



SAPIENZA
UNIVERSITÀ DI ROMA



TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA



Roma Tre



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**4th National Meeting
Division of Chemistry for Technologies
Italian Chemical Society**

**Roma Tre University
Department of Industrial, Electronic, and Mechanical Engineering
Via Vito Volterra 62, 00146 Rome
June 16-19, 2026**

Book of Abstracts

WELCOME and PREFACE

The 4th National Meeting of the Division of Chemistry for Technologies of the Italian Chemical Society is organized by researchers of CHEM/06 scientific sector of the four major Roman universities: Sapienza University of Rome, University of Rome Tor Vergata, Roma Tre University, and Campus Bio-Medico University of Rome.

The scientific topics covered by the Conference primarily concern the chemical and physico-chemical foundations of various fields of technology, with particular attention to those related to materials, their properties, and their interaction with the environment.

The goal of the Conference is to provide participants with food for thought and discussion and to facilitate the exchange of ideas, knowledge, and experiences between Academy and Industry.

Topics

- micro- and nanostructured materials: synthesis, characterization, and properties;
- innovative chemical process technologies;
- polymeric and composite materials;
- materials and devices for energy conversion/storage;
- materials and devices for chemical, physical, and biological sensors;
- materials and devices for environmental monitoring and protection;
- materials for biomedical applications.

We look forward to meet you in Rome,

The Organizing Committee



CONFERENCE VENUE

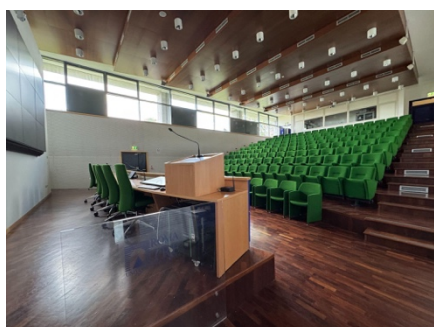
The conference will be held at the Department of Industrial, Electronic, and Mechanical Engineering (DIIEM) of Roma Tre University.

The venue is located in the Ostiense-Marconi neighborhood, a former industrial area along the Tiber that has been progressively redeveloped to become a vibrant university and cultural hub, combining historic industrial heritage with contemporary urban life. The new building was renovated on the foundations of the "National Tank for Naval Architecture Experiments" complex, built in the 1920s to test hull and propeller models. Close to the city center, the neighborhood is easily accessible by public transportation.

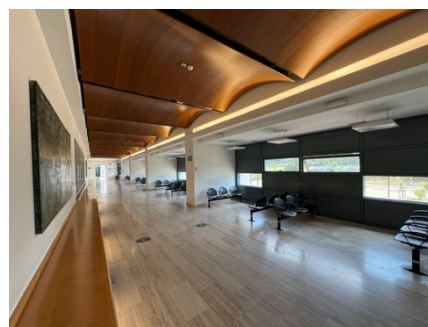
The scientific sessions will be held in the Department's Conference Hall, a modern amphitheater-style hall designed to provide a stimulating and comfortable environment for academic exchange. Immediately adjacent to the auditorium, the large common area on the ground floor will serve as an exhibition and networking space, hosting sponsor booths and a permanent exhibition of the posters presented during the conference.



DIIEM building



Conference Room



Exhibition Area



ITALIAN CHEMICAL SOCIETY

CHEMISTRY FOR TECHNOLOGIES DIVISION

In line with the objectives of the Italian Chemical Society, the Chemistry for Technologies Division proposes, in the specific disciplinary field, to advance research, promote teaching and develop profitable relationships between academia and industry.

To this end, various initiatives have been activated over the years with continuity and regularity, such as the National Congress of the Division which is biannually jointly organized with the AICING (the Italian Association of Chemists for Engineering), Master and Doctoral Thesis Awards and the Newsletter.

