyl cation (benzylium, Bn^+) is a fundamental molecule in organic chemistry. Some pioneering works[1, 2, 3] early demonstrated that the benzyl and the tropylium (Tr^+) cations were in equilibrium after the ionization of toluene ($Bn^+ \leftrightarrow Tr^+$), but that both molecules rapidly reacted with the starting aromatic precursor. In this study we demonstrated the spontaneous formation of a stable Bn^+. It requires the following premises: a non–nucleophilic starting material; the ultrafast physical isolation of the so–formed Bn^+, in the absence of any nucleophilic reagent, including any other aromatic precursor; and an extremely soft counter anion (host) able to further stabilize the carbocation. The first requirement could be fulfilled by the same Tr^+. For the second and third requirements, a highly delocalized but micro structured anion would be necessary. The zeolite´s aluminosilicate framework can be considered one of the biggest and softer anions known, with an extremely high degree of negative charge delocalization. The native structure of the zeolites makes them ideal hosts for carbocations, as widely demonstrated for a variety of organic cations, provided that the cation is sterically accommodable inside the zeolite pores.[4] Herein, the present work was able to demonstrate that the spontaneous unimolecular rearrangement reaction of homogeneously distributed Tr^+ inside zeolites produces Bn^+, which stays for weeks within the confined structure of the zeolite. Various techniques were used such as UV–vis, NMR, TAS, computational calculations, and reactivity results, everything supporting the existence and stability of Bn^+ in the solid state. These results bring this fundamental organic textbook carbocation to our laboratories as a manageable organic compound for further mechanistic and reactivity studies in zeolites.

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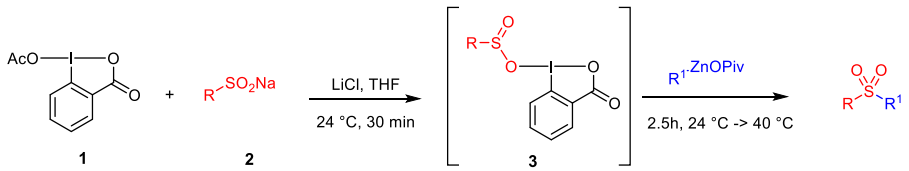
HYPERVALENT IODINE-MEDIATED SYNTHESIS OF SULFONES USING ORGANOZINC PIVALATES AND SULFINATE SALTS

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Sulfones are highly valuable organic molecules due to their widespread presence in pharmaceuticals, agrochemicals, biologically active compounds, and polymer materials.[1,2] Despite the synthetic efforts towards sulfones,[3] reported methods often suffer from limitations such as narrow substrate scope and substitution patterns. Our group has been investigating the umpolung reactivity of hypervalent iodine reagents (HIR), particularly the benziodoxolones, in the synthesis of sulfonamides[4] and sulfinyl hydrazides.[5] In this work, we present a new approach to sulfone synthesis.[6] By taking advantage of our know-how on the generation of sulfonyl-containing HIR intermediate, we achieved high to quantitative yields of diverse sulfones using stable sulfinate salts in combination with organozinc pivalates (Scheme 1).



Scheme 1: General scheme for Sulfone Synthesis

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A GREEN APPROACH TO 2-ARYLQUINOLINES VIA PALLADIUM-CATALYSED C–H ACTIVATION

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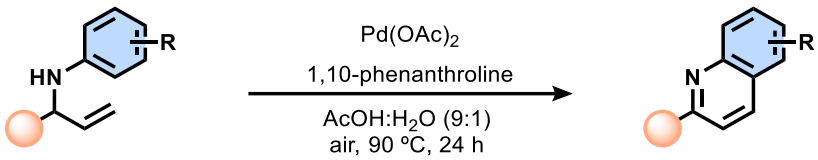
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Quinoline derivatives constitute an important class of nitrogen-containing heterocycles frequently encountered in pharmaceuticals, agrochemicals, and biologically active molecules. Among them, 2-arylquinolines are particularly relevant due to their broad spectrum of biological activities, including antimalarial and anticancer properties.[1–2] Over the years, several synthetic methodologies have been established for the preparation of these compounds; nevertheless, many reported procedures still depend on severe reaction conditions.

In this context, we report a practical and straightforward approach for the synthesis of 2-arylquinolines via palladium-catalyzed intramolecular cyclization of allyl amines through C−H activation (Scheme 1).[3]



Scheme 1: Synthetic Approach to 2-Arylquinolines via Palladium-Catalyzed C-H Activation.

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SYNTHESIS, PHYSICAL PROPERTIES AND HYDROLYTIC DEGRADATION OF NOVEL BIOBASED POLY(HEXAMETHYLENE FURANDICARBOXYLATE-*CO*-OXALATE) COPOLYESTERS

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From a sustainable viewpoint, the synthesis, structure, and properties study of biobased polyesters with outstanding thermal, mechanical, barrier, and degradation properties is of great interest and importance [1, 2]. In this research, a series of novel biobased poly(hexamethylene furandicarboxylate-*co*-oxalate) (PHFO) copolyesters were successfully synthesized with hexamethylene oxalate (HO) unit contents ranging from about 10 to 30 mol%. The structure and properties of PHFO copolyesters were systematically studied and compared with those of the two parent homopolyesters poly(hexamethylene furandicarboxylate) (PHF) and poly(hexamethylene oxalate) (PHO). PHFO still exhibited good thermal stability and maintained thermal decomposition temperatures above 340 ^{o}C. As the HO unit content increased, both the glass transition temperature and melting point of PHFO copolyesters decreased; moreover, the melt crystallization temperature of PHFO also shifted to low temperature range, indicating that the copolymerization weakened the crystallization ability of PHF. PHFO copolyesters displayed the same crystal structures as PHF, suggesting that the presence of HO unit should mainly reside in the amorphous region of PHF crystals. The introduction of a small amount of HO units remarkably improved the toughness of PHFO copolyesters without compromising its strength. For instance, PHFO30 (HO unit content = 30 mol%) displayed a higher elongation at break of 955.0 ± 48.0% and a tensile strength of 28 ± 1.8 MPa, which was comparable or even superior to the well-known commercial poly(butylene adipate-*co*-terephthalate). Compared with PHF, the hydrophilicity and hydrolytic degradation rate of PHFO were improved to some degree under different environments. The hydrolysis mechanism of PHFO was further elucidated on the basis of ^{1}H Nuclear magnetic resonance study. The HO segments were more susceptible to hydrolysis; therefore, PHFO copolyester with high HO unit content displayed a relatively faster hydrolysis rate in both deionized water and artificial seawater than PHF. This study demonstrated that incorporating aliphatic co-units into furan based polyesters offers a sustainable and valuable alternative to terephthalic acid based analogues.

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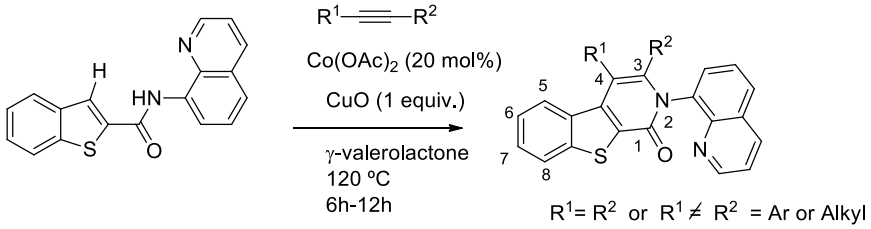
COBALT-CATALYZED C-H ACTIVATION/ANNULATION OF A BENZOTHIOPHENE AMIDE WITH ALKYNES IN γ-VALEROLACTONE

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Heterocycles are widely found in natural products and medicinally relevant compounds. Sustainable C-H functionalization catalyzed by earth-abundant transition metals such as cobalt has become an important strategy for their synthesis and modification [1].

Herein, we report a sustainable cobalt-catalyzed C-H/N-H activation and annulation that provides access to benzothienopyridinones through the reaction of a previously prepared benzothiophene amide with several internal alkynes. The reaction is carried out using $Co(OAc)_2$ and inexpensive CuO as the oxidant in the bio-based γ-valerolactone at 120 °C for several hours (Scheme 1).



Scheme 1. Cobalt-catalyzed synthesis of benzothienopyridinones.

Optimization of the reaction conditions to improve both efficiency and sustainability is ongoing. Removal of the *N*-quinoline is also planned. This methodology will also be applied to the synthesis of pyridine-fused thiophene pyridinones, constituting a greener improvement over our earlier Rh-catalyzed C-H activation/cycloaddition of carboxylic acids with alkynes [2].

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Acknowledgments:

To FCT-Portugal through CQ-UM (UID/00686) and the research project SCHAR4Het (ref. 16355, operation COMPETE2030-FEDER-00751800), which also supports J.P.S. with a research grant.

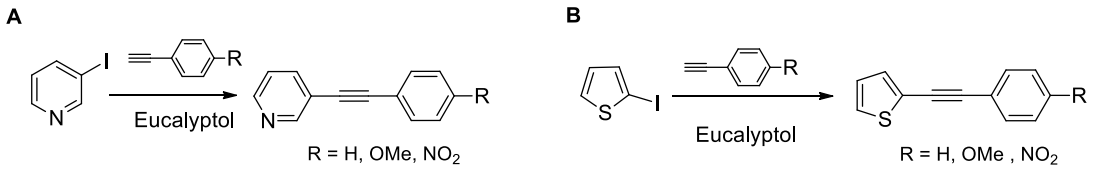
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NaY ZEOLITE-SUPPORTED Pd(II) FOR GREEN SONOGASHIRA COUPLING OF HETEROARYL HALIDES IN EUCALYPTOL

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In recent years, significant efforts have focused on developing greener and sustainable strategies for organic synthesis, including Pd-catalyzed heterogeneous systems for Sonogashira coupling reactions in the synthesis of heterocycles relevant to pharmaceuticals, materials science, and agrochemicals [1]. In this work, a heterogeneous palladium catalyst, $[Pd(NH_3)_4]^{2+}$NaY, was prepared using a NaY zeolite framework and a $PdCl_2/NH_3$ solution. The catalyst was characterized by SEM/EDX and XPS, confirming the preservation of the zeolite structure and the successful incorporation of palladium species. The $[Pd(NH_3)_4]^{2+}$NaY was applied in Sonogashira couplings of heteroaryl halides with arylacetylenes under mild conditions, using eucalytpol as a green solvent and Et_3N as a base at 80 °C. Sonogashira products were obtained in moderate to high yields (50-90%) using 3-iodopyridine (**A**) or 2-iodothiophene (**B**) with phenylacetylene and substituted arylacetylenes containing electron-donating (OMe) or electron-withdrawing (NO_2) groups (Scheme 1).



Scheme 1. Heterogeneous catalysis in Sonogashira reactions using eucalyptol.

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SUSTAINABLE POLYESTER PLASTIC CHEMICAL TRANSFORMATION AND VALORISATION

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Plastic materials are widely used but persist in the environment for centuries, fragmenting into smaller particles that exhibit increased surface area, low degradation rate, and high toxicity, particularly below 10 µm. Their environmental and health impacts demand for sustainable recycling solutions. Therefore, the development of greener chemical and biochemical strategies for their transformation and facilitating their biodegradation has become increasingly important [1].

Herein, a novel, simpler and greener chemical transformation approach for non- and poorly biodegradable polyester-based plastics is presented with emphasis on polyethylene terephthalate (PET). The methodology employs choline hydroxide (ChOH) as a sustainable reagent for PET depolymerization under mild conditions. This strategy aims to enhance plastic biodegradation and enable valorisation of the resulting products for biogas production, contributing to circular plastic economy concept.

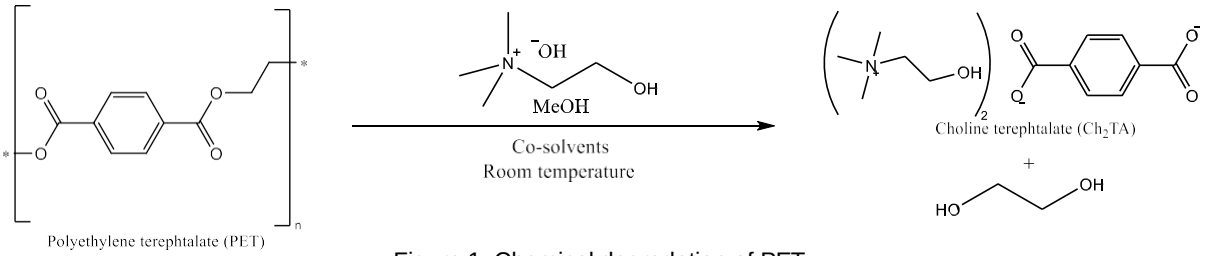


Figure 1. Chemical degradation of PET

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Acknowledgments:

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SUSTAINABLE HYDROTROPE-BASED EXTRACTION OF ARTEMISININ FROM ARTEMISIA ANNUA

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Malaria remains a major global health challenge, with an estimated 282 million cases reported in 80 endemic countries in 2024 [1]. Artemisinin and its derivatives remain the most effective antimalarial drugs, with *Artemisia annua* L. extracts as the primary industrial source. This study aims to develop a more sustainable hydrotrope-based extraction strategy combined with advanced techniques to overcome the limitations of conventional petroleum-based and organic solvents. Nicotinamide was selected as a promising hydrotrope due to its low cost, low toxicity, and potential role in improving drug absorption [2]. Ethanol and its aqueous mixtures were used as benchmarks. Ball-milling-assisted extraction (BMAE) and ultrasound-assisted extraction (UAE) were evaluated using the selected solvent mixtures, with BMAE providing higher extraction yields and lower energy consumption. Response surface methodology (RSM) was applied to optimize BMAE variables. Under optimized conditions, nicotinamide–water mixtures containing 25 wt.% nicotinamide yielded up to 5.60 mg of artemisinin per gram of plant, comparable to ethanol–water mixtures. Further studies will assess the *in vitro* antimalarial efficacy and perform life-cycle assessments (LCAs) to compare ethanol and nicotinamide mixtures, as well as different extraction techniques, and quantify their environmental impact in terms of energy consumption, waste generation, and carbon footprint.

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GREENER SYNTHESIS TO ENHANCE THE COMPETITIVENESS OF NEW ANTIFOULING ADDITIVES AS SUSTAINABLE ALTERNATIVES TO TOXIC BIOCIDES IN MARINE COATINGS: SUPPORTING SDG 14

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Marine biofouling is a persistent challenge for maritime industries, leading to increased fuel consumption, greenhouse gas emissions, and maintenance costs. To mitigate this problem, marine antifouling coatings containing biocides are widely used; however, these substances pose risks to marine ecosystems, contributing to harmful effects on life below water. In the context of the UN Decade of Ocean Science for Sustainable Development, there is an increasing need to develop antifouling solutions as alternatives to conventional toxic biocides. We had successfully synthesized nature-inspired antifouling agents (NIAFs) that balance effectiveness and environmental safety [1,2]. In this work, efforts were made to reduce the environmental impact of the chemical reactions and purification methods involved in the production of the patented NIAFs. Freely available software was used to score the improvements in greenness. By integrating the Green Principles into the production of these synthetic antifoulants, this work enhances their competitiveness and supports global efforts to protect marine ecosystems in line with Sustainable Development Goal 14 (Life Below Water).

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Acknowledgments: This work was supported by FCT - Fundação para a Ciência e a Tecnologia, I.P., and by the European Commission's Recovery and Resilience Facility, within the scope of UID/04423/2025 (https://doi.org/10.54499/UID/04423/2025), UID/PRR/04423/2025(https://doi.org/10.54499/UID/PRR/04423/2025), and LA/P/0101/2020 (https://doi.org/10.54499/LA/P/0101/2020) and by FEDER funds through the Programa Inovação e Transição Digital in the framework of the project NANOBIOESCUDO (COMPETE2030-FEDER-01194000; Ref.ª 17414).



METAL-FREE CARBON NITRIDE FOR ENHANCED CONTINUOUS-FLOW VICINAL HALOTRIFLUOROMETHYLATION OF VINYL COMPOUNDS.

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The trifluoromethyl (–CF_3) group is a key functional motif in fine chemical synthesis. Vicinal halotrifluoromethylation of alkenes is especially useful, enabling the simultaneous installation of both –CF_3 and a halide handle. While reported vicinal halotrifluoromethylations rely on homogeneous catalysts[1], we report a metal-free, base- free carbon nitride-photocatalyzed method under visible light that uses triflyl halide as a bifunctional radical source, delivering β-CF_3 alkyl halides in high yields with broad functional group tolerance. Carbon nitride (gCN_x and nCN_x) was synthesized and evaluated for photocatalytic performance. Batch studies identified nanosheet CN_x as the most active material, delivering quantitative yields. Scalability was demonstrated under continuous-flow conditions using packed-bed reactors, where complete conversion was achieved within 60 min. Time-on-stream analysis confirmed catalyst recyclability over five cycles. The method exhibits broad substrate scope, being applied in more than 20 aliphatic and aromatic alkenes, including structurally complex pharmaceutical scaffolds. By integrating metal-free heterogeneous photocatalysis with flow system, this approach provides a sustainable platform for vicinal halotrifluoromethylation.