Take a look at our [website](#)

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TECHNICAL SUPPORT

Marco Di Pilato, Sapienza Università di Roma

STUDENT HELPERS

Omar Al Zeer, Sapienza Università di Roma
Daria Ballardini, Sapienza Università di Roma
Claudiu Bostan, Sapienza Università di Roma
Nicolò Cambise, Università Roma Tre
Chiara Frezza, Università Roma Tre
Miryam Gulino, Sapienza Università di Roma
Cristiana Margarita, Sapienza Università di Roma
Seyedeh Maryam Hassani Vanhari, Università degli Studi di Roma Tor Vergata
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Special Collection

Innovative Materials and Processes for Energy, Environment, and Emerging Technologies: Insights from the Italian Chemical Community

Guest Editors:



Monica Orsini
Università di Roma
"Roma Tre"



Serena de Santis
Università di Roma
"Roma Tre"

**Submission
deadline:**
31.12.2026

For additional info:
chemistryopen@Chemistry-Europe.org or
chemistry-methods@Chemistry-Europe.org

Dear Participant,

the **4th National Meeting of the Division of Chemistry for Technologies of the Italian Chemical Society** will take place in Rome from 16th to 19th June 2026.

To highlight the scientific contributions presented during the meeting and to further promote the dissemination of research activities within the Italian chemical community, the Organizing Committee is pleased to invite participants to contribute an original research article, review, or methodological paper to the Special Issue **"Innovative Materials and Processes for Energy, Environment, and Emerging Technologies: Insights from the Italian Chemical Community"** dedicated to the contents of SCI-DCT 2026 meeting.

The Special Issue will be jointly hosted by ChemistryOpen and Chemistry—Methods and will be edited by [Prof. Monica Orsini](#) and [Dr. Serena De Santis](#) (University of Roma Tre).

The Guest Editorial team invites you to submit your manuscript as soon as it is finalized, noting that the issue will remain open for submissions until **December 31st, 2026**.

All articles published by ChemistryOpen and Chemistry-Methods are fully open access: immediately freely available to read, download, and share, thus increasing the visibility of your research. To cover the costs of publishing, these journals charge a publication fee as listed [here](#) and [here](#). Through the affiliation with Wiley, our authors are often able to benefit from [transformative agreements and Wiley Open Access Accounts](#), which are each individually tailored to the needs of the respective partner. Automatic waivers and discounts will be given to authors from countries on this [list](#). On the occasion of this Special Collection, the journals will offer a selection of waivers. Please do let us know in case you are not eligible for one of the agreements and would like to apply for one.

All submitted manuscripts will undergo the standard peer-review process, and once accepted, will be published online promptly with full citation details. Early submissions are therefore strongly encouraged.

Please let us know if you are interested in contributing to this Special Collection. In the message, also indicate the object: CONTRIBUTION FOR SCIDCT2026 SPECIAL ISSUE.

For any questions, please do not hesitate to contact the Editorial Office at the given address or the Guest Editors.

Kind regards,

Monica and Serena

P.S.: General requirements for individual contributions can be found in the [Notice to Authors](#), which reports ChemElectroChem guidelines for the preparation of the article. You can also find more information about the hosting journals at the [ChemistryOpen](#) and [Chemistry—Methods](#) Homepages.



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**Società
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4th National Meeting Division of Chemistry for Technologies Italian Society of Chemistry June 16-19, 2026

Università di Roma Tre
Dipartimento di Ingegneria Industriale,
Elettronica e Meccanica
Via Vito Volterra 62, 00146 Roma

	16/6 TUESDAY	
14:30	REGISTRATION	
16:30		
17:15	PL	Aust Nicola Christiane
18:00	WELCOME PARTY	
19:30		

	17/6	WEDNESDAY
9:00	KL.01	Graiff Claudia
9:30	OP.01	Fioravanti Giulia
9:45	OP.02	Di Pietro Maria Enrica
10:00	OP.03	Gentile Davide
10:15	OP.04	Musio Biagia
10:30	OP.05	De Santis Arianna
10:45	OP.06	Margarita Cristiana
11:00	COFFEE BREAK & POSTER SESSION	
11:30	IL.01	Aliberti Francesca
11:50	FP.01	Riva Laura
11:55	FP.02	Iennaco Alessia
12:00	OP.07	Civitavecchia Annafelicia
12:15	OP.08	D'Angelo Antonio
12:30	OP.09	Spinelli Elodia
12:45	OP.10	Lemma Enrico Domenico
13:00	LIGHT LUNCH	
14:00	IL.02	Raffaini Giuseppina
14:20	TP	Technical Presentation
14:30	FP.03	Petroselli Marina
14:35	FP.04	Pagot Gioele
14:40	FP.05	Corrente Giuseppina
14:45	FP.06	Ghezzi Simone
14:50	FP.07	Battaglia Matteo
14:55	FP.08	Gulino Miryam
15:00	OP.11	Mancini Luca
15:15	OP.12	Seggio Mimimorena
15:30	OP.13	Rossetti Arianna
15:45	OP.14	Silva Ferraz Jose Miguel
16:00	COFFEE BREAK & POSTER SESSION	
16:30	OP.15	Celesti Consuelo
16:45	OP.16	Baldassarre Francesca
17:00	OP.17	Bruno Beatrice
17:15	OP.18	Muscolino Emanuela
17:30	GENERAL ASSEMBLY	
19:30		