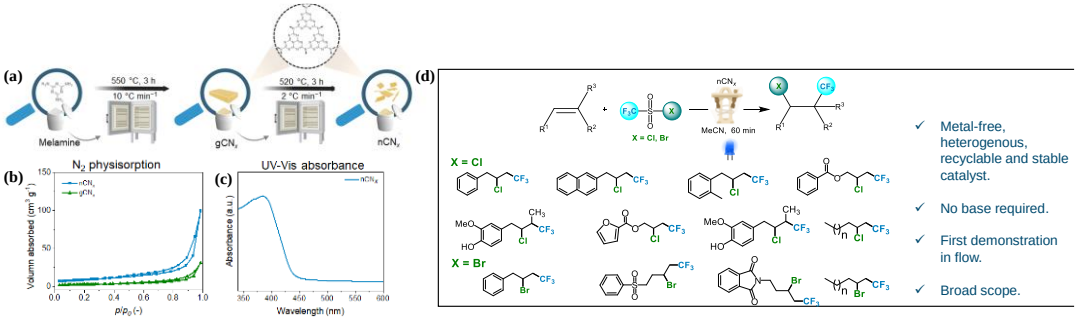


Figure 1. (a) Synthesis of graphitic and nanosheet carbon nitride (gCN_x and nCN_x), (b) N_2 adsorption isotherms, (c) UV-Vis- DRS absorbance spectroscopy, and (d) schematic representation of vicinal halotrifluoromethylation reactions with the heterogenous catalyst.

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PARAMETRISATION OF THE OXIDATION OF ACETOL USING GREEN CHEMISTRY PRINCIPLES

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Over the last few years oxidation reactions of alcohols have transformed from Cr(VI) reactants to TEMPO-mediated systems, which sometimes also use a catalyst.[1] Both approaches offer high selectivity but lack a compatibility with the environment due to toxicity, the usage of large amounts of solvents, the need for additional mediators and high costs. Therefore, we aim for the catalysts to be simple earth-abundant metal salts and, in general, using ambient conditions. We follow a holistic approach investigating the effects of systematically varying different parameters using a parallel synthesis reactor system and HPLC as our analysis method for the product spectrum.



The green chemistry principles offer a framework for possible reaction conditions: The chosen conditions include water as a solvent, ambient temperatures between 20-40 °C, halides as anions as well as hydrogen peroxide as the terminal oxidant. Currently, the highest yield of 17% was obtained in a system using $NiCl_2$ as the catalyst and a semi-batch approach dosing the oxidant gradually. However, $CoBr_2$ in a batch system led to the highest selectivity of 39%. The conversion only reached 100% using iron salts, but this was mainly due to overoxidation, presumably via a Fenton reaction.

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THERMOELECTROCHEMISTRY-ENABLED PHASE AND MORPHOLOGY CONTROL OF METAL PHOSPHIDE

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Precise control over nanocrystal morphology remains a challenge in direct electrochemical synthesis of transition metal phosphides (TMPs), typically requiring post-synthetic thermal treatment. This study exploits selective surface heating during electrochemical synthesis to overcome kinetic barriers for crystallization, enabling preparation of highly ordered cobalt and nickel phosphide nanostructures. Systematic voltage modulation yielded Co_2P nanostructures with controlled morphologies including single nanorods, branched rods, and bundled rods with tunable dimensions and facet orientation. Extension to nickel precursors produced Ni_2P with octahedral and plate-like morphologies, suggesting the generalizability of this approach. Electrochemical characterization unveiled important structure-activity relationships: Co_2P nanorod bundles exhibiting superior electrocatalysis (for both hydrogen and oxygen evolution reactions) compared to that of single nanorods, owing to the virtue of overexpressed active facets. This straightforward electrochemical synthetic platform enables rational design of catalysts through direct morphological engineering without complex post-treatment, and is readily extensible to other transition metal compounds.[1]

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Acknowledgments:

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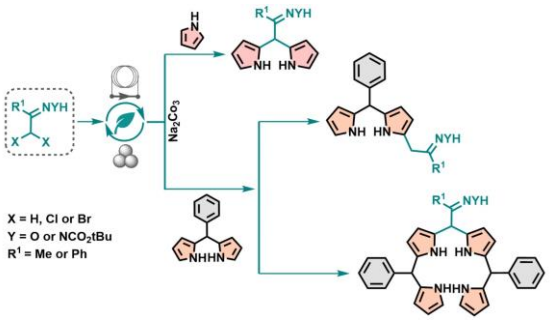
GRINDING AND FLOWING WITH NITROSO- AND AZOALKENES

Bruna D. P. Costa*[1], João C. S. Simões*[1], Marta Pineiro[1], Teresa M. V. D. Pinho e Melo[1]

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We previously reported on the reactivity of nitroso- and azoalkenes generated *in situ* from halogenated oxime and hydrazone precursors toward pyrrolic systems. When pyrrole is used as the substrate, *meso*-substituted dipyrromethanes are obtained, whereas reactions with dipyrromethanes yields either *α*-functionalized dipyrromethanes or bilanes, depending on whether mono- or di-halogenated oximes or hydrazones are employed, respectively. [1] In the context of sustainable synthesis, we now explore alternative activation modes to develop greener routes to these compounds: mechanochemistry, using ball milling, which enables solvent-minimized transformations; and continuous flow chemistry which provides enhanced reaction control and straightforward scalability. The resulting compounds can then be employed as building blocks for the synthesis of porphyrins [2] and corroles [3].



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Acknowledgments:

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Synthesis of 2D π-d Conjugated Conductive Thin-Film MOF via Electrochemical Anodic Deposition

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Conductive Metal-Organic Frameworks (MOFs)[1] are an emerging class of porous conductive materials that offer simultaneous control over charge transport and molecular adsorption. In this work, first time, we report the fabrication of highly oriented, 1.7µm thick Cu-HHTP ($Cu_3(HHTP)_2$; HHTP = 2,3,6,7,10,11-hexahydroxy triphenylene) thin films on copper (99.98% pure) anode via a controlled electrochemical anodic deposition[2]. The Cu-HHTP framework forms planar honeycomb sheets with delocalized π-electron networks coordinated through Cu^{2+} centers, resulting in a well-defined morphology. Characterization techniques, including P-XRD, FT-IR, SEM, BET and EDS analysis confirmed the structure and composition of the MOF thin film. TGA & DTG confirms the structural thermal stability of the framework up to 320ºC indicating robust coordination bonding and resistance to framework collapse during processing. This study highlights the potential of conductive MOFs for applications in gas separation, although commercial applications are yet to be finalized.

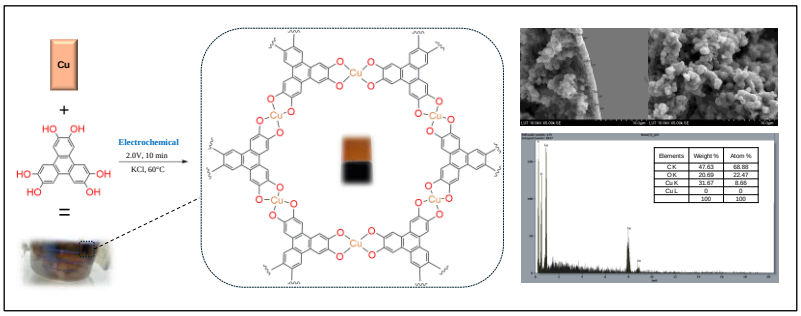


Figure 1. Schematic illustration of electrochemical anodic deposition of $Cu_3(HHTP)_2$ MOF thin film.

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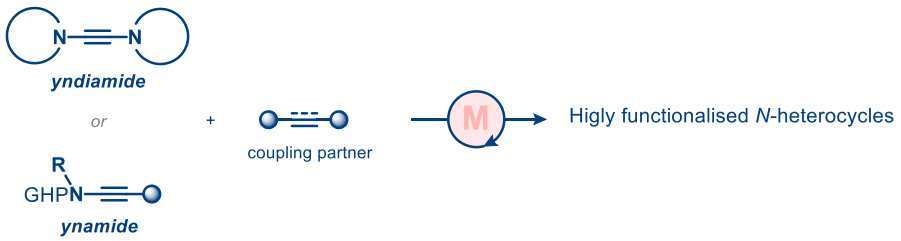
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N-HETEROCYCLE FORMATION *VIA* YN(DI)AMIDE REACTIVITY

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N-Heterocycles are fundamental structural motifs in medicinal chemistry and are found in most FDA-approved small-molecule drugs.[1] Metal-catalysed cycloaddition of ynamides - and the later discovered yndiamides - emerged as an atom-economical and efficient method for constructing highly functionalised *N*-heterocycles.[2-4] Herein, we report a metal-catalysed methodology including yn(di)amides providing a diverse range of highly functionalised heterocyclic scaffolds (**Scheme 1**).



Scheme 1: Formation of highly functionalised N-heterocycles via cycloaddition between yn(di)amides and a second coupling partner.

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Acknowledgments:

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EXPLORING TITANIA-BASED PHOTOCATALYSTS FOR HYDROGEN GENERATION VIA GLYCEROL AND AMMONIA PHOTOREFORMING

Lisa Della Vecchia, Giulia Toro, Cristiana Cesari, Jacopo De Maron, Francesco Basile

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The transition to a hydrogen-based economy requires sustainable production pathways, such as photochemical green hydrogen generation. This study investigates H_2 production via solar-driven photoreforming of glycerol - a biodiesel by-product - and photocatalytic decomposition of ammonia, an effective energy carrier. Two sets of titania-based catalysts were evaluated in a batch reactor under simulated solar irradiation. For glycerol photoreforming, commercial TiO_2 P25 and DT51 was compared with synthesized anatase and rutile phases [1]. For ammonia decomposition, metallic clusters [2] were supported on P25 to analyze active site-support interactions. Characterization via XRD, UV-Vis, and IR spectroscopy, combined with GC-TCD gas monitoring, established key structure-activity correlations. Results demonstrate that H_2 productivity is strongly dependent on support architecture. Regarding Glycerol synthesized anatase (TiO_2-A-m) achieved the highest productivity (~2500 µmol/gh), outperforming both P25 (~1750 µmol/gh) and rutile (~1000 µmol/gh), confirming the superiority of anatase in charge separation. In the ammonia system, the integration of metal clusters significantly enhanced the activity of the P25: the Ru_6C/P25 proved to be the most efficient (~800 µmol/gh), closely followed by HRu_3 (~ 780 µmol/gh) while Fe_6C and $AuFe_4$ showed lower but still significant productivity compared to bare P25. These findings highlight how judicious catalyst selection allows for fine-tuning reactivity, providing a versatile platform for sustainable hydrogen production.

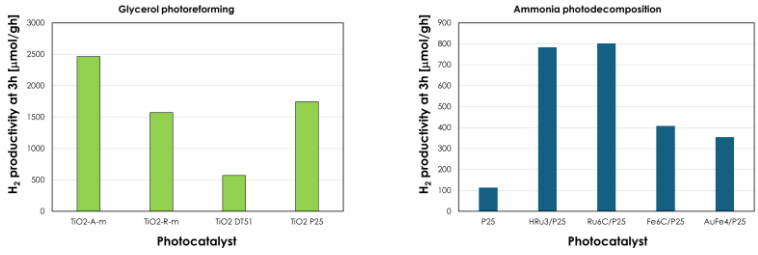


Figure 1. H_2 Productivity

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FLURBIPROFEN IONIC LIQUIDS AS A GREEN STRATEGY FOR SUSTAINABLE TRANSDERMAL FORMULATIONS

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Poor aqueous solubility limits flurbiprofen's formulation for topical and transdermal use. We present a green ion-exchange approach to convert flurbiprofen into ionic liquids (ILs) with biocompatible counter-ions and evaluate their suitability as sustainable formulation solvents [1]. A concise, low-waste synthesis route with minimal organic solvent use was implemented to produce a set of flurbiprofen ILs. Compared to the parent acid, IL formation substantially enhances aqueous solubility and alters lipophilicity in a cation-dependent manner, offering tunable physicochemical properties for either enhanced skin flux or local skin depot [2].

Key evaluations include the assessment of the synthetic efficiency of the ion-exchange process together with selected physicochemical and biological properties of the obtained ionic liquids. Particular attention is given to their aqueous solubility and lipophilicity compared to the parent drug, as well as to preliminary cytocompatibility on keratinocyte and fibroblast cell lines and skin permeation behaviour evaluated using Franz diffusion cells.

From a sustainability perspective, the study highlights the use of relatively benign cations, reduced consumption of organic solvents during synthesis, and the potential of ionic-liquid formation to improve formulation performance without additional excipients [3]. Overall, these results demonstrate that the transformation of flurbiprofen into ionic liquids represents a promising strategy consistent with green-chemistry principles, supporting the development of more sustainable pharmaceutical formulations and contributing to the goals of improved health and responsible production.

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Reverse Water–Gas Shift Reaction over $Ru_xCo_yCe_{1-x-y}O_2$ Catalysts: Insights into Apparent Activation Energy and Enthalpy

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The Reverse Water–Gas Shift (RWGS) reaction has attracted considerable attention as a promising route for CO_2 utilization and sustainable syngas production [1]. In this work, a series of Ru–Co modified CeO_2 catalysts were synthesized by reverse microemulsion precipitation, a method that enables controlled nanoparticle formation and precise compositional tuning [2]. A set of Ru–Co modified ceria catalysts was prepared by fixing the Ru content at 2 and 10 mol%, while the Co content was varied from 0 to 10 mol%. This resulted in two compositional series, $Ru(2\%)Co(0-10\%)/CeO_2$ and $Ru(10\%)Co(0-10\%)/CeO_2$. At the highest Ru loading (10 mol%), the appearance of a RuO_2 secondary phase indicates that the solubility limit of Ru in the ceria lattice is exceeded. Catalytic tests for CO_2 hydrogenation showed significant activity, reaching approximately 50-60% CO_2 conversion at 500 °C. Catalysts containing Co exhibited higher selectivity toward CO formation, favoring the RWGS pathway. This behavior is consistent with the catalytic roles of the metals, since Ru tends to promote deeper hydrogenation pathways leading to CH_4 formation, while Co generally shows lower activity for deep hydrogenation. Kinetic analysis under differential conditions allowed the determination of apparent activation energies (E^{app}) and apparent activation enthalpies ($\Delta H^{\ddagger}_{app}$) for CO_2 conversion as well as for CO and CH_4 formation. As result, the activation energy associated with methane formation is significantly higher than that for CO formation ($E^{app}(CH_4) > E^{app}(CO)$), indicating that methanation is kinetically more demanding than the RWGS pathway. The $\Delta H^{\ddagger}_{app}$ values vary with catalyst composition, reflecting the influence of Ru–Co interactions and structural modifications in the ceria lattice.

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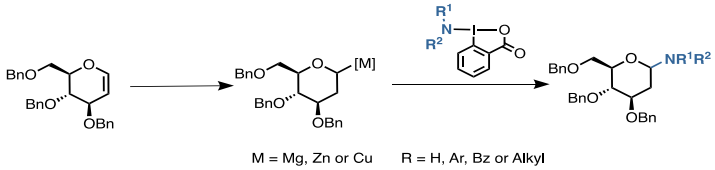
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N-GLYCOSYLATION VIA HYPERVALENT IODINE

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N-Glycosides are biologically relevant carbohydrate derivatives with activities such as antineoplastic, antibacterial, immunosuppressive, and antimicrobial effects [1]. Conventional glycosylation methods rely on ionic pathways but often face limitations including unstable donors and harsh conditions [2]. Hypervalent iodine reagents (HIRs), particularly benziodoxolones and benziodoxoles, offer a stable alternative and have proven effective in oxidative transformations [3]. Recently, we reported a new class of HIRs capable of transferring aminated groups to nucleophiles [4]. Here, we combine these reagents with organometallic chemistry to generate a metal–carbohydrate intermediate in situ, enabling amine transfer and providing a new route to N-glycals **(Scheme 1)**.