18/6	THURSDAY	
9:00	KL.02	Berrocal José Augusto
9:30	OP.19	Cinelli Patrizia
9:45	OP.20	Dalle Vacche Sara
10:00	OP.21	Lippi Martina
10:15	OP.22	Marotta Angela
10:30	OP.23	Righetti Maria Cristina
10:45	OP.24	Sola Antonella
11:00	COFFEE BREAK & POSTER SESSION	
11:30	IL.03	Capuano Rosamaria
11:50	FP.09	Boncrisiani Chiara
11:55	FP.10	Marcolli Giulia
12:00	OP.25	Chelly Meriam
12:15	OP.26	Ferlazzo Angelo
12:30	OP.27	Rossi Damiano
12:45	OP.28	Rizzuti Antonino
13:00	LIGHT LUNCH	
14:00	IL.04	Imparato Claudio
14:20	FP.11	Bonaldo Beatrice
14:25	FP.12	Corea Carmen
14:30	FP.13	Fiorentino Marika
14:35	FP.14	D'Addario Anna
14:40	FP.15	Shrestha Rekha
14:45	FP.16	Conelli Daniele
14:50	FP.17	De Robertis Francesca
14:55	FP.18	Zribi Rayhane
15:00	OP.29	Rodríguez-Padrón Daily
15:15	OP.30	Marzorati Stefania
15:30	OP.31	Napolitano Martina
15:45	OP.32	Genua Francesco
16:00	COFFEE BREAK & POSTER SESSION	
16:30	OP.33	Barbera Vincenzina
16:45	OP.34	Lunedei Eugenio
17:00	OP.35	Mortalò Cecilia
17:15	OP.36	Venezia Virginia
17:30	FP.19	Barbero Margherita Teresa
17:35	FP.20	De Gregorio Emmanuel
17:40	FP.21	Trisolini Maria
17:45	FP.22	Alberti Emanuele
20:30	SOCIAL DINNER	

19/6	FRIDAY	
9:00	KL.03	Gerbaldi Claudio
9:30	OP.37	Nsanzimana Jean Marie
9:45	OP.38	Freitas Williane
10:00	OP.39	Occhicone Alessio
10:15	OP.40	Magni Mirko
10:30	OP.41	Motta Daniele
10:45	OP.42	Frezza Chiara
11:00	COFFEE BREAK & POSTER SESSION	
11:30	AWARDS CEREMONY	
12:00	CLOSING CEREMONY	

1	PL	Plenary Lecture
3	KL	Keynote Lectures
4	IL	Invited Lectures
42	OP	Oral Presentations
22	FP	Flash Presentations
1	TP	Technical Presentation

Per ragioni di sicurezza e di gestione della rete, durante il congresso non sarà disponibile una rete Wi-Fi dedicata all'evento.
Sarà comunque disponibile la rete Eduroam, accessibile con le credenziali della propria istituzione aderente al servizio.