Scheme 1. *Organometallic route for the synthesis of N-glycosides using HIRS.*

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IONIC LIQUID DERIVATIVES OF MEFENAMIC ACID: A GREEN STRATEGY TO IMPROVE DRUG SOLUBILITY AND SKIN DELIVERY

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Green chemistry principles increasingly support the development of sustainable pharmaceutical systems for improving poorly water-soluble drugs. Ionic liquids have attracted interest due to their negligible vapor pressure and the possibility of forming active pharmaceutical ingredient ionic liquids (API-ILs) via simple acid–base reactions, enabling modification of drug properties without complex synthesis or extensive formulation strategies [1–2].

In this work, ionic derivatives of the nonsteroidal anti-inflammatory drug mefenamic acid were prepared using selected organic cations, including didecyldimethylammonium, 1-ethyl-3-methylimidazolium, and choline. The synthesis was performed in ethanol as the reaction medium, providing a simple and low-solvent approach to obtain the ionic forms of the drug.

The obtained derivatives showed strongly increased solubility in aqueous and physiologically relevant media compared with the parent compound. The nature of the counterion also influenced lipophilicity and drug transport across biological barriers. Skin permeation studies using Franz diffusion cells demonstrated clear differences in transdermal delivery between the derivatives. In vitro studies further confirmed that several systems retained strong anti-inflammatory activity while remaining compatible with human fibroblasts and THP-1 cells.

These results demonstrate that ionic derivatives of mefenamic acid provide a versatile platform for improving drug solubility, delivery efficiency, and potential bioavailability while supporting more sustainable pharmaceutical design through simplified synthesis and tunable molecular systems.

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SELECTIVE ELECTROCHEMICAL BROMINATION OF FURANS

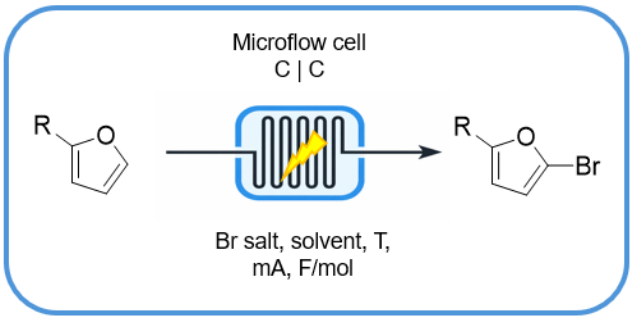
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Furan rings are widely present in biomass-derived platform molecules, yet their sustainable and selective functionalisation remains challenging. Therefore, this research explores electrochemistry as a green, tuneable strategy for functionalising furan platform molecules. In particular, electrochemical bromination of furan substrates using inorganic bromide salts is reported. Although electrochemical halogenation is well established for benzenes and various S- and N-heteroaromatics [1,2], analogous functionalisation of furans have not been reported due to competing polymerisation and mineralisation pathways.

Initial reaction screenings were therefore directed toward suppressing polymerisation by systematically tuning solvent, temperature, and electrochemical parameters in a continuous-flow electrochemical cell. These initial screenings resulted in high yields of monobrominated furan products, while minimising polymer formation. To further optimise both reaction efficiency and environmental performance, an integrated Bayesian Optimization (BO) workflow is implemented with a dual-objective function.



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CYCLODEXTRIN-BASED SUPRAMOLECULAR DEEP EUTECTIC SOLVENTS FOR GREEN EXTRACTION OF PHENOLIC COMPOUNDS FROM *PINUS SYLVESTRIS* NEEDLES

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Needles of *Pinus sylvestris* are a valuable source of phenolic compounds responsible for their antioxidant and biological activities [1]. In this study, cyclodextrin-based (β-CD) supramolecular deep eutectic solvents (SUPRADES) were studied as green extraction media for determination of phenolic compounds from *Pinus sylvestris* needles using shaking-assisted extraction methods followed by HPLC-PDA detection. The SUPRADESs were consisted of β-CD and different organic acids: tartaric, citric, malonic, levulinic, and ascorbic acids. The SUPRADES composed of β-CD:ascorbic acid provided the highest extraction yields of phenolic compounds at a molar ratio of 1:60. The optimal extraction conditions were found to be: extraction time – 30 min, extraction temperature – 20 °C shaking speed – 1500 rpm and liquid-to-solid ratio – 1:60 (mL mg^{-1}).

Under optimized conditions, untargeted LC–MS-qTOF analysis was performed to characterize the extracts and to compare SUPRADES extracts with 70% methanol. The notable differences in chemical profiles were observed between the tested SUPRADES and methanol extracts, due to the ability of cyclodextrins to encapsulate phenolic compounds through host-guest complex formation and the creation of inclusion complexes [2,3]. The results demonstrate that β-CD SUPRADESs are promising green solvents for the selective extraction of phenolic compounds and sustainable alternatives to conventional organic solvents.

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MERGING LIGHT AND ELECTRICITY: ELECTROPHOTOCATALYTIC HETEROARYLATION OF PYRAZOLES

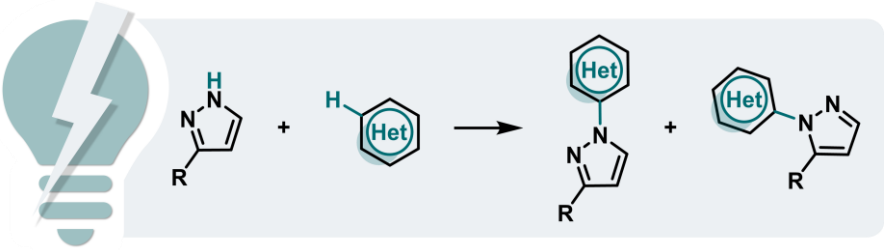
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Electrophotocatalysis (EPC) has emerged as a powerful strategy that combines the strengths of electrochemistry and photocatalysis to enable highly selective organic transformations. By operating under light and using electricity as a clean redox input, EPC provides a pathway to reduce chemical waste and improve overall sustainability. Its integration into continuous flow using a single-pass cell with a transparent electrode can significantly enhance productivity and scalability by balancing and accelerating the photochemical and electrochemical processes simultaneously [1].

Herein, an electrophotocatalytic platform for the (hetero)arylation of pyrazoles is reported. The synergistic interaction of electrochemical catalyst oxidation and photoexcitation generates aryl and heteroaryl radicals in a controlled manner, enabling efficient C–H functionalization across diverse pyrazoles. Moreover, the choice of electrolyte is shown to influence the electrophotocatalytic *N*–arylation in a regioselective manner, thereby adding an additional level of control over regioselectivity in electrophotocatalytic C–N bond formation.



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GREEN CHEMISTRY: NEW CATALYTIC PATHWAYS WITH PHOSPHATE-ZIRCONIA HYBRID

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This study reports the synthesis of a Zro_2–P_2O_5 xerogel using the sol–gel method. The synthesized xerogel was designed as a heterogeneous catalyst with potential applications in various catalytic processes. In particular, it was evaluated for the environmentally friendly synthesis of 2,3-dihydroquinazolin-4(1H)-ones (DHQs), a class of compounds known for their significant pharmacological importance.

The structural and physicochemical properties of the material were investigated using several analytical techniques, including Fourier Transform Infrared Spectroscopy (FTIR), Raman spectroscopy, X-ray diffraction (XRD), scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS), and thermogravimetric analysis coupled with FTIR (TGA-FTIR). These techniques provided comprehensive information about the structure and properties of the synthesized material.

The results confirmed the structural integrity and chemical homogeneity of the Zro_2–P_2O_5 xerogel. The catalyst demonstrated high efficiency in promoting multicomponent reactions in organic synthesis. Moreover, it exhibited good recyclability, maintaining its catalytic performance for up to five successive cycles. The reaction yield showed only a slight decrease from 93% in the first cycle to 90% after the fifth cycle, highlighting the excellent stability and reusability of the Zro_2–P_2O_5 catalyst.

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TURNING CORK INDUSTRIAL WASTE INTO LOW-COST EFFECTIVE CATALYSTS FOR DESULFURIZATION OF FUELS

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The removal of refractory S-compounds from fuels remains a major environmental challenge due to increasingly strict regulations on sulfur emissions [1]. In this context, the development of sustainable catalytic materials derived from renewable resources represents an important strategy for greener fuel purification processes [2, 3]. In this work, waste cork stoppers were converted into biochar through pyrolysis and used as a porous support for the preparation of a magnetic POM-based catalyst. A nanocomposite catalyst ($NiFe_2O_4$@BC@PW_{12}) was prepared by immobilizing PW_{12} onto nickel ferrite particles synthesized in the presence of cork-derived biochar. The resulting magnetic composite was characterized, confirming the preservation of the Keggin PW_{12} structure and its successful immobilization on the biochar-based support. The catalyst was evaluated in the oxidative desulfurization of simulated diesel containing refractory sulfur compounds using H_2O_2 as a green oxidant. Under optimized conditions (70 °C, EtOH as extraction solvent), the catalyst achieved approximately 89% sulfur removal and showed good stability over six catalytic cycles.

These results demonstrate that biomass waste can be transformed into high-value catalytic materials, contributing to circular economy strategies and the development of greener technologies for fuel desulfurization.

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BIO-BASED MALEIC ANHYDRIDE FROM 1-BUTANOL : PROCESS OPTIMIZATION AND REACTION SCHEME INVESTIGATION

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Maleic Anhydride (MA) is a highly versatile chemical intermediate, crucial for the production of Unsaturated Polyester Resins (UPR), 1,4-butanediol (BDO), and lubricating oil additives. While MA is traditionally produced through the selective oxidation of fossil-based feedstocks like *n*-butane over Vanadyl Pyrophosphate (VPO) catalysts, the transition toward sustainable chemistry passes through the efficient exploitation of renewable alternatives. Therefore, we investigated the gas-phase oxidation of 1-butanol - a renewable resource potentially derived from ABE fermentation or the Guerbet upgrading of ethanol [1] - as a sustainable, renewable replacement for bio-based MA production [2]. To optimize this process, catalytic testing was performed in a continuous-flow, fixed-bed glass reactor at atmospheric pressure, feeding a mixture of 1-butanol in air over different VPO-based catalysts. The study initially focused on the optimization of the reaction temperature at high contact times (W/F), comparable to those employed in the industrial butane process and previous work reported for 1-BuOH oxidehydration. Then, the contact time was fine-tuned to maximize selectivity to MA. The study successfully achieved MA yields comparable to the established fossil-based process, increasing also MA productivity at lower temperature compared to butane. Furthermore, this detailed investigation isolated key reaction intermediates, revealing that the oxidative formation of butyraldehyde shifts selectivity toward undesired oxidized by-products. Additionally, water co-feeding tests demonstrated that steam significantly impacts both the catalyst's structure and its overall performance.

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EXPLORING METASTABLE FCC-RU VIA SURFACE-HEATED ELECTRODEPOSITION OF FACETED NANOSEEDS FOR ELECTROCATALYTIC APPLICATIONS

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Controlling crystal phases and facet exposure in nanomaterials remains a key challenge, as conventional electrochemical methods often yield polycrystalline particles. Here, we present an electrodeposition strategy combined with localized surface heating that enables surfactant-free synthesis of single-crystalline nanoseeds. Selective heating at the electrode enhances interfacial atomic mobility, directing nuclei into stable crystallographic orientations while leaving the bulk solution unaffected. Charge-based analysis further reveals distinct growth pathways: single-crystal seeds evolve into octahedra, whereas twinned seeds transform into isodecahedra. These Pd nanocrystals act as epitaxial templates for Ru deposition. Precise potential control proves critical—low overpotentials promote layer-by-layer epitaxy, whereas higher overpotentials trigger heterogeneous nucleation. Unlike vapor-phase methods, this electrochemical route achieves low-temperature synthesis with fine compositional control. While fcc-Ru is metastable, epitaxial stabilization on Pd offers access to unique coordination environments and facet-dependent reactivity relevant to oxygen evolution catalysis (OER). The potential for reversible transformation between fcc-Ru and RuO2 remains under investigation, yet it motivates exploration of “breathable” OER catalysts capable of regenerating active sites without structural degradation. Overall, this work highlights electrodeposition with surface heating as a versatile platform to access metastable structures for electrochemical energy conversion.



A RECYCABLE HETEROGENEOUS CATALYST FOR THE CHEMO- AND ENANTIOSELECTIVE HYDROGENATION OF C=C BONDS

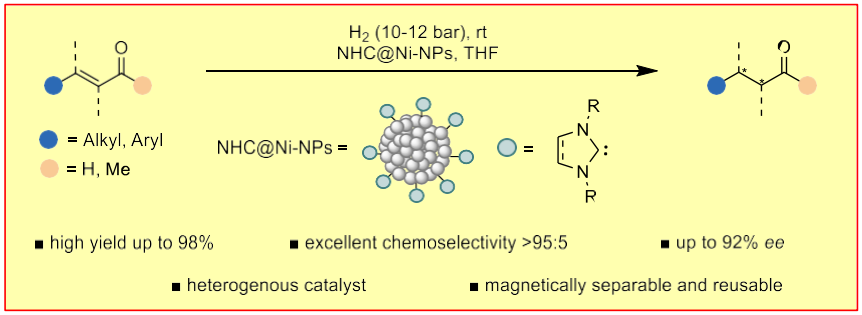
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The chemoselective reduction of C=C bonds in α,β-unsaturated carbonyls remains challenging in organic synthesis, as traditional homogeneous catalysts often have limited functional group tolerance and are not easily recycled. Here, we present a high-performance heterogeneous catalytic system utilising N-heterocyclic carbene (NHC)-modified nickel nanoparticles. In this system, the NHC ligands play a dual role, providing exceptional colloidal stability without the need for bulky solid supports, while also significantly enhancing the catalytic activity. This catalyst achieves excellent yields and chemoselectivity across diverse substrates, offering facile magnetic separation and recyclability.

Furthermore, by using chiral NHC modifiers, we demonstrate an innovative and efficient method for asymmetric hydrogenation in a heterogeneous system. This approach combines the high enantioselectivity typically observed for molecular catalysts with the practical, eco-friendly benefits of a recoverable heterogeneous system. It offers a new concept in catalyst design for synthesising enantioenriched products.



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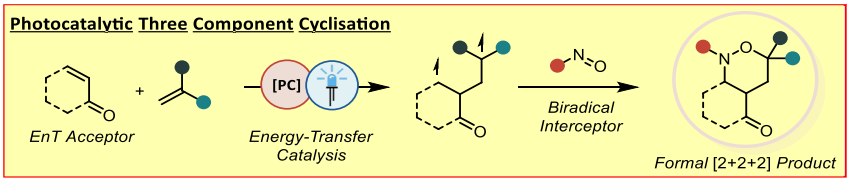
THREE-COMPONENT CYCLISATION ENABLED BY TRIPLET-SENSITIZED BIRADICAL INTERCEPTION USING PHOTOCATALYSIS

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Visible-light photocatalysis provides a sustainable alternative to traditional (photo-)chemistry by avoiding harsh conditions and high-energy UV irradiation. In particular, energy-transfer (EnT) catalysis allows access to long-lived triplet states, enabling controlled open-shell reactivity and offering a green strategy for the synthesis of structurally complex molecules. Cyclization reactions under mild photocatalytic conditions enable the construction of complex and highly strained molecular scaffolds that are difficult to access through conventional closed-shell reactivity.[1,2]



Recent efforts have largely focused on two-component reactivity. We reasoned that, through careful reaction design guided by principles of radical stability and philicity,[3] the short-lived nature of biradical intermediates could be overcome. Nitrosoarenes, known as efficient spin traps, were identified as suitable partners to intercept biradicals prior to intersystem crossing and [2+2] ring closure. This strategy enables a formal intermolecular [2+2+2] process, providing access to saturated, sp^3-rich molecular scaffolds. The resulting products feature rare N–O bonds within multifused ring systems that are otherwise difficult to access.

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ORGANIC CARBONATE MEDIATED FUNCTIONALIZATION OF ISOSORBIDE AND ITS EPIMERS

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Within the biorefinery framework, the so-called bio-based platform chemicals play an important role and among C6 carbohydrates, D-sorbitol and its cyclic derivative form, isosorbide, are of particular interest.[1] Isosorbide is a very important building block for a wide range of applications and it can be used as a monomer of natural origin for the synthesis of bio-based polymers, such as polycarbonates and polyesters. [2] Moreover, the functionalization of the two hydroxyl groups has allowed the synthesis of numerous derivatives with various applications such as surfactants, plasticizers, flame retardants and coalescent paint derivatives.[3] From these premises, the present work focuses on different strategies for the functionalization of isosorbide, with particular emphasis on the use of dialkyl carbonate (DAC) chemistry; DACs are well-known green solvents and reagents that can act as alkylating and carboxyalkylating agents.[4] In the first case, a comprehensive synthesis of dimethyl isosorbide (DMI) using dimethyl carbonate was carried out in an autoclave. Reaction conditions were optimized with a nitrogen organocatalyst (N-methyl pyrrolidine) and heterogeneous acid catalyst (Amberlyst-36 and Purolite CT275DR). In the second case, dialkyl carbonate chemistry was used for the preparation of dipropargyl derivatives of isosorbide via alkoxycarbonylation reaction conducted in mild conditions using catalytic amount of 1,5,7-triazabicyclo[4.4.0]dec-5-ene (TBD). In both cases, the best reaction conditions were applied for the functionalization of isosorbide epimers, isoidide and isomannide, and for some preliminary scale-up tests.

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GREEN HYDROTHERMAL SYNTHESIS AND CHARACTERIZATION OF MAGNETIC CORE-SHELL PARTICLES FROM LEAF EXTRACTS OF CINNAMOMUN CAMPHORA

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Iron oxide–based nanocomposites exhibit unique physical and chemical properties and are important materials in many technological applications. In this study, we report the hydrothermal synthesis of iron oxide core–shell particles (CSPs) from an iron nitrate ($Fe(NO_3)_3 \cdot 9H_2O$) solution using cinnamomum camphora leaf (CCL) extract as a stabilizing and reducing agent. The extract contains a rich composition of phytochemicals, such as flavonoids, phenols, and terpenoids. The CCL was washed, crushed, and stirred with deionized water for 60 min. The resulting solution was then filtered to obtain the CCL extract. The synthesized particles were characterized by thermogravimetric analysis (TGA), X-ray diffraction (XRD), transmission electron microscopy (TEM), Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), vibrating sample magnetometry (VSM), and ultraviolet–visible spectroscopy (UV–Vis). XRD and TEM analyses reveal that the as-synthesized particles consist of a Fe_3O_4 core and an α-Fe_2O_3 shell structure. The mean crystallite sizes are 8.7 nm and 32.6 nm for the core and shell phases, respectively. Room-temperature hysteresis loop measurements indicate that the core–shell particles exhibit a coercivity of 40 Oe and a saturation magnetization of 2.63 emu/g. TGA measurements recorded under an applied magnetic field display two magnetic ordering transition temperatures, T_{m1}= 358 °C and T_{m2}= 582 °C. The former corresponds to the core‐shell interface magnetic transition temperature, while the latter corresponds to the Curie temperature of Fe_3O_4. The proposed mechanisms are further supported by spectroscopic and magnetic analyses of the core–shell nanocomposites.

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ECO-FRIENDLY SYNTHESIS OF AG-NPS ON HOPG FOR SUSTAINABLE APPLICATIONS: EXPERIMENTAL AND COMPUTATIONAL STUDIES

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The study of metallic nanoparticles has gained significant relevance in recent decades due to their wide range of applications in catalysis, medicine, bioengineering, water treatment, electronics, and optics. Among them, silver nanoparticles stand out for their antimicrobial properties, known since earlier centuries and enhanced through the development of nanotechnology. The achievement of successful deposition of nanoparticles on solid substrates using green technology is a fundamental step for their characterization offering an environmentally friendly, sustainable, and scalable production method.

We present a combined approach that integrates the electrochemical synthesis of silver nanoparticles (Ag-NPs) on Highly Oriented Pyrolytic Graphite (HOPG) using cyclic voltammetry and chronoamperometry, together with a computational analysis based on Density Functional Theory (DFT) to study the interaction between the substrate and metallic clusters. This experimental–computational strategy aims to establish a comprehensive understanding of the nucleation, growth, and stability processes of Ag-NPs on HOPG, with a view toward their application in functional coatings and technologically relevant devices through sustainable green-chemistry.

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COLLABORATIVE STEREOCONTROL IN ENANTIOSELECTIVE HYDROARYLATION: A SUSTAINABLE APPROACH TO CHIRAL MOLECULE SYNTHESIS

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The development of sustainable catalytic methods that maximize efficiency while minimizing waste is a central objective of modern synthetic chemistry. Direct C–H functionalization offers an attractive strategy to improve atom and step economy by transforming abundant C–H bonds into valuable C–C bonds without the need for substrate prefunctionalization. When combined with asymmetric catalysis, such transformations provide environmentally responsible routes to chiral molecules of importance in pharmaceuticals, agrochemicals, and functional materials.

Our research focuses on the development of ruthenium(II)-catalyzed enantioselective hydroarylation reactions as sustainable platforms for asymmetric synthesis. These transformations proceed through direct C–H activation and exhibit excellent atom economy, enabling efficient construction of chiral heterocycles while reducing synthetic steps and waste generation. Central to this work is the concept of collaborative stereocontrol, in which multiple components of the catalytic system—including the metal center, ligands, and transient substrate interactions—cooperatively govern enantioselectivity. Mechanistic investigations reveal how these synergistic interactions dictate stereochemical outcomes and provide design principles for developing highly selective catalytic processes.

By integrating catalyst design with mechanistic understanding, our work establishes practical and sustainable approaches to asymmetric C–H functionalization. These studies demonstrate how fundamental insights into catalytic cooperativity can enable greener synthetic methodologies for the efficient preparation of chiral molecules while advancing the broader goals of green chemistry.

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GREEN SYNTHESIS OF 1,2,4-TRIAZOLE-THIOACETAMIDE DERIVATIVES AND THEIR ANTIMICROBIAL ACTIVITY

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The design of sustainable synthetic routes to biologically active heterocycles is one of key objectives of green organic chemistry [1]. Heterocyclic compounds are of fundamental importance in medicinal chemistry because they constitute the core structural fragments, which enable diverse biological activities, improved target selectivity, and optimized pharmacokinetic properties. They are important in the development of new antimicrobial agents, as their structural diversity and tuneable biological properties make them key scaffolds for addressing the growing threat of antimicrobial resistance.

In this study, an efficient and environmentally considerate approach to the synthesis of functionalized 1,2,4-triazole derivatives is reported. 2,4-Triazole-3-thiones bearing 2-amino-5-chloropyridine or 2-amino-3,5-dibromopyridine moieties were selectively *S*-alkylated with a series of substituted bromoacetamides to afford the corresponding 1,2,4-triazole-3-thiols. The reactions were performed under mild conditions, using green solvents, ensuring high chemoselectivity toward sulphur alkylation, reduced energy input, straightforward work-up procedures, and minimized waste generation, in accordance with green chemistry principles [2]. 2-((5-(2-((3,5-Dibromopyridin-2-yl)amino)ethyl)-4-phenyl-4*H*-1,2,4-triazol-3-yl)thio)-*N*-(*p*-tolyl)acetamide exhibited significant antifungal potency, which surpassed nystatin, and antibacterial activity on par with vancomycin. A green synthetic strategy for the preparation of novel triazole-based scaffolds with potential application as antimicrobial agents contributes to the development of sustainable approaches in medicinal chemistry.

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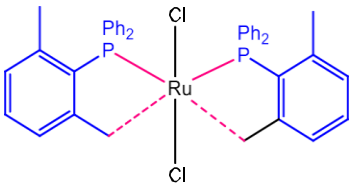
CYCLOMETALATED RUTHENIUM(II) CATALYSTS FOR ESTER HYDROGENATION

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Cyclometalated ruthenium catalysts have drawn considerably attention in the last decade since the pioneering work on PC complexes[1] based on the agostic 14-electron “butterfly” Ru(II)[2] framework. Our recent work built on this chemistry, led to the synthesis and new cyclometalated Ru complexes bearing carboxylate ligands. The development of these systems and the deep experimental commitment reflect the necessitate of advancing in the preparation of systems for broad catalytic applications. The resulting complexes provide a clear and reliable platform for studying reactivity and have been applied to the selective hydrogenation of esters and triglycerides[3] under mild in-situ conditions. Their performance was evaluated alongside with the established PC systems[1] and with the Ru–MACHO as an external benchmark. Under optimized conditions (S/C = 10 000, 27.5 bar H_2, 16 h), our complexes show competitive activity and demonstrate how subtle ligand variations shape ruthenium-mediated hydrogenation.





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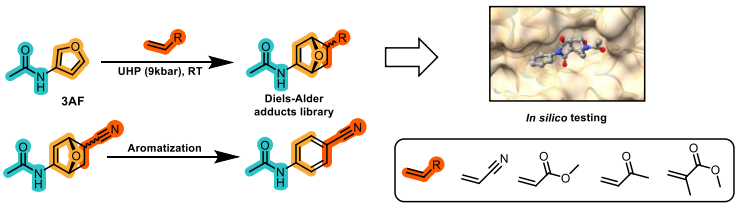
SYNTHESIS AND *IN SILICO* TESTING OF NOVEL NITROGEN-RICH CANTHARIDIN ANALOGS PROMOTED BY ULTRA HIGH PRESSURE

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With 7 million tonnes of seafood waste generated annually, chitin is an abundant resource [1], and its hydrolysis product, N-acetylglucosamine (NAG), is a valuable precursor to nitrogen-rich furans [2]. These electron-rich furans undergo Diels–Alder reactions with maleimides to form stable adducts [3,4], though reactivity with other dienophiles remains limited. Here, chitin-derived 3-acetamidofuran (3AF) was explored as a diene under ultra-high-pressure (UHP) conditions [5], enabling catalyst-free synthesis of new adducts with challenging dienophiles at room temperature. Aromatization conditions were then investigated to access biomass-derived aniline building blocks. Additionally, due to structural similarity to cantharidin derivatives [6], preliminary in silico docking studies were performed to assess potential biological activity **(Scheme 1)**.



Scheme 1- Synthesis of Biomass-derived Diels-Alder adducts, *in silico* studies and aromatization strategies.

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MECHANOCHEMICAL REACTIVITY OF BIOMASS-DERIVED BIS-FURANS TOWARD NITROSOALKENE CYCLOADDITIONS

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Furans derived from lignocellulosic biomass are valuable renewable building blocks for the development of sustainable synthetic methodologies.[1] Their rich reactivity, combined with their bio-based origin, makes them attractive substrates for the preparation of structurally diverse and value-added compounds. In particular, bis-furans are especially interesting platforms, as the presence of two furan units connected by different linkers offers multiple possibilities for tuning reactivity and selectivity. In this context, the hetero-Diels–Alder reaction of furans within situ generated nitrosoalkenes represents a useful strategy for probing their behaviour and expanding the accessible furan-based chemical space.[2, 3]

Herein, we explore the reactivity of several structurally distinct bis-furans toward a p-nitrophenyl-derived α-bromo oxime under mechanochemical conditions. A small library of bis-furans bearing different spacers between the two furan moieties, including sulfur-, disulfide-, carbonyl-, methyleneoxy-, and oxalamide-based linkers, was selected to evaluate the influence of structural features on reaction outcome. Their reactivity was investigated in the presence of sodium carbonate under mechanochemical conditions previously shown to promote the formation of dihydrofurooxazine cycloadducts from simpler furans. This study aims to identify the most reactive bis-furan scaffolds and to assess how the nature of the linker affects the formation of the corresponding cycloadducts.

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SOLVENT-FREE TIN(IV) CHLORIDE–CATALYZED STRECKER-TYPE CYANATION OF BENZALDEHYDE DIMETHYL ACETAL: MECHANISTIC AND EXPERIMENTAL STUDIES

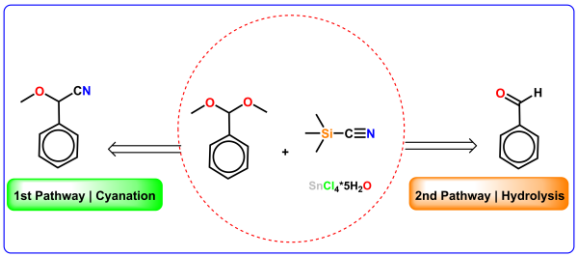
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Strecker-type reactions remain among the most versatile approaches for the synthesis of organic nitriles.[1] Yet, the participation of acetals as substrates in such transformations is notably rare and mechanistically underexplored. In this study, we investigate the cyanation of benzaldehyde dimethyl acetal ($PhCH(OMe)_2$) with trimethylsilyl cyanide (TMSCN) in the presence of a tin(IV) chloride ($SnCl_4 \cdot 5H_2O$, denoted as Sn(IV)) catalyst using a combination of density functional theory (DFT) calculations and NMR spectroscopy. The results reveal two competitive reaction pathways operating under the studied conditions. The first pathway is a Strecker-type cyanation of the acetal, yielding PhCH(OMe)(CN). It involves TMSCN coordination to the Sn(IV) catalyst, TMS transfer to the acetal, C–OMe bond cleavage, and ion recombination to form the product. The second pathway involves catalytic hydrolysis of the acetal to benzaldehyde. Protonation by Sn(IV)-coordinated water leads to an ion-pair intermediate and methanol, followed by hemiacetal formation and further methanol elimination to give benzaldehyde. Overall, the Sn(IV) catalyst facilitates both pathways by activating TMSCN toward Si–C bond cleavage and increasing the acidity of coordinated water.



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GREEN PROCESSING-INDUCED DEVELOPMENT OF IN-SITU GENERATED PTFE NANOFIBRILS AND HALLOYSITE NANOCLAYS DELINEATED FOR PLA FOAMING

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High-performance cellular biopolymer foams are promising sustainable alternatives to conventional petroleum-based foams, provided that their microstructure can be precisely controlled during processing [1,2]. In this study, poly(lactic acid) (PLA)-based composite foams containing halloysite nanoclay (HNC) and polytetrafluoroethylene (PTFE) were fabricated by twin-screw extrusion foaming using azodicarbonamide as the blowing agent. The influence of screw speed (20-120 rpm) on cellular morphology, crystallization behaviour, rheology and compressive properties was systematically investigated. In PLA/HNC composites, increasing screw speed enhanced filler dispersion and heterogeneous nucleation, reducing cell size by approximately 50-60% and producing a maximum void fraction of ~20.5% at 60 rpm. In contrast, PLA/PTFE composites exhibited in-situ fibrillation, forming a three-dimensional nanofibrillar network (~100-500 nm) whose density increased progressively with screw speed. The PTFE nanofibrillar network accelerated PLA crystallization, reducing the crystallization half-time at 130 °C by more than 20-fold compared with neat PLA (versus ~4-fold for HNC), owing to its significantly high nucleation surface area. Consequently, PLA/PTFE foams exhibited superior compressive performance, achieving specific compressive strengths of ~68-70 MPa·cm³/g and toughness values of ~11 J/g at 120 rpm, exceeding PLA/HNC foams by approximately 50% and 80%, respectively. These findings demonstrate an effective processing strategy for tailoring the structure and performance of lightweight biopolymer foams, providing insights for the development of high-performance and more sustainable cellular materials.

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HIGH PRESSURE TORSION: A GREEN SOLID STATE STRATEGY FOR RECYCLING PAPER BASED POLYMER COMPOSITES

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Paper based polymer composites are attractive sustainable materials; however, conventional recycling methods often degrade fibre morphology and require repeated melting or chemical treatments, leading to deterioration of composite performance. Here, we demonstrate high-pressure torsion (HPT) as a green, solvent-free, solid state recycling strategy that preserves and enhances the reinforcing capability of paper fibres through hierarchical structural rescaling. Using polymer paper composites as a model system, we show that the extreme confined shear generated during HPT transforms macroscopic paper sheets into a three dimensional, percolating cellulose nanofibrillar network through interfibre sliding, without fibre isolation or chemical modification [1]. Simultaneously, the solid state deformation restructures the polymer matrix, promoting nanoscale homogenisation of initially immiscible polymer blends, redistributing paper derived fillers throughout the composite volume, and suppressing residual porosity [2]. This structural evolution converts the polymer matrix into an active load bearing phase that stabilises the nanofibrillar network, improves stress redistribution, and reduces moisture transport. Consequently, significant increases in stiffness and yield strength are achieved at paper contents as low as 20–30 wt%.These findings establish high pressure torsion as a sustainable solid state recycling approach.