Tuesday, 16th June 2026

Afternoon Session

14:30 Meeting Registration

16:30 Opening Ceremony

Chairpersons: Cristina Leonelli, Giovanni Sotgiu

Plenary Lecture

17:15	PL	Nicola Christiane Aust BASF SE - Germany	Unlocking Technology Potential - An Example from the Chemical Industry
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18:00 Welcome Party

Wednesday, 17th June 2026

Morning Session

Chairpersons: Andrea Mele, Maria Laura Santarelli

Keynote Lecture

09:00	KL.01	Claudia Graiff Università di Parma	Bio-Inspired Materials for Cultural Heritage: Merging Nature and Technology in Sustainable Conservation Science
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Oral Presentations

09:30	OP.01	Giulia Fioravanti Università degli Studi dell'Aquila	When 2D materials meet green solvents: hydrogen bonds in action at the Graphene Oxide-Deep Eutectic Solvent interface
09:45	OP.02	Maria Enrica Di Pietro Politecnico di Milano	Why TOPO Works: Intermolecular Interactions in Hydrophobic Deep Eutectic Solvents
10:00	OP.03	Davide Gentile Politecnico di Milano	Reversible Aerogels for Heavy-Metal Capture and Reuse as Cross-Coupling Catalysts
10:15	OP.04	Biagia Musio Politecnico di Bari	Potential of halophyte species to bioremediate salted soils and to serve as a valuable natural source of polyphenols
10:30	OP.05	Arianna De Santis Politecnico di Milano	Upcycling of textile waste into nanocellulose-based aerogels for sustainable water treatment
10:45	OP.06	Cristiana Margarita Sapienza Università di Roma	Electrochemical Activation of Imidazolium-based Covalent Organic Frameworks

11:00 Coffee Break and Poster Session (exhibition area)

Chairpersons: Francesco Mauriello, Stefano Vecchio Cipriotti

Invited Lecture

11:30	IL.01	Francesca Aliberti Università degli Studi di Salerno	Integration of smart functions in 3D-printed polymers: material design and process parameters optimization
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Flash Presentations

11:50	FP.01	Laura Riva Politecnico di Milano	Hydrophobic Eutectics-based Supramolecular Gels and Cellulose-based Nanosponges: Breakthrough Solutions for Water Remediation
11:55	FP.02	Alessia Iennaco Politecnico di Bari	Synthesis and characterization of polyurethane foams from waste cooking oil (WCO)

Oral Presentations

12:00	OP.07	Annafelicia Civitavecchia Università Politecnica delle Marche	Innovative bioactive PLA-films for a sustainable packaging
12:15	OP.08	Antonio D'Angelo Università degli Studi di Salerno	Investigation on SiO ₂ /PEG hybrid biomaterials synthesized via the sol-gel route
12:30	OP.09	Elodia Spinelli Università degli Studi di Roma Tor Vergata	Sustainable Self-Healing Waterborne Polyurethane Coatings for Enhanced Corrosion Protection of Metallic Artworks
12:45	OP.10	Enrico Domenico Lemma Università Campus Bio-Medico di Roma	Light-Induced Radical Grafting for Selective Surface Modification of Acrylate Photoresists in 2PL

13:00 Light Lunch and Poster Session (exhibition area)

Wednesday, 17th June 2026

Afternoon Session

Chairperson: Monica Orsini

Invited Lecture

14:00	IL.02	Giuseppina Raffaini Politecnico di Milano	DNA as Drug Carrier: a Hydrophobic β -Cyclodextrin Channel in a Supramolecular Structure via Molecular Dynamics Study
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Technical Presentation

14:20	TP	Waters Platinum Sponsor	Calorimetry as a tool to assess Battery Runaway Reactions
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Chairpersons: Sara Maria Giannitelli, Daniele Rocco

Flash Presentations

14:30	FP.03	Marina Petroselli Università Politecnica delle Marche	Ab initio characterization of transition metals: a comparative study to overcome inaccuracies in calculations
14:35	FP.04	Gioele Pagot Università degli Studi di Padova	Acetate-Driven Control of Zinc Deposition in Zn-I ₂ Redox Flow Batteries
14:40	FP.05	Giuseppina Anna Corrente Università degli Studi di Messina	Bio-Based Polysaccharides for Low-Temperature Thermochemical Energy Storage
14:45	FP.06	Simone Ghezzi Università degli Studi di Milano	Recovery, characterization and purification of LiPF ₆ extracted from lithium-ion batteries
14:50	FP.07	Matteo Battaglia Università degli Studi di Roma Tor Vergata	Performance study and characterization of mixed oxides for thermal energy storage applications
14:55	FP.08	Miryam Gulino Sapienza Università di Roma	PVD carbon and nitride coatings for application in metallic bipolar plates