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Acknowledgments:

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NATURAL SOLVENTS FOR SUSTAINABLE POLYPROPYLENE RECYCLING: DISSOLUTION-PRECIPITATION

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The plastic sector generates an enormous amount of waste each year, with the yearly consumption surpassing 460 Mt, in 2019. However, recycling rates remain below 15%.[1] The urge to shift to a more circular paradigm is intertwined with the need for greener sustainable recycling processes, that yield polymers of sufficient quality to fulfil the requirements of most applications, including those with severe restrictions, such as food packaging. Common recycling techniques fail to handle many materials that are commonly used in packaging and other applications, namely mixed-polymer materials, and materials containing colorants and other additives. Physical recycling, and particularly dissolution-precipitation, has the potential to fill this gap. It allows the purification, separation, and recovery of polymers similar to the pristine, while still consisting of an overall simple process, but state-of-the-art solvents carry strong safety and environmental concerns.[2]

This work delves into the design of dissolution-precipitation processes for polyolefins, using widely available, natural-based solvents: α- and β-pinene. The impact of key operating conditions, including initial polymer content, dissolution temperature, and solvent composition, was evaluated. The process' performance show high robustness across different polymer samples and mixtures, achieving high polymer and solvent recoveries while preserving the recyclates' structural and thermal properties. In particular, small variations in solvent's composition in the two isomers did not yield significant changes in the recyclates quality and recovery. The great robustness and adaptability of the developed process, while resorting to naturally sourced solvents, represent an important step towards truly sustainable recycling routes for polyolefins.

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Acknowledgments:

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PROCESS DEVELOPMENT FOR HYDROGEN PRODUCTION FROM AMMONIA DECOMPOSITION AT HIGH PRESSURES

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The growing demand for hydrogen requires efficient storage and transportation solutions. Ammonia is a promising hydrogen carrier due to its high hydrogen density and ease of liquefaction, enabling large-scale energy storage and distribution [1,2]. Catalytic ammonia decomposition provides a clean pathway for hydrogen recovery, avoiding NOx emissions associated with direct combustion. In this work, a high-pressure membrane reactor is proposed to enhance hydrogen production from ammonia. The system integrates a packed-bed reactor with Ni- or Ru-based catalysts and a Pd/Ag selective membrane for in situ hydrogen separation. This configuration shifts the reaction equilibrium, enabling higher ammonia conversion and high-purity hydrogen production at reduced temperatures. The reactor design ensures efficient heat management and stable operation. The results demonstrate that reaction–separation integration under high-pressure conditions is a promising strategy for sustainable hydrogen production.

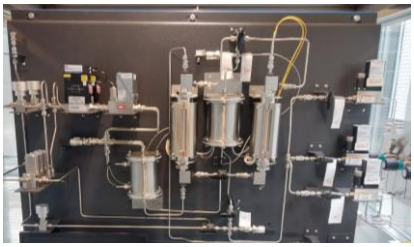


Figure 1- Photograph of the developed high-pressure ammonia decomposition system, showing two reactor configurations for hydrogen production.

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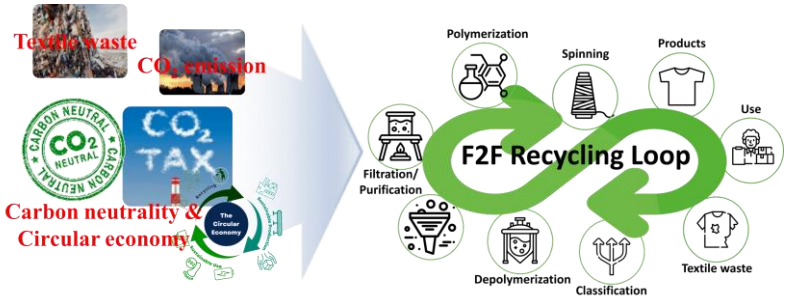
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PHYSICAL AND CHEMICAL RECYCLING OF WASTE PET FABRICS FOR CLOSED-LOOP FIBER-TO-FIBER RECYCLING

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Recycled PET yarns are increasingly used due to environmental concerns, stricter regulations, carbon neutrality initiatives, and the growth of green consumerism.[1] However, most rely on post-consumer bottles; while bottle-to-bottle recycling is closed-loop, conversion into fibers disrupts circularity. Therefore, sustainable fiber-to-fiber (F2F) recycling offers a potential solution to these challenges. In this study, both physical and chemical recycling pathways for 100% PET fabric waste were investigated. For physical recycling, PET waste was converted into recycled chips via shredding, popcorn conversion, extrusion, and solid-state polymerization (SSP), which were then characterized using I.V., MFI, rheology, DSC, TGA, and FT-IR. Concurrently, a chemical pathway utilized glycolysis-based depolymerization and low-temperature recrystallization to purify bis(2-hydroxyethyl) terephthalate (BHET).[2,3] GC, TGA, and UV–Vis analyses confirmed a BHET purity above 97%, which is comparable to that of commercial-grade monomers. Future work will involve the repolymerization of the chemically derived BHET, followed by a comparative study on the melt-spinning behavior and property evaluation of both physically and chemically recycled PET chips.



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SUSTAINABLE RECOVERY OF BATTERY-GRADE MANGANESE SULFATE FROM STEELMAKING DUST

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The rapid growth in battery demand has increased the need for high-purity manganese sulfate($MnSO_4$), a critical raw material for lithium-ion battery cathodes. However, current $MnSO_4$ production mostly relies on conventional mining-based processes, resulting in a substantial environmental burden, including high energy consumption and waste generation. Against this background, steelmaking dust generated as a by-product during ferromanganese production has strong potential as an alternative Mn source because it contains a high amount of Mn and is generated in large quantities. However, it is not widely used because its high Fe content makes purification difficult.

In this study, high-purity $MnSO_4$ was recovered from steelmaking dust through a simple process that enabled effective impurity removal without the addition of extra chemicals. Hydrogen peroxide(H_2O_2) was employed to enhance Mn dissolution during sulfuric acid leaching. Depending on the pulp density, iron was removed without additional chemical additives, either by natural pH-induced precipitation or by a simple washing step prior to crystallization. As a result, a manganese recovery of more than 90% was achieved, and effective removal of the main impurity, Fe, was demonstrated. This process presents a sustainable route for recovering high-purity $MnSO_4$ from an underutilized industrial by-product while reducing reliance on conventional mining and complex purification processes.

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OSMIUM COMPLEXATION ANALYSIS IN AQUATIC SAMPLES BY X-RAY FLUORESCENCE, AFTER MEMBRANE EXTRACTION

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Osmium is an element that belongs to Platinum Group Metals (PGM), with important applications as a catalyst and, also, it gives excellent resistance to alloys used in extreme corrosion conditions. In this work, we present results on the extraction of osmium with appropriate complexing membranes, and the analysis of osmium at extremely low concentrations by Energy Dispersive X-Ray Fluorescence (EDXRF) [1, 2].

Specifically, candidate ligands were investigated for the extraction of osmium from aqueous samples and it was shown that triphenyl-phosphate was the most efficient. This ligand was introduced into an anion membrane ethylene-vinyl-acetate (1cm.1cm.1mm) which was placed in aqueous osmium solutions (250 mL) and was left under stirring for 24 hours. Then the membrane was removed from the solution and analyzed with EDXRF.

The membrane's ability to bind osmium under different pH conditions (optimal pH 4), the effect of water hardness and any interference from other metals were examined. The minimum detection limit achieved was 70 ng/L (ppt) in deionized water and 100 ng/L in seawater with a recovery equal to 96 %. The method showed excellent linearity (R^2=0.998) while there were no interferences from metals commonly found in natural waters.

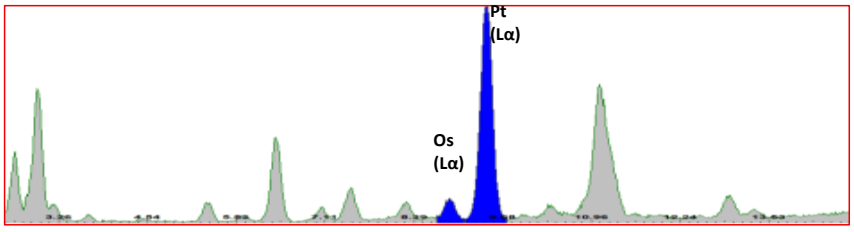


Figure 1. EDXRF spectrum from analysis of 250 mL distilled water spiked with 1 μg/L Os and 20 μg/L Pt internal standard for 300 s. The aquatic sample were acidified at pH 4, and $MgCl_2$ (0.29 % w/v) was added.

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DETERMINATION OF IRON BY PIPETTE-TIP MICRO-SOLID PHASE EXTRACTION FOLLOWED BY UV-VIS DETECTION

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Iron present in natural and drinking waters significantly affects their organoleptic properties, such as colour, taste, and turbidity. Because these properties depend on the oxidation state of iron, reliable speciation analysis of Fe(II) and Fe(III) is important for water quality assessment. Spectrophotometric determination based on the Fe(II)–1,10-phenanthroline complex is widely used; however, its sensitivity may be insufficient for trace-level determination in water samples [1].

In this work, a method based on pipette-tip micro-solid phase extraction (PT-µSPE) combined with UV–Vis spectrophotometric detection was developed for the selective determination of Fe(II). The method relies on the formation of the Fe(II)–1,10-phenanthroline complex followed by its preconcentration using PT-µSPE, while the main parameters affecting extraction efficiency and detection were optimized.

The developed method provides good linearity, low detection limits, and satisfactory precision, enabling reliable determination of iron at low concentration levels. Selective determination of Fe(II) in the presence of Fe(III) was achieved, and reduction of Fe(III) by ascorbic acid allowed the determination of total iron.

The applicability of the method was demonstrated using several real water samples, including tap water, well water, and mineral water. The method also complies with the principles of green analytical chemistry, using only small amounts of solvent (200 µL), sample (6 mL), and sorbent (8 mg), while the pipette tip can be reused several times.

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BIOELECTROCHEMICAL METAL RECOVERY FROM SPENT LITHIUM-ION BATTERY CATHODES

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The increasing use of lithium-ion batteries has raised the need for sustainable recycling and resource recovery. While bioleaching has been considered an environmentally friendly alternative, its efficiency can be limited by metal toxicity, highlighting the need for improved recovery methods.

In this study, we employed a microbial fuel cell (MFC) system as a bioelectrochemical platform for metal recovery from spent lithium-ion battery cathodes. We designed a dual-chamber MFC reactor to spatially separate microbial metabolism from the metal reduction environment, enabling electrons generated by microbial oxidation to drive cathodic metal reduction while simultaneously generating electricity. Under a solid-to-liquid ratio of 3.5 g/L, the maximum leaching efficiencies of Ni, Co, and Mn reached 27.8 %, 21.8 %, and 16.2 %, respectively. In addition, we observed manganese phosphate precipitates on the cathode surface after the reaction, suggesting secondary mineral formation during the bioelectrochemical process.

This result demonstrates that MFC-based systems can provide a sustainable bioelectrochemical approach for recovering valuable metals from spent lithium-ion battery cathodes while simultaneously producing energy, offering a promising alternative to conventional recycling technologies.

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QUANTITATIVE SPATIAL RESOLUTION FRAMEWORK FOR SCANNING ELECTROCHEMICAL MICROSCOPY TOWARD RELIABLE CATALYTIC ACTIVITY MAPPING

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Understanding spatially heterogeneous catalytic activity is critical for the rational design of efficient electrocatalysts for sustainable energy conversion. Scanning electrochemical microscopy (SECM) provides a powerful platform for mapping local electrochemical reactivity; however, a rigorous and quantitative definition of planar spatial resolution in SECM imaging remains elusive. Herein, we establish a quantitative framework for defining SECM spatial resolution based on an effective diffusion ellipsoid (EDE) model that describes the diffusion field surrounding an ultramicroelectrode probe. By integrating COMSOL simulations with systematic SECM imaging experiments using probes of different radii, we identify the intersection diameter between the EDE and the substrate as the upper limit of the imaging step-size that preserves local electrochemical information without spatial averaging. Under these conditions, the imaging resolution becomes equivalent to the step-size. Experimental validation across both feedback and generation–collection modes further demonstrates that smaller electrodes confine the diffusion field and enable more localized detection of catalytic activity. The proposed framework establishes practical quantitative guidelines linking probe size, probe–substrate distance, and imaging step-size, providing a robust foundation for reliable high-resolution SECM analysis. This approach enables more accurate spatial mapping of catalytic reactivity and facilitates the rational development of advanced electrocatalysts for sustainable energy technologies.

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SESQUICHIC: CHICORY SESQUITERPENE LACTONES AS BIOBASED INSECTICIDES

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Chemical insecticides are becoming increasingly restricted on the European market, which combined with a limited number of new registrations is posing major challenges for integrated management of insect pests [1]. Leads for novel insecticides are sought in natural sources. An interesting class of natural products in this regard are the sesquiterpene lactones (SLs), which are produced by many Asteraceae, including industrial chicory. The Sesquichic project aims to identify leads for a novel botanical insecticide by examining the residual waste stream of the chicory cultivation industry.

This industry focuses on the extraction of inulin, a dietary fibre, from the taproots of *C. intybus* L. var. *Sativum*. The resulting biomass waste is enriched in sesquiterpene lactones; these secondary metabolites likely play a role in chicory's high level of resistance against generalist insect pests [2]. Aiming to isolate the SLs in sufficient quantities from chicory biomass, we are developing and scaling up mild extraction and purification workflows that integrate chromatographic, crystallization, and precipitation techniques [3,4]. Besides structural elucidation, the insecticidal properties of individual SLs will be evaluated in bioassays involving thrips to establish structure-activity relationships (SAR), ultimately guiding the identification of promising biobased insecticide leads.

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THE VISIBLE LIGHT INDUCED ANTIMICROBIAL ACTIVITY OF TiO_2 NANOPARTICLES ANCHORED ONTO CELLULOSE ACETATE FILM CONTAINING GALLOYL MOIETY

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TiO_2 is one of the most studied photocatalysts. Due to its large bandgap (3.2 eV), TiO_2 absorbs only UV photons, which represent less than 5% of the available solar light photons. One of the possible methods to extend the absorption of TiO_2 into the visible spectral region is the formation of interfacial charge transfer (ICT) complexes between TiO_2 and small colourless organic molecules [1-3]. Cellulose acetate porous films, containing different gallic acid esters, were prepared. TiO_2 colloid particles (4.5 nm) were attached to the film surface by a condensation reaction between -OH groups (at TiO_2 surface) and galloyl moiety (at film surface). The intense colour of films after adsorption of TiO_2 and appearance of the absorption in the visible spectral region indicate ICT complexes formation. So prepared hybrid materials show good photo-induced antimicrobial activity against the Gram-negative bacteria *E. Coli* and Gram-positive bacteria *S. aureus*, under monochromatic light irradiation (457 nm).

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EFFICIENT MINERALIZATION OF POLY(TETRAFLUOROETHYLENE-*CO*-HEXAFLUOROPROPYLENE) COPOLYMER (FEP) USING SUBCRITICAL WATER

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Fluoropolymers have been used across various applications due to their stability against chemicals, heat, UV light and aging—properties that are difficult to achieve with other materials. Thanks to these unique characteristics, fluoropolymers are currently utilized in numerous industries, from common industrial equipment to high-tech applications. Poly(tetrafluoroethylene-*co*-hexafluoropropylene) (FEP) is a widely used melt-processable fluoropolymer. The majority of FEP are utilized in electrical applications, such as insulation for electrical wiring, as well as in chemical applications, including tank linings, pipe linings, and hoses. However, fluoropolymers are now classified as per- and polyfluoroalkyl substances (PFAS), raising concerns about their environmental impact.

Under the circumstances, effective waste-treatment technologies capable of completely breaking down these compounds are needed [1]. If fluoropolymer waste can be decomposed to F^- ions (i.e., mineralization) under mild conditions, F^- can be converted into CaF_2 by a reaction with Ca^{2+} ion, which can contribute the recycling of fluorine element.

This presentation shows the efficient mineralization of FEP—using subcritical water in combination with an alkaline reagent [2]. When FEP was reacted in 3.0 M of KOH at 360 °C under argon for 18 h, the F^- yield reached 98%. Therefore, complete fluorine mineralization was achieved. On the other hand, the remaining ratio of TOC in the aqueous phase was 17%. These results indicate that the resulting organic compounds in the reaction solution do not contain fluorine atoms, because most of the fluorine atoms in FEP were mineralized. ^{19}F-NMR of the reaction solutions showed only the peak of F^-, even in cases where the mineralization was incomplete. Raman spectroscopy for the residue generated under insufficient mineralization conditions indicated that the residue was a mixture of FEP and amorphous carbon. FEP decomposed, releasing F^- into the reaction solution, resulting in the formation of amorphous carbon in the residue.

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MODIFICATION OF POLY(LACTIC ACID) COMPOSITES BY PROCESSING TECHNIQUE

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Poly(lactic acid) (PLA) is a biodegradable polymer derived from renewable resources and has attracted considerable attention as a sustainable alternative to petroleum-based plastics [1,2]. However, PLA generally exhibits a relatively slow crystallization rate, which often limits its production cost and heat resistance. Therefore, controlling the crystallization behavior of PLA during processing is important to widen its practical applications.