Chairpersons: Giuseppe Consiglio, Marcella Trombetta

Oral Presentations

15:00	OP.11	Luca Mancini Università degli Studi di Perugia	Tailoring Bilayer Graphetrayne for Enhanced CO ₂ Capture: Insights from Multiscale Simulations
15:15	OP.12	Mimimorena Seggio Università Telematica Pegaso	Pollen-based nano-plasmonic chips with MIP-NPs as receptors for Protein Detection at the attomolar levels
15:30	OP.13	Arianna Rossetti Politecnico di Milano	TEMPO-functionalized nanogels: advanced nanoparticles for the mitigation of oxidative stress
15:45	OP.14	Jose Miguel Silva Ferraz Sapienza Università di Roma	A Dual-Mode Effusion Device: Vapour Pressure Measurements and Thin Film Deposition

16:00 Coffee Break and Poster Session (exhibition area)

Wednesday, 17th June 2026

Afternoon Session

Chairpersons: Larisa Lvova, Candida Milone

Oral Presentations

16:30	OP.15	Consuelo Celesti Università degli Studi di Messina	Zwitterionic Surface Functionalization of Titanium as an Antifouling Strategy for Biomedical Applications
16:45	OP.16	Francesca Baldassarre INSTM - UdR Salento	Shaping Antioxidants-loaded Nanoparticles Performance: How Surfactants Influence Stability, Activity, and Uptake in Human Skin Models
17:00	OP.17	Beatrice Bruno Università Campus Bio-Medico di Roma	Microfluidic Synthesis of Cerium Oxide Nanoparticles
17:15	OP.18	Emanuela Muscolino Università degli Studi di Palermo	Bioactive Hydrogel Wound Dressings Incorporating Egg White Proteins and Polysaccharides Developed through Radiation

Chairpersons: Cristina Leonelli, Giovanni Sotgiu

17:30 General Assembly

Thursday, 18th June 2026

Morning Session

Chairpersons: Marta Feroci, Piero Mastrorilli

Keynote Lecture

09:00	KL.02	José Augusto Berrocal Institut Català d'Investigació Química	Mechanically Triggered Reactivity in Polymer Materials: From Pathway Control to Mechanochromic Functionality
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Oral Presentations

09:30	OP.19	Patrizia Cinelli Università di Pisa	Polybutylenesuccinate-co-adipate (PBSA), a versatile, highly biodegradable matrix polymer for composites and nanocomposites.
09:45	OP.20	Sara Dalle Vacche Politecnico di Torino	Dynamic covalent chemistry in biobased composites for additive manufacturing
10:00	OP.21	Martina Lippi Università degli Studi di Firenze	Tuning Structural Adaptability in One-Dimensional Coordination Polymers for VOC Capture
10:15	OP.22	Angela Marotta Università degli Studi di Napoli Federico II	Role of epoxy/anhydride stoichiometry in governing curing behavior and reprocessability of bio-based vitrimers
10:30	OP.23	Maria Cristina Righetti CNR IPCF - Pisa	Effect of Nanosilica Aggregates/Agglomerates on Functional Properties of Poly(butylene 2,5- furandicarboxylate)-based Nanocomposites
10:45	OP.24	Antonella Sola Università degli Studi di Modena e Reggio Emilia	Towards sustainable ceramic powder bed fusion: An LCA-based perspective

11:00 Coffee Break and Poster Session (exhibition area)

Chairpersons: Sara Nardis, Manuela Stefanelli

Invited Lecture

11:30	IL.03	Rosamaria Capuano Università degli Studi di Roma Tor Vergata	From Collection to Detection: How Materials Shape Clinical Volatilomics
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Flash Presentations

11:50	FP.09	Chiara Boncristiani Università del Salento	Microfluidic BBB Spheroids: Metabolomic Biomarkers for Brain Injury Detection
11:55	FP.10	Giulia Marcolli Politecnico di Milano	Enhanced metal ion recognition with bispidine-based fluorinated chemosensors