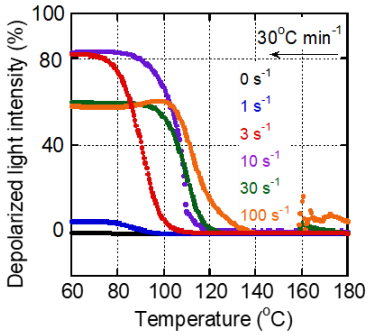


Figure 1. DLI–temperature curves of PLA/PTFE. Applied shear at 3 and 10 s^{-1} maximizes flow-induced crystallization.

In this study, the crystallization behavior of PLA composites under shear flow was investigated using PLA composites containing polytetrafluoroethylene (PTFE) fibers. The samples were prepared by melt blending, and the crystallization behavior was evaluated by depolarized light intensity (DLI), defined as a light transmittance under crossed polarizers, differential scanning calorimetry, and rheological measurements.

The results indicate that the addition of PTFE significantly influences the crystallization behavior of PLA under shear flow. As shown in Fig. 1, the DLI curves during cooling reveal that exposure to shear histories at 3 and 10 s^{-1} strongly increases the onset temperature of crystallization. Fibrous PTFE promotes nucleation and accelerates crystallization, leading to the formation of oriented crystalline structures during flow-induced crystallization. Furthermore, the crystals in the PLA/PTFE composites have a prolonged lifetime as nuclei even beyond its nominal melting point.

These findings provide insights into the control of crystallization behavior in biopolymers and contribute to the development of sustainable polymer processing technologies.

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MECHANOCHEMICAL RECYCLING OF VANADIUM AND TUNGSTEN FROM SPENT SELECTIVE CATALYTIC REDUCTION CATALYSTS

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Background and motivation: Selective catalytic reduction (SCR) catalysts are extensively utilized in power plants to convert highly toxic NO_x emissions into harmless N_2. However, due to their limited service lifetime (typically 2-3 years), deactivated SCR catalysts inevitably become hazardous solid waste. Recovering valuable metals (V and W) from spent SCR catalysts is therefore an effective and sustainable waste management strategy. Notably, V and W are listed as critical raw materials by the European Union.[1] In this study, mechanochemical recycling of V and W from spent SCR catalyst (V_2O_5-WO_3/TiO_2) was investigated by conducing the solid-state reaction via ball milling, a solvent-free and energy-efficient approach compared with conventional hydrometallurgical and pyrometallurgical processes.

Materials and methods: All mechanochemical experiments were carried out using a Fritsch Pulverisette 7 planetary ball mill equipped with two 45 mL zirconia jars, each containing ten 10 mm zirconia balls. 400 mg of spent SCR catalyst and a specific amount of NaOH or Na_2CO_3 were milled at 500 rpm for a specific reaction time. Subsequently, 10 mL of Milli-Q water was added to collect the milled powders. The leachate and solid residues were separated by centrifugation and filtration. The concentrations of extracted elements in leachates were determined by ICP-OES.

Results and discussion: Two basic compounds, NaOH and Na_2CO_3, were used as leaching agents. NaOH yielded V and W at a recovery rate of 49 wt% and 59 wt%, whereas Na_2CO_3 resulted in lower recovery rates of 27 wt% and 25 wt% after 3 h of milling. The same approach was subsequently applied to different SCR catalyst monoliths, demonstrating good applicability for diverse technical samples. Furthermore, a successive dry milling process (two-step leaching of the same catalyst batch) increased the recovery rate of V and W to 55 wt% and 75 wt%, respectively. A model reaction using stoichiometric amounts of V_2O_5 and NaOH showed complete conversion to $NaVO_3$ during the solid-state milling reaction.

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ADSORPTION AND RECOVERY OF NI-BIPYRIDINE COMPLEXES FROM SPENT CATALYST WITH XAD RESINS

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Recovering Ni-bpy complexes from spent catalysts is challenging due to the high solubility and stability of these complexes [1]. Pyridine-based compounds can be adsorbed onto polymer sorbents, such as XAD resins [2]. Therefore, this study investigated the separation of Ni-bpy complexes using the interaction between bpy and XAD resins. We evaluated the effects of XAD properties and the bpy/Ni molar ratio on separation and recovery efficiency. Additionally, for actual spent catalysts, we examined the effects of the methanol (MeOH) mixing ratio and pH on recovery efficiency.

The sample solution contains Ni at a concentration of approximately 10 mM, with a bpy/Ni molar ratio of 0–3 and 0–50 vol% MeOH. XAD-2, XAD-4, and XAD-7HP were packed to a volume of 20 mL in a polypropylene column, and the sample solution was passed through at a flow rate of 1 mL min^{-1}. The adsorbed fraction was then eluted and collected with MeOH.

The acrylic resin XAD-7HP was ineffective, while the styrene-based resins XAD-2 and XAD-4 effectively adsorbed Ni-bpy complexes. The adsorption capacity of XAD-4 was twice that of XAD-2, likely due to differences in effective surface area. Ni was not adsorbed or separated without the addition of bpy. The adsorption capacity more than doubled when the bpy/Ni ratio increased from 1 to 2, but showed a slight decrease when the ratio increased from 2 to 3, due to steric interference from the $Ni(bpy)_3$ complex. The adsorption capacity of Ni(bpy)3 on XAD-4 did not significantly change with pH; however, the vol% of MeOH in the sample solution significantly affected adsorption performance. The adsorbed components were easily eluted with MeOH, with recovery rates of approximately 55% for $Ni(bpy)_1$ and over 95% for $Ni(bpy)_2$ and $Ni(bpy)_3$. Ni-bpy complexes were finally recovered by removing MeOH and freeze-drying, and their chemical structures were confirmed by FT-IR analysis.

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KINETIC MODELING OF BIOTIC FE(II) OXIDATION AND PRECIPITATION IN PASSIVE TREATMENT OF ACID MINE DRAINAGE

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Acid mine drainage (AMD) from abandoned mines creates a long-term environmental and economic burden. Passive treatment, which relies on natural biogeochemical processes, is considered a sustainable alternative to conventional active treatment. Iron oxidation tanks using rice husk and limestone as filter media, microbial culture scaffolds, and pH buffers facilitate the oxidation of Fe^{2+} to Fe^{3+} and subsequent precipitation [1]. However, a quantitative geochemical model that integrates microbial activity and limestone neutralization under various conditions has not yet been established. In this study, we developed a kinetic model to predict the impact of this passive treatment for evaluation and to determine the conditions at other sites.

The model was coded using PHREEQC (ver. 3) based on long-term field data from an abandoned mine in Japan. Conventional abiotic oxidation [2] did not reproduce the rapid Fe^{2+} removal observed in the field. Thus, an extended kinetic equation incorporating a microbial oxidation rate constant (k_3) and an activity factor (α) was implemented. Biotic oxidation in the field showed seasonal variations that were strongly correlated with dissolved oxygen (DO), as iron-oxidizing bacteria are aerobic. The DO-dependent coefficient was defined as α, and the model successfully reproduced the seasonal variations in the Fe^{2+} oxidation rate observed in the field data. Furthermore, by coupling the iron oxidation model with a limestone dissolution kinetic equation, the integrated model successfully reproduced the pH buffering dynamics observed in the field.

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EFFECTIVE REMOVAL OF DYES AND HAZARDOUS CHEMICALS FROM DECOLORIZATION WASTEWATER IN TEXTILE RECYCLING

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The textile industry is a major contributor to massive waste generation and water pollution, with polyester composite fibers exhibiting a recycling rate of less than 1% due to complex dyes and finishing agents [1]. Consequently, high-purity recycling technologies are being actively investigated to comply with global environmental regulations and achieve carbon neutrality. To prevent secondary environmental pollution caused by effluents generated during the color stripping step of these recycling processes [2], this study developed an effective method for removing residual dyes and refractory chemicals. An inorganic metal salt-based coagulant was first introduced into standardized decolorization effluents to induce the primary coagulation of fine dye particles. Subsequently, a composite system of Cu-impregnated activated carbon and zeolite was applied to achieve high-efficiency adsorption and filtration of the remaining hazardous compounds. UV-Vis spectroscopy and analyses of organic pollution indicators conducted before and after the treatment revealed 80–90% color removal, along with a substantial decrease in organic content. This enhanced removal efficiency is attributed to a synergistic mechanism involving electrostatic charge neutralization by metal ions and physicochemical pore-filling adsorption by the porous materials [3]. These results demonstrate that the proposed integrated technology provides an economically and environmentally viable foundation for managing textile recycling effluents, contributing to the recovery of high-purity regenerated fibers and the establishment of a sustainable circular economy.

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TAILORED ELECTROCHEMICAL SYSTEMS FOR REAL-TIME QUANTIFICATION OF HYDROGEN PEROXIDE GENERATED FROM PHOTOACTIVE ORGANIC MATERIALS

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Securing clean water resources has become an increasingly important global challenge due to climate change and the expansion of industrial activities. Accordingly, there is growing interest in water purification technologies that operate efficiently while minimizing energy consumption. In this context, an ongoing international collaborative project involves the development of water purification materials based on photoactive molecules. The French research team is developing various types of materials derived from benzothioxanthene imide (BTI)[1], including dispersible microparticles and thin films deposited on plastic or glass substrates. The Korean research team is responsible for the quantitative electrochemical evaluation of the photochemical performance of these materials.

In this research, we design and fabricate electrochemical cells tailored for the analysis of materials in different physical forms. Using probe microelectrodes, reactive oxygen species (ROS) generated under light irradiation are measured in real time. These measurements enable the quantitative determination of ROS generation rates and quantum yields for each material system. In addition, both single-entity and bulk analyses are performed with high temporal and spatial resolution. Through this electrochemical approach, the performance of various organic hybrid photoactive materials is systematically compared and evaluated, ultimately aiming to demonstrate new possibilities for environmentally friendly water purification technologies driven solely by light.

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A SIMPLE WATER-BASED ROUTE FOR FABRIC-TO-FIBRE RECYCLING OF PBT/COTTON TEXTILE BLENDS

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The increasing global demand for textiles has intensified textile waste generation, much of which is landfilled or incinerated, increasing the industry's carbon footprint. As polyester and cotton together represent ~75% of the textile fibre market, poly(butylene terephthalate) (PBT)/cotton blends are widespread but difficult to recycle, and current mechanical and chemical routes remain limited by fibre-separation challenges, downcycling, and scalability. Here, we introduce a novel physical recycling approach based on a two-step separation of PBT and cotton fibres using only water at ambient temperature and pressure. The method achieved a total mass recovery yield above 94%, producing distinct PBT-rich and cotton-rich fractions. FTIR, DSC, and TGA confirmed high fraction purity, with three iterations yielding cotton-rich fractions with negligible PBT contamination, while XRD showed preservation of the native cellulose I crystalline structure. PBT-rich fractions also showed progressive purity improvements, although residual cotton traces remained. Environmental performance was significantly improved by water recovery, reducing the E-factor from ~500 to 26 without compromising efficiency. Overall, these results demonstrate the potential of this methodology as a scalable and sustainable fabric-to-fibre recycling route, supporting circularity in the textile industry.

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MECHANICAL AND OPTICAL RESPONSE OF A BIODEGRADABLE POLYESTER FILM UNDER TENSILE DEFORMATION

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The mechanical responses of a poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) (PHBHHx) film were evaluated using a cyclic tensile test containing first loading, unloading, and reloading processes. The film showed typical semi-crystalline behavior in the first loading. In the reloading process, in contrast, the film exhibited rubber-like behavior, including an inverted S-shaped stress-strain curve, low modulus, and small residual strain. Crossed polarizers revealed negative birefringence after unloading (ε=0). Since PHB crystals have negative intrinsic birefringence, thus result suggested that the well-developed crystals oriented to the pre-stretching direction. During the reloading process, no light transmission was detected at ε=0.3, and positive birefringence was observed at ε=0.7. This rubber-like response occurs due to the orientation of amorphous chains connected to the well-developed crystals.

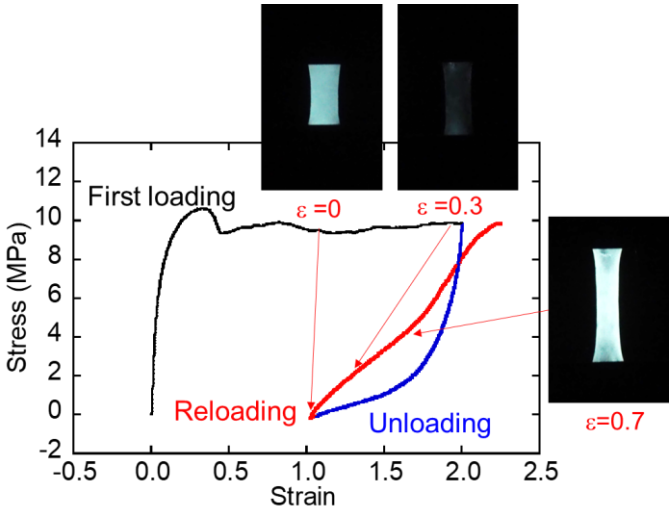


Figure Stress-strain curve of the PHBHHx blown film under the cyclic tensile test and photograph under crossed polars at various strain in the reloading process.

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SEGREGATION BEHAVIOR OF POLY(VINYL CHLORIDE) PLASTICIZED WITH ACETYL TRIBUTYL CITRATE UNDER TEMPERATURE GRADIENT

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The segregation behavior of plasticized polystyrene has recently been studied under exposure to a temperature gradient [1]. This phenomenon can lead to a gradient distribution of plasticizer in a polymer bulk and then modify the surface properties. However, the plasticizer content in the previous study was not high due to poor miscibility. Therefore, the segregation behavior of poly(vinyl chloride) (PVC) plasticized with a large amount of acetyl tributyl citrate (ATBC) was investigated in this study. ATBC is known as a green plasticizer and has a potential to replace phthalate-based plasticizers. After ATBC/PVC (100/100 v/v) films were exposed to a temperature gradient (25 °C/90 °C), attenuated total reflection infrared (ATR-IR) spectroscopy was used to quantify the ATBC content at the film surfaces. The results revealed that ATBC segregated toward the high-temperature side after exposure to the temperature gradient. Furthermore, the interaction parameter and its temperature dependence were also investigated to clarify the effect of the temperature gradient on the segregation behavior of ATBC/PVC films.

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RHEOLOGICAL MODIFICATION OF BIODEGRADABLE PHBHHX THROUGH POLYMER BLENDING

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Poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) (PHBHHx) is a biodegradable polyester, as it is derived from renewable resources and readily biodegrades into carbon dioxide and water even in marine environments. However, PHBHHx has poor processability due to its high melt viscosity and limited thermal stability. To broaden its potential uses, improving the rheological properties is important to develop a scalable pathway for industrial applications. In this study, therefore, the flowability was modified by melt blending with polycaprolactone (PCL), a biodegradable polyester, and triethyl citrate (TEC), a bio-based plasticizer. As theoretically predicted, the shear viscosity of PHBHHx/TEC reduced significantly in the low shear rate region. In contrast, the addition of PCL significantly lowered the steady-state shear viscosity over a range of shear rates, despite the limited decreases in the oscillatory shear moduli in the linear viscoelastic region. Moreover, the presence of PCL affected the crystallization behaviour of PHBHHx. These findings show that polymer blending is a promising method for improving the processability of high-molecular-weight PHBHHx in practical applications.

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SINGLE-AMINE CO_2 HYDROGENATION TO FORMIC ACID: PROCESS SIMPLIFICATION WITH NBIM AND HETEROGENEOUS RU CATALYSIS

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The catalytic hydrogenation of carbon dioxide (CO_2) to formic acid (FA) is a promising route for carbon utilization and hydrogen storage. However, conventional dual-amine processes are limited by the energy-intensive amine-exchange step required for FA recovery.[1] To address this issue, we investigated a single-amine process in which N-butylimidazole (NBIM) serves as both the reaction and separation amine, simplifying the overall process.

Because the relatively low basicity of NBIM creates a kinetically demanding reaction environment, the key challenge in this process is to identify a catalyst capable of sustaining high activity under single-amine conditions. In this context, Ru-MACHO-POMP proved particularly effective, showing the highest FA productivity in 1.0 M aqueous NBIM together with stable recyclability. These results demonstrate that a highly active Ru-based heterogeneous catalyst can make the NBIM single-amine platform practically workable. Since the maximum equilibrium acid-to-amine ratio (AAR) is a key design parameter in this process, temperature-dependent studies were conducted to determine the practical operating window. These results identified 80 °C as the optimal temperature, providing a favorable balance between productivity and AAR, with the AAR approaching ~0.9 under the NBIM/H_2O condition.