Oral Presentations

12:00	OP.25	Meriam Chelly Università degli Studi di Messina	Volcanic ash: from Etna to applications in electrochemical sensors
12:15	OP.26	Angelo Ferlazzo Università di Catania	Electrochemical Biosensor for Urea in Environmental and Biological Media
12:30	OP.27	Damiano Rossi Università di Pisa	Synthesis and Characterization of Silica-Encapsulated Phase Change Materials Derived from Waste Cooking Oil
12:45	OP.28	Antonino Rizzuti Politecnico di Bari	Combined NMR and HPLC-HRMS metabolomics for discriminating the response of susceptible and resistant olive cultivars to Xylella fastidiosa infection

13:00 Light Lunch and Poster Session (exhibition area)

Thursday, 18th June 2026

Afternoon Session

Chairperson: Giovanni Sotgiu

Invited Lecture

14:00	IL.04	Claudio Imparato Università degli Studi di Napoli Federico II	Dual-purpose hybrid and mixed oxides: from catalysis to multifunctional polymer composites
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Chairpersons: Serena De Santis, Giovanni Sotgiu

Flash Presentations

14:20	FP.11	Beatrice Bonaldo Università di Trento	Sustainable Synthesis of Boron Carbide via Polyol-Based Precursors and Rapid Carbothermal Reduction
14:25	FP.12	Carmen Corea Politecnico di Milano	Sustainable scale-up of fatty acids and polyphenols extraction from Spent Coffee Grounds
14:30	FP.13	Marika Fiorentino Università degli Studi della Campania Luigi Vanvitelli	ZrO ₂ /Orange Peel Extract Hybrids as Active Glass-Based Packaging Materials
14:35	FP.14	Anna D'Addario Università degli Studi dell'Aquila	Functionalized Graphene Oxide as a Neurogenic Trigger in Neural and Stem Cell Models
14:40	FP.15	Rekha Shrestha Politecnico di Milano	Hydrophobic Eutectic Solvent-Loaded Cellulose Hydrogel for Microextraction of Emerging Pollutants from Water
14:45	FP.16	Daniele Conelli Politecnico di Bari	Exploiting Metal Halide Perovskites for Photocatalytic Organic Transformations
14:50	FP.17	Francesca Derobertis Politecnico di Bari	Biobased jet fuel from orange peel waste: limonene hydrogenation using Raney-nickel catalyst
14:55	FP.18	Rayhane Zribi Università degli Studi di Messina	Biomass-Derived Carbon Dots as Sensitive Fluorescent Probes for Mercury Detection.

Chairpersons: Alessandra D'Epifanio, Leonardo Mattiello

Oral Presentations

15:00	OP.29	Daily Rodríguez-Padrón Università degli Studi di Padova	Biomass-Derived Catalytic Architectures: Chitin valorisation for the synthesis of modified N-doped carbons
15:15	OP.30	Stefania Marzorati Università degli Studi di Milano	From Coffee Waste to Sustainable Packaging: a Cascade Approach for Coffee Silverskin Valorization
15:30	OP.31	Martina Napolitano Università degli Studi di Modena e Reggio Emilia	Engineering circular nutrient systems through material design and bio-assisted processes for environmental protection and soil restoration
15:45	OP.32	Francesco Genua Università degli Studi di Modena e Reggio Emilia	Multi-methods approach for room temperature immobilization of heavy metals cations and amphoteric moieties from industrial wastes

16:00 Coffee Break and Poster Session (exhibition area)

Thursday, 18th June 2026

Afternoon Session

Chairpersons: Alberto Rainer, Francesca Anna Scaramuzzo

Oral Presentations

16:30	OP.33	Vincenzina Barbera Politecnico di Milano	Janus-Driven Carbon-Silver Nanohybrids for Biocidal and Flexible Electronic Applications
16:45	OP.34	Eugenio Lunedei CNR ISMN - Bologna	Enhancing External Quantum Efficiency in OLETs by exploiting the transient electro-optical properties of luminescent radicals
17:00	OP.35	Cecilia Mortalò CNR ICMATE - Padova	Eco friendly Eu ³⁺ :YPO ₄ – alginate luminescent water-based suspensions as inks for potential anticounterfeiting applications
17:15	OP.36	Virginia Venezia Università degli Studi di Napoli Federico II	Biobased electrospun fibers for the recovery of precious and rare earth metals from e-waste leachate solutions

Flash Presentations

17:30	FP.19	Margherita Teresa Barbero Politecnico di Milano	Homochiral-based Diastereomeric (Deep) Eutectic Systems (DIADES)
17:35	FP.20	Emmanuel De Gregorio Università di Napoli Parthenope	Tailoring Phosphoric Acid Doping in Electrospun Polybenzimidazole Membranes: From Adsorption Modeling to Proton Transport
17:40	FP.21	Maria Trisolini Politecnico di Bari	An NMR-Based Approach for Monitoring the slow-growing bacterium <i>Xylella fastidiosa</i>
17:45	FP.22	Emanuele Alberti Università degli Studi di Milano-Bicocca	Morphological and Structural Engineering of CeO ₂ Nanoparticles

20:30 Social Dinner (*Hotel Quirinale, Sala Verdi - Via Nazionale 7, 00184 Roma*)

Friday, 19th June 2026

Morning Session

Chairpersons: Matteo Bonomo, Barbara Mecheri

Keynote Lecture

09:00	KL.03	Claudio Gerbaldi Politecnico di Torino	Advanced polymer-based electrolytes for solid-state batteries: addressing energy density, safety and sustainability
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Oral Presentations

09:30	OP.37	Jean Marie Vianney Nsanzimana Università degli Studi di Padova	High-current density Binder-free Electrocatalysts for Efficient Hydrogen Production in AEMWE
09:45	OP.38	Williane Freitas Università degli Studi di Roma Tor Vergata	Toward High-Performance NiFe Alloys Electrocatalysts for pH-Universal OER in Polymer Electrolyte Water Electrolyzers
10:00	OP.39	Alessio Occhicone Università di Napoli Parthenope	Nanostructured Pt Catalyst Layers Fabricated by PLD and iMAPLE for Low-Load PEMFC Applications
10:15	OP.40	Mirko Magni Università degli Studi di Milano	The challenge of recycling spent lithium-ion batteries: an academy-industry joint project
10:30	OP.41	Daniele Motta Università di Torino	Low-temperature transition glycerol-based electrolyte toward sustainable zinc-ion batteries
10:45	OP.42	Chiara Frezza Università Roma Tre	Towards flexible and sustainable microsupercapacitors: combining electrodeposited manganese on carbon felt with starch-based solid electrolytes

11:00 Coffee Break and Poster Session (exhibition area)

Chairpersons: Cristina Leonelli, Giovanni Sotgiu

11:30 Awards Ceremony

12:00 Closing Ceremony

POSTER CONTRIBUTIONS

Place Code	Presenting Author	Title
<u>01</u> FP.10	Giulia Marcolli Politecnico di Milano	Enhanced metal ion recognition with bispidine-based fluorinated chemosensors
<u>02</u> PS.01	Luigi Vertuccio Università degli Studi della Campania Luigi Vanvitelli	Temperature sensor based on expanded graphite/nylon composites
<u>03</u> PS.02	Giuseppe Consiglio Università di Catania	A new water-soluble Zn(salmal) complex as chemosensor for the enzymatic recognition of Phenylalanine
<u>04</u> PS.03	Giuseppe Consiglio Università di Catania	Lanthanide-Driven Modulation and Glass-Induced Switching in Photoswitchable Macrocycles
<u>05</u> PS.46	Antonio Aronne Università degli Studi di Napoli Federico II	Sol-gel synthesis of nonlinear optical materials
<u>06</u> PS.04	Rayhane Zribi Università degli Studi di Messina	Sustainable Cellulose-Based Nanocomposite for Sensitive Electrochemical Detection of Environmental Pollutants
<u>07</u> PS.05	Giuseppina Luciani Università degli Studi di Napoli Federico II	Nanotechnology meets circular bioeconomy: lignin nanostructured materials as active factory of metal nanoclusters for environmental sensing
<u>08</u> FP.09	Chiara Boncristiani Università del Salento	Microfluidic BBB Spheroids: Metabolomic Biomarkers for Brain Injury Detection
<u>09</u> PS.06	Martina Lamacchia Istituto Nazionale di Fisica Nucleare - Roma	New Plastic Scintillators for Nuclear Medicine Applications
<u>10</u> FP.02	Alessia Iennaco Politecnico di Bari	Synthesis and characterization of polyurethane foams from waste cooking oil (WCO)
<u>11</u> PS.07	Maurizio Galimberti Politecnico di Milano	Biomass engineering. Tuning the structure of BSF proteins for high performance bionanocomposites
<u>12</u> FP.01	Laura Riva Politecnico di Milano	Hydrophobic Eutectics-based Supramolecular Gels and Cellulose-based Nanosponges: Breakthrough Solutions for Water Remediation
<u>13</u> PS.08	Roberta Bongiovanni Politecnico di Torino	Photoinduced Frontal Polymerisation for Wood Composites
<u>14</u> PS.09	Benedetta Malvagna Università Roma Tre	Design, synthesis and Characterization of a Bio-Based Ionic Liquid as Plasticizer for Starch Films