The experimental results were further analyzed by Aspen-based process simulation and techno-economic assessment. The analysis estimated a levelized FA cost of \$0.583 kg^{-1} for 85 wt% FA, while also identifying steam demand for water removal as the major contributor to cost and environmental burden. To address this issue, mechanical vapor recompression (MVR) was introduced, reducing external steam consumption by 50–70% and lowering cradle-to-gate global warming potential. This work establishes the first practical single-amine CO_2-to-FA platform and demonstrates a scalable route to simplified and sustainable formic acid production.

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DESIGN AND DEVELOPMENT OF MULTIFUNCTIONAL MATERIALS FOR CO2 CAPTURE AND VALORIZATION

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Developing sustainable CO2 management strategies remains challenging despite significant progress in capture and valorization technologies. Current capture processes are still dominated by amine-based systems associated with high regeneration energy requirements [1]. At the same time, CO2 valorization strategies are increasingly focusing on the production of higher-value chemicals and fuels. Synthetic alcohols are attractive targets due to their potential use as energy carriers and fuel additives, contributing to the development of a carbon circular economy and the transition toward more sustainable energy systems [2].

In CO2 capture, an initial exploration with amino acid-based ionic liquids derived from proline paired with the tetrabutylphosphonium cation (P4444) was conducted as greener absorbents [1]. CO2 uptake tests showed loadings of ~0.9 mmol CO2 mmol-1. Regeneration recovered ~98% capacity after repeated cycles. Current work focuses on supported ionic liquids to improve mass transfer and evaluate performance under CO2 concentrations relevant to flue gas and ambient air.

In CO2 conversion, multifunctional catalysts are being developed for the production of alcohols. The synthesis of the heterogeneous catalysts is performed by combining Cu and Fe active phases, a mesoporous support, and silatrane-based surface modifiers which provide CO2-activating and hydrophobic functionalities. The silatrane-based modifiers enable homogeneous surface functionalization of silica, achieving ~71% surface coverage and their catalytic performance is being evaluated to assess the impact of surface engineering on CO2 hydrogenation.

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NA-PROMOTED LDH-DERIVED CUAL CATALYSTS FOR THE REVERSE WATER-GAS SHIFT REACTION UNDER LOW-TEMPERATURE AND HIGH-PRESSURE CONDITIONS

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The reverse water-gas shift (RWGS) reaction converts CO_2 into CO, an intermediate for downstream processes such as Fischer-Tropsch and methanol synthesis. Process integration remains difficult because RWGS is favored at high temperatures, whereas downstream processes usually operate at lower temperatures and higher pressures. Cu-based catalysts are attractive for RWGS because of their high CO selectivity at relatively low temperatures, but their performance can be limited by Cu sintering and re-oxidation at high loadings [1].

In this work, Na-promoted CuAl catalysts derived from layered double hydroxide (LDH) precursors were prepared for RWGS under low-temperature and high-pressure conditions [2]. The LDH-derived structure maintained highly dispersed Cu species above 49 wt% Cu and suppressed sintering. Characterization results indicated strong Cu-Al interactions and electronic modification by Na.Catalytic tests showed that Na promotion improved CO_2 conversion and CO selectivity over a wide range of temperatures, pressures, GHSV, and H_2/CO_2 ratios. At 400 °C and 2 MPa, the optimized 5NaCuAl catalyst showed the highest CO formation rate with CO selectivity above 99%. This study proposes that both Na-free and Na-promoted catalysts follow a redox pathway, and that Na enhances the intrinsic activity of Cu sites while facilitating CO desorption.

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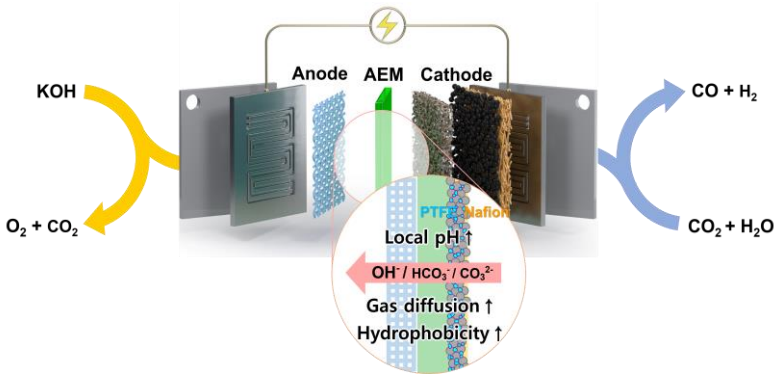
POLYMER BINDER-CONTROLLED MICROENVIRONMENTS FOR CO_2 REDUCTION IN NICKEL SINGLE-ATOM CATALYST LAYERS

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Electrochemical CO_2 reduction reaction (CO_2RR) is a promising route for carbon utilization, enabling the conversion of CO_2 into valuable chemicals and fuels. Nickel single-atom catalysts (Ni SACs) have attracted considerable attention for CO_2RR due to their high selectivity toward CO production at low overpotentials. However, achieving high current density and long-term stability remains challenging for practical CO_2RR applications. Recently, membrane electrode assemblies (MEAs) have been investigated to enable high product selectivity, low energy consumption, and stable operation under industrially relevant conditions. In this study, a mixed-binder strategy is explored to achieve efficient and stable CO_2RR in zero-gap MEAs. A mixed binder composed of Nafion and polytetrafluoroethylene (PTFE) demonstrated a high current density of 245 mA cm^{-2} with 91.65% CO Faradaic efficiency and 59.53% CO energy efficiency at 2.3 V, outperforming electrodes with single binders. The enhanced performance is attributed to the synergistic effects of Nafion and PTFE in regulating the microenvironment of the Ni SAC. In particular, the mixed binder modulates hydrophobicity, gas diffusion, and local pH, thereby improving CO_2 reduction activity and stability.



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BRØNSTED ACIDITY–CRACKING CORRELATION IN FE/ZSM-5 CATALYSTS FOR FISCHER–TROPSCH SYNTHESIS

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Fischer–Tropsch synthesis (FTS) is a promising technology for producing environmentally friendly liquid fuels from syngas derived from waste biomass, plastics, or carbon dioxide. However, low-temperature FTS (LT-FTS) yields a broad distribution of long-chain hydrocarbons, necessitating additional hydrocracking to produce liquid fuels. Bifunctional catalysts that combine FTS catalysts with acidic zeolites provide an effective approach for controlling hydrocarbon distribution [1].

In this study, bifunctional model catalysts were prepared by physically mixing precipitated iron-based FTS catalysts (P-Fe) with H-ZSM-5 to avoid undesired interactions [2]. Catalyst acidity was tuned by varying the P-Fe/H-ZSM-5 ratio and the Si/Al ratio of H-ZSM-5. Brønsted acid sites (BAS) were quantified using NH_3-TPD and pyridine-adsorbed FTIR.

The addition of H-ZSM-5 introduced BAS without degrading the catalytic activity of P-Fe, maintaining high CO conversion (73–78%), comparable to that of P-Fe alone (73%). A clear linear correlation between cracking rate and BAS concentration was observed in the bifunctional FTS–cracking process. Increasing BAS significantly enhanced C_5–C_{20} selectivity up to 72 wt%, twice that obtained with P-Fe alone (36 wt%).

These results highlight the decisive role of Brønsted acidity in controlling hydrocarbon distribution and provide guidance for designing bifunctional catalysts for selective liquid fuel production.

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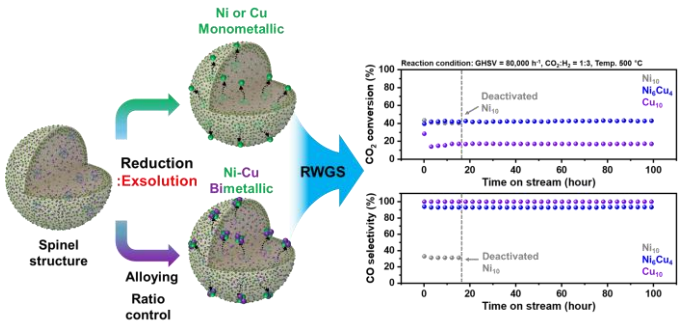
COMPOSITIONAL TUNING OF EXSOLUTION-DERIVED SPINEL NI-CU CATALYSTS FOR ENHANCED CO SELECTIVITY AND STABILITY IN RWGS REACTION

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The urgent need to mitigate CO_2 emissions has driven increasing interest in catalytic CO_2 utilization technologies. The reverse water–gas shift (RWGS) reaction is a promising route for CO_2 utilization, producing CO as a key intermediate for sustainable fuels and chemicals. In this study, we report exsolution-driven spinel Ni–Cu bimetallic catalysts with systematically tuned compositions to improve catalytic stability and CO selectivity in the reverse water–gas shift (RWGS) reaction. Among the tested catalysts, the Ni_6Cu_4 composition (Ni:Cu = 6:4) exhibited the most balanced performance, achieving more than 40% CO_2 conversion and over 90% CO selectivity at 500 °C while maintaining stable operation for over 100 h. The enhanced performance arises because Ni facilitates H_2 activation while Cu suppresses methanation, improving CO selectivity [1]. Mechanistic insights were obtained from *in-situ* DRIFTS measurements under RWGS reaction conditions, which revealed that the Ni_6Cu_4 catalyst suppresses methanation-related intermediates while preferentially stabilizing adsorbed CO species. Overall, this study highlights exsolution-driven compositional tuning as an effective strategy for developing stable and selective non-precious metal catalysts for RWGS.



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HIGH-PERFORMANCE AMINATED POROUS POLYMER FOR DIRECT AIR CAPTURE AND CO_2 CONVERSION

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The development of porous functional materials that combine efficient CO_2 capture with the potential for CO_2 conversion is crucial for advancing sustainable carbon management [1]. Direct air capture, in particular, requires sorbents that exhibit high CO_2 uptake at low CO_2 partial pressure, strong performance under humid conditions, fast adsorption kinetics, and mild regeneration temperature [2]. Here, we report an aminated crosslinked porous polymer as a promising sorbent for direct air capture and CO_2 conversion. The sorbent shows a CO_2 uptake of 0.54 mmol g^{-1} at 400 ppm CO_2 and 25 °C under dry conditions, which further increases to 1.21 mmol g^{-1} at 80% relative humidity, demonstrating pronounced humidity-enhanced CO_2 capture behaviour. In addition, the sorbent exhibits fast adsorption-desorption kinetics and can be regenerated at a mild temperature as low as 60 °C, indicating its potential as an energy-efficient sorbent. Beyond its high capture performance, the polymer framework also provides a platform for catalytic CO_2 conversion, as the accessible amine functionalities and porous network may enable the transformation of captured CO_2 into value-added products such as cyclic carbonates. Overall, this work highlights the potential of porous aminated polymers as candidates for integrated CO_2 capture and conversion technologies.

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DYNAMIC MACHINE LEARNING FRAMEWORK FOR CO_2-TO-METHANOL CATALYST DISCOVERY

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CO_2 hydrogenation to methanol is a key technology for carbon neutrality. Although commercial $Cu/ZnO/Al_2O_3$ catalysts show high activity [1], rational optimization of catalyst composition and reaction conditions remains challenging. Most machine learning (ML) models rely on static property prediction and cannot capture catalyst evolution under reaction conditions [2]. To address this limitation, we developed a reaction-conditioned conditional variational autoencoder (CVAE) framework integrating density functional theory (DFT) and experimental datasets [3].

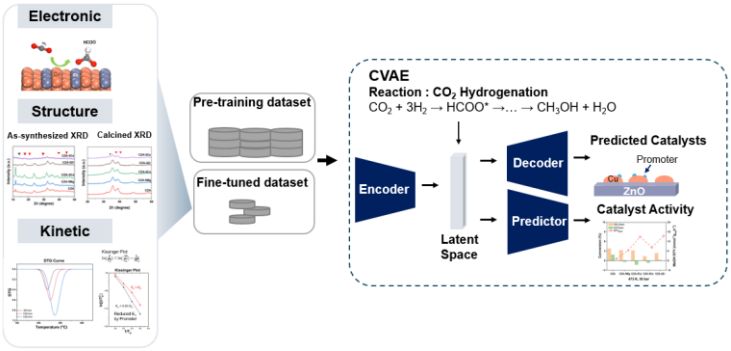


Fig. 1. Reaction-conditioned CVAE framework for CO_2-to-methanol catalyst discovery.

The pre-trained CVAE model was fine-tuned using multi-scale descriptors (Fig.1) combining theoretical and experimental information. These include DFT-derived electronic descriptors (adsorption energies of key intermediates), structural information from X-ray diffraction, and kinetic parameters derived from Kissinger analysis. By integrating simulation and experimental data within a unified generative framework, this platform enables the identification of high-performance catalysts and provides a promising strategy for accelerating CO_2 utilization technologies.

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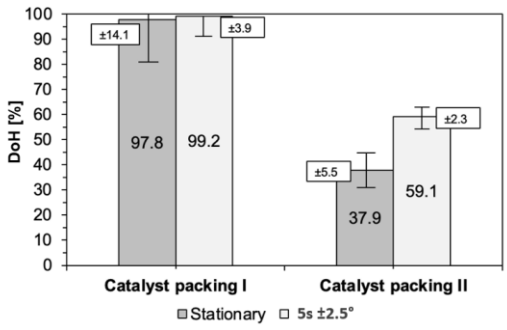
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BENZYLTOLUENE HYDROGENATION UNDER OFFSHORE CONDITIONS IN A TRICKLE BED REACTOR

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The cubic dependence of wind power on wind velocity makes offshore regions particularly attractive for green hydrogen production via water electrolysis using desalinated seawater. However, hydrogen storage and transport remain as a critical challenge. In this context, Liquid Organic Hydrogen Carriers (LOHCs) provide a promising solution by enabling hydrogen storage via exothermic catalytic hydrogenation reaction [1]. On the other hand, the effect of the oscillatory wave motion on reaction performance is still unknown, since the previous studies in the literature only conducted for onshore applications. To understand the movement effect on hydrogenation performance, a trickle bed reactor with a motorized arm was assembled. The setup enabled constant inclination and oscillatory motion with adjustable inclination amplitudes and oscillation periods. It was observed that oscillation has a positive effect on degree of hydrogenation (DoH) as it can be seen in the figure thanks to weakening of liquid channels and better catalyst wetting. With the increasing inclination amplitude, DoH increased, while increase in the oscillation period resulted in decrease in DoH.



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TUNGSTEN CARBIDE-BASED CATALYSTS FOR HYDROGEN EVOLUTION REACTION

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Objectives: Green hydrogen production by water electrolysis is a promising strategy for clean energy production. However, large-scale implementation is limited by the high overpotential for the oxygen evolution reaction (OER), and the reliance on Pt-based catalysts for the Hydrogen Evolution Reaction (HER). Although Pt shows outstanding catalytic activity and stability, its scarcity, high costs, environmental impact and supply risks motivate the development of earth-abundant alternatives. Among the investigated materials, tungsten carbides (WC, W_2C and W_xC) have attracted attention due to their high chemical and thermal stability, corrosion resistance, mechanical robustness, electrical conductivity and Pt-like catalytic behavior. This work aims to develop a low-cost WC based catalyst with HER performance comparable to conventional Pt/C.

Methods: WC nanostructures were synthesized following the approach reported by Han et al. [1] Initially, WO_3 was synthesized hydrothermally directly on a C-based substrate and subsequently converted into WC via chemical vapor deposition (CVD). The effect of various carbon sources (sucrose, dopamine, waste rice husk, melamine, ABS, or urea) and their amounts on the morphology, chemical composition and catalytic activity were investigated. The prepared electrodes were characterized through X-Ray Diffraction, Raman Spectroscopy and Scanning Electron Microscopy and tested for the HER inside a three-electrode electrochemical cell, using H_2SO_4 0.5 M as electrolyte.

Results: All the prepared samples exhibited an increase of current density associated to the HER after the conversion of WO_3 into tungsten carbides. Among the tested samples, the one synthesized using 2g of dopamine as the carbon source resulted in a mixture of different tungsten carbides, WO_3 and W_xN and showed particularly promising results in terms of overpotential and current density.

Conclusions: This study highlights the potential of WC–based nanomaterials as efficient and sustainable catalysts for HER. The combination of chemical stability, cost-effectiveness, and Pt-like catalytic activity makes them promising candidates for applications in green hydrogen production.