Place Code	Presenting Author	Title
<u>15</u> PS.10	Nadia Lotti Alma Mater Studiorum Università di Bologna	Thermally weldable, degradable and high barrier sustainable flexible food packaging cast film from a novel furan based aromatic copolyester
<u>16</u> PS.11	Giulia Maccaroni Alma Mater Studiorum Università di Bologna	Design of novel furan-based copolyesters for sustainable antimicrobial medical packaging
<u>17</u> PS.12	Claudio Ferone Università di Napoli Parthenope	Innovative Hybrid Red Mud-Metakaolin-Polydimethylsiloxane Geopolymers for Rapid Methylene Blue Adsorption
<u>18</u> PS.13	Maurizia Seggiani Università di Pisa	Processing and Characterization of PBSA/Biochar Composite Films for Biodegradable Mulching Applications
<u>19</u> PS.14	Liberata Guadagno Università degli Studi di Salerno	Manufacturing of sustainable biobased composites by means of Joule-heating-assisted curing with recycled carbon fibers
<u>20</u> FP.16	Daniele Conelli Politecnico di Bari	Exploiting Metal Halide Perovskites for Photocatalytic Organic Transformations
<u>21</u> FP.17	Francesca Derobertis Politecnico di Bari	Biobased jet fuel from orange peel waste: limonene hydrogenation using Raney-nickel catalyst
<u>22</u> FP.19	Margherita Teresa Barbero Politecnico di Milano	Homochiral-based Diastereomeric (Deep) Eutectic Systems (DIADES)
<u>23</u> PS.15	Francesco Marcaccio Sapienza Università di Roma	Voltammetric behaviour of beta-amino alcohols
<u>24</u> PS.16	Stefania Marzorati Università degli Studi di Milano	Methacrylation of Fibrillar Marine Collagen: Production of Sustainable and Functional Hydrogels for Regenerative Medicine
<u>25</u> PS.47	Maria Luigia Raimondo Università degli Studi di Salerno	Improvement of the morphological features and functional properties of non-covalently functionalized carbon nanotubes and graphite nanosheets
<u>26</u> PS.17	Maria Michela Dell'Anna Politecnico di Bari	Purification of spent cigarette butts by natural deep eutectic solvents (NADES)
<u>27</u> FP.12	Carmen Corea Politecnico di Milano	Sustainable scale-up of fatty acids and polyphenols extraction from Spent Coffee Grounds
<u>28</u> PS.18	Carlo Punta Politecnico di Milano	Waste-to-Wastewater-Treatment: Valorization of Sewage Sludge Ash as Multifunctional Materials for contaminant adsorption

Place Code	Presenting Author	Title
<u>29</u> PS.19	Alessandro Sacchetti Politecnico di Milano	Innovative hydrophilic ligands for the selective recovery of Am(III) from spent nuclear fuel
<u>30</u> FP.15	Rekha Shrestha Politecnico di Milano	Hydrophobic Eutectic Solvent-Loaded Cellulose Hydrogel for Microextraction of Emerging Pollutants from Water
<u>31</u> PS.20	Daria Ballardini Sapienza Università di Roma	Deep Eutectic Solvent-enabled recovery of spent solar cells
<u>32</u> PS.21	Claudiu Bostan Sapienza Università di Roma	Green Asymmetric Synthesis: Electrodimerization of p-Fluoroacetophenone
<u>33</u> PS.22	Alessio Varotto Sapienza Università di Roma	Synthesis of Pt/CeO ₂ from a leachate solution containing recycled platinum
<u>34</u> PS.23	Larisa Lvova Università degli Studi di Roma Tor Vergata	Optical Detection