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PHASE-TUNABLE ELECTROLYTES BASED ON IONIC HYDROPHOBIC EUTECTIC SYSTEMS FOR SUPERCAPACITORS

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The growing demand for safe and sustainable energy storage devices has driven the search for alternatives to commercial organic-based electrolytes, which present safety and toxicity issues.[1] Here, we present Ionic Hydrophobic Eutectic Systems (IHES) based on natural compounds, combining fatty acids and their corresponding organic salts of earth-abundant metals such as potassium and sodium.[2] Water addition is essential for their use as electrolytes, as it significantly enhances ionic conductivity and results in a variety of physical states (e.g., homogeneous liquid, biphasic systems, gels, or solids). By tuning their composition, these systems can form conductive gels, attractive for quasi-solid-state devices as they reduce leakage issues typical of liquid electrolytes. Although these IHES-based electrolytes exhibit a relatively narrow electrochemical potential window (1.0–1.2V), liquid formulations display promising performance, with rate capability above 80% at 10 A/g and capacitance retention over 80% after 10,000 charge–discharge cycles.

This study highlights the potential of IHES as greener, safer alternatives for energy storage, enabling the development of low-cost, environmentally friendly supercapacitors based on widely available resources.

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Acknowledgments:

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Characteristics of Biofuels Obtained from One-step Hydrothermal Reaction of Microalgae *C.*Nibukawa

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Algae oil fuel is expected to have many merits such as CO_2 reduction effect and contribution to a sustainable society. However, algae oil fuel costs are several orders of magnitude higher than petroleum fuel costs. On the other hand, the algal crude oil production process using hydrothermal reaction (HTR) is expected to lead to cost reduction as it is a shortening process. Here, we report the characteristics of biofuel obtained from a one-step HTR of a microalga *Chlorococcum* sp. Nibukawa HS-A (*C*. Nibukawa)[1].

A 10 wt% algal slurry was prepared by adding distilled water to *C*. Nibukawa and sealed in an Inconel HTR container. The temperature and pressure were raised to 300°C or 350°C with stirring and shaking at 75 rpm, and kept for 30 min. After the gas was recovered from the valve, the treated components were separated from the reaction vessel. The aqueous phase was separated from the liquid phase by solvent extraction with *n*-hexane and CH_2Cl_2, and algal crude oil (oil phase) was recovered by distillation of the solvent. An extremely high oil phase recovery of 48 wt% was obtained at 300°C. When the oil phase was subjected to GC/MS measurement, C16 palmitic acid ～C22 docosanoic acid were detected at 300°C (Run 1), and C12 andecanoic acid ～C20 eicosadienoic acid were detected at 350°C (Run 2). Elemental analysis showed that 4 g of *C.* Nibukawa contained 2.1 g (51 wt%) of carbon. When this value was 100 wt%, the carbon fraction transferred to each phase was tracked (**Table**). The amount of carbon in the aqueous phase was determined from TOC measurements. In Run 1, carbon component loss was suppressed to about 10%, and about 50% and 20% were transferred to oil phase and water phase, respectively.

Table. Results of movement of algal carbon into each phase after HTR treatment

Run	HTR	Recovery rate of each phase					
	Temp (℃)	Algae (wt%)	Oil phase (wt%)	Solid phase (wt%)	Gas phase (wt%)	Aque. phase (wt%)	Not clear (wt%)
1	300	100	53	9	4	22	12
2	350	100	25	16	4	8	47

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ADVANCES IN MICROENCAPSULATION OF FERTILIZERS: ENHANCING NUTRIENT EFFICIENCY AND SUSTAINABLE AGRICULTURE

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The increase in the world's population is elevating the need for food production, placing considerable pressure on agricultural systems, especially on the need for fertilizers application, to enhance crop yields. Yet, inefficient application of the fertilizers and its excessive use can potentially contribute to the pollution of the soil and water systems. Micro and nanotechnology-based fertilizers represent a novel strategy, as they can significantly enhance nutrient retention and promote crop optimal growth. This work explores the use of different agro-food wastes as resources to be applied in the microencapsulation of urea, with a primary focus on improving nutrient efficiency and promoting sustainable agricultural practices. Starch, pectin, and chitosan, obtained from different agro-food wastes were tested as encapsulating materials. Those polysaccharides were used as coating materials where urea was dispersed, forming through agitation, the microcapsules. After, impact on nutrient release dynamics, was evaluated in water and in sandy and clay soils. Results show that chitosan was the most promising coating, because it was the one that showed a slower release of the urea.

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ENERGY CROPS TO BIOENERGY, BIOFUELS AND BIOPRODUCTS: WHAT ARE THE LOCAL IMPACTS?

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Dedicated crops represent an important feedstock to decarbonise the energy sector and to meet the no net emissions of greenhouse gases by 2050, as set by the European Green Deal. However, the greenhouse gas performance of biomass to energy, biofuels and bio-based products, can be negatively impacted by Indirect land use change (ILUC) effects. Consequently, cultivation of energy crops on marginal land is suggested as an approach to minimize land use competition with food crops and land use change controversies. Therefore, the objective of this work was to identify the potential and limitations associated with the cultivation of oilseed crops in marginal soils. In the study, crop management options were assessed, namely the use of innovative farming systems (e.g. irrigation systems, soil amendments), amount of fertilizers and pesticides applied, irrigation needs, among others. Effects of the cultivation of those crops in the marginal soils were addressed towards yields, impact on soil and water and on the biodiversity and landscape. Results obtained suggest that growing these crops in marginal soils provide benefits regarding soil properties and erodibility, although yields are affected by the degree of marginality. Impacts associated with water resources and fertilizer related emissions were high, but impacts associated with pesticide related emissions were low. The use of appropriate management practices (e.g. adequacy between crop and location, fertilizers balanced application) and innovative farming systems (e.g. soil amendments, water harvesting) established on marginal land at farm level may reward biological diversity, soil quality index, impact on water resources and on emissions.

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CHITOSAN FILMS ENRICHED WITH OPUNTIA FICUS-INDICA EXTRACT FOR FOOD PACKAGING APLICATIONS

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Driven by the transition toward a circular bioeconomy, sustainable alternatives to fossil-based plastic packaging materials are urgently needed. Chitosan stands as a promising biodegradable matrix due to its film-forming ability and antimicrobial properties [1]. Furthermore, the valorisation of agricultural by-products, such as *Opuntia ficus-indica* (OFI) fruit peels, provides a source of bioactive compounds (e.g betalains) that can be used to enhance the active properties of a film packaging material [2]. This study evaluates the effect of chitosan films enriched with OFI extracts on poultry meat shelf-life. Films containing 0%, 1%, and 2% OFI extract were developed via solvent casting. Wrapped poultry meat was stored at 7ºC for 14 days and analyzed periodically (days 0, 3, 7, 10, 14) for moisture, pH, titratable acidity, color, lipid oxidation (TBARS), total volatile basic nitrogen (TVB-N). During 14 days of refrigerated storage, the 2% OFI-enriched chitosan films significantly delayed poultry spoilage. Compared to the uncoated control, which exhibited a rapid pH increase indicative of spoilage (reaching 6.65), the active films maintained a highly stable pH (5.79) and titratable acidity. Furthermore, the films kept TVB-N accumulation at considerably lower levels than the control, while TBARS evaluation indicated the films contributed to the overall oxidative stability of the samples. In conclusion, the valorisation of *Opuntia ficus-indica* by-products into chitosan-based active packaging offers a highly effective, sustainable strategy for food packaging applications.

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RESEARCH ON AI IN GREEN CHEMISTRY AND ENVIRONMENTAL GOVERNANCE

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Artificial intelligence is revolutionizing both green chemistry and environmental governance, offering powerful tools for sustainable molecular design and ecosystem management. However, AI systems themselves impose substantial environmental costs. AI transforms green chemistry: generative models design low-toxicity, biodegradable molecules; machine learning screens efficient catalysts; and reaction pathways cut solvent and energy use. AI also predicts full life-cycle impacts, advancing safe-and-sustainable-by-design for low-carbon, zero-waste synthesis. Artificial intelligence is reshaping environmental governance, it is increasingly used to address climate change, biodiversity loss, and pollution, yet also introduce risks such as high energy and water resources consumption and potential environmental degradation. However, AI also raises ethical challenges: high energy consumption, algorithmic bias, data divides, and the 'green paradox'. This paper examines AI applications in green chemistry and environmental governance, while critically analyzing the ethical and policy challenges arising from AI's own ecological footprint. AI holds transformative promise for green chemistry and environmental governance. AI's 'optimal solutions' by pass public deliberation; black boxes and hallucinations cause trust and legal risks. In terms of technical bottlenecks, there are issues such as data silos, insufficient computing power, and contradictions between real-time performance and accuracy. AI as both a lever and a test of our capacity to innovate responsibly for a climate-resilient and nature-positive future.

Keywords: Artificial Intelligence; Green chemistry; Environmental Governance; Ethical challenge

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INTEGRATING SUSTAINABLE DEVELOPMENT GOALS INTO CHEMISTRY LABORATORY SUBJECTS

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The subject **"Basic Laboratory Operations II (OBL-II),"** part of the Bachelor's Degree in Chemistry at the University of Jaén, is taught during the second semester of the first year. This subject complements the fundamental laboratory training students acquire in the first-semester prerequisite, "Basic Laboratory Operations I (OBL-I)." In OBL-I, students familiarize themselves with safety protocols in the chemical laboratory and learn fundamental operations such as weighing, the preparation and titration of solutions, and the separation of mixture components through simple extraction. In OBL-II, students apply these foundational experimental skills to more complex case studies, including the analysis of the physicochemical properties of inorganic compounds and the isolation of organic compounds from natural and commercial sources.

The United Nations Sustainable Development Goals (UN SDGs) [1] have provided significant impetus to the development of sustainable chemical manufacturing methods to reduce adverse effects on human health and the environment. Consequently, we have initiated a comprehensive review of each experimental procedure scheduled for OBL-II, aiming to:

- **Minimize water waste** (SDG 6).
- **Reduce the generation of aqueous waste** (SDG 14).
- **Minimize the quantity of reagents** required to get known compounds (SDG 12).
- **Eliminate or reduce the use of solvents** hazardous to both students and the environment (SDGs 3, 13-15). [2]
- **Implement a circular approach** by converting the final products of certain experiments into the starting materials for others (SDG 12). [3]

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BRIDGING THE GAP: SCIENCE OUTREACH AS A PEDAGOGICAL STRATEGY FOR TACKLING EMERGING POLLUTANTS AND PLASTIC WASTE IN URUGUAY

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This work describes a teaching experience within the 'Green Chemistry' course at the Faculty of Chemistry (Udelar, Uruguay). The objective is to analyse the chemist's role in sustainable development by applying Green Chemistry principles to real-world challenges. Through a pedagogical approach that integrates science communication, students were challenged to conduct extensive research using scientific and governmental sources to produce outreach articles and 2-minute videos for social media (@lso_fq), providing a comprehensive perspective on current environmental issues.

Two of the cases studied were: emerging pollutants, specifically the presence of estrogens in water streams, and the management of household plastic waste. Regarding the first case, students identified that while international standards require high removal rates for hormones, Uruguayan legislation lacks specific controls. This is particularly concerning as the Santa Lucía River basin serves as the country's primary source of drinking water, where significant estrogenicity has already been detected. [1]. They proposed the use of laccases as a green biocatalytic alternative for estrogen degradation [2]. In the second case, the research highlighted that Uruguay recycles less than 5% of its plastic waste, in contrast to more successful models from developed countries. The outreach article emphasized domestic classification as a critical factor for improving recycling rates, alongside state-sponsored programs to incentivize these practices [3]. Furthermore, the work analyses different physical and chemical recycling alternatives, highlighting their respective advantages and disadvantages.

Through this teaching methodology, students were able to link Green Chemistry with issues of social concern, generating a critical discussion about possible strategies to address these problems from a sustainable perspective.

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DETERMINATION OF VITAMIN C CONTENT IN VARIOUS FRUIT JUICES USING IODOMETRIC TITRATION AT DIFFERENT CONDITIONS

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Vitamin C (ascorbic acid, ascorbate) is a water-soluble vitamin that plays an important role in general health and brain function [2]. This experiment investigated how storage temperature, air exposure, and storage time affected the vitamin C content of packaged pineapple, apricot, and apple juice. The main aim of this paper is to determine Vitamin C content in various fruit juices at different conditions by using iodometric titration [1,3] using iodine solution and starch indicator. Fresh samples were first tested at room temperature, then retested after one day of storage at 25°C in open containers. Additional samples were prepared in beakers, stored at 3°C in either open or closed conditions, and analyzed after one and two days. The room-temperature results showed a decrease in iodine volume for all three juices, suggesting a decrease in vitamin C content over time. Under refrigerated conditions, pineapple juice generally gave higher values in closed samples, apricot juice showed smaller differences, and apple juice showed variable results. Overall, the results suggest that storage conditions influence vitamin C retention in various fruit juices.

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A EMBEDDING LIFE-CYCLE THINKING AND ACTIVE LEARNING IN SUSTAINABLE CHEMISTRY EDUCATION

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Green chemistry education requires approaches that help students connect molecular and materials science with environmental responsibility, life-cycle impacts and real-world decision-making. This poster presents a transferable teaching model developed at Lodz University of Technology to embed life-cycle thinking, sustainability and active learning into chemistry-related engineering education. The model combines two linked educational developments. The first is the institution-wide implementation of a Fundamentals of Life Cycle Analysis module, supported by teaching resources, syllabus-related materials and assessment approaches used across different faculties. These resources help students analyse environmental impacts across the life cycle of products and technologies and relate sustainability concepts to engineering practice. The second development concerns the Advanced Biobased and Bioinspired Materials programme, delivered by the International Faculty of Engineering in collaboration with the Faculty of Chemistry. In this context, teaching materials and learning activities were redesigned using active and flipped learning, including problem-based, case-based and discussion-based tasks. The redesigned activities connected sustainable materials education with European and global professional, legal and workplace perspectives. Student engagement extended beyond course participation and contributed to diploma work, conference presentations and peer-reviewed publications on sustainability-related topics. The initiative demonstrates how life-cycle assessment, systems thinking and active learning can be integrated into higher education to support SDG 4 and prepare graduates to address environmental and professional challenges. The proposed model is adaptable across chemistry, materials, environmental science and engineering programmes, particularly where educators aim to move from sustainability awareness to applied, research-informed and student-centred learning.

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EFFECT OF ALKYL CHAIN LENGTH IN IMIDAZOLIUM IONIC LIQUIDS ON THE THERMOELECTRIC BEHAVIOR OF POLYANILINE

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Ionic Liquids (ILs) are green, tunable solvents and functional additives in polymer science, with negligible volatility and high thermal stability. Conductive polymers, are promising for organic thermoelectrics due to their low cost, flexibility, and tunable electrical properties [1–3]. Incorporating ILs into polymer-based thermoelectric systems can enhance performance and harvest low-grade waste heat from solar panels, improving energy efficiency. In this work, we investigate the effect of the cationic moiety of imidazolium (Im) ILs on Polyaniline's (PANI) thermoelectric properties. EMImCl and BMImCl, differing in alkyl chain length, were added during oxidative polymerization of Aniline using ammonium persulfate as oxidant and HCl as dopant [4]. Composites were characterized via FTIR, Raman, XRD, and SEM, and their thermoelectric performance assessed through electrical conductivity, Seebeck coefficient, thermal conductivity, power factor, and figure of merit. BMImCl-PANI exhibited the best performance, with Seebeck coefficient 13.7 $\mu V.K^{-1}$ and $ZT = 4.8082 \times 10^{-6}$, showing that longer alkyl chains enhance microstructure and charge transport. These results underscore the role of IL's cation structure in tuning conductive polymer thermoelectrics.

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OPTIMIZATION OF PREPARATION PARAMETERS FOR THE SYNTHESIS OF ACTIVATED CARBON FROM AGRICULTURAL RESIDUES (OLIVE STONE).

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This study aims to investigate the role of the carbonization temperature and atmosphere on the BET surface, the porosity and the surface functional groups of activated carbons.

Activated carbons are prepared using a mixture of olive residue and zinc chloride [1]. This mixture is carbonized at different temperature (300 °C, 380 °C and 450°C) [2,3]. respectively on two different atmospheres, one is inert using nitrogen (N_2) gas and the second without using any gas (autogenerated atmosphere).

The porosity of the prepared carbons is investigated using N_2 isotherms at -196 °C. Long- and short-range orders are studied respectively by X-ray diffraction (XRD) and Raman spectroscopy. The investigation of the carbons functionalities is carried out by Boehm titration and Fourier transformed infrared spectroscopy (FTIR).

Summarily, the results demonstrate that:

✓ The carbonization without inert atmosphere gives an activated carbon not so different from that prepared in an inert one [2,3].

✓ At very low temperature (300°C), possible to obtain activated carbons with significant properties such as high BET surface (1200 m^2/g) and large pore volume (0.757 g/m^3) [1,2].

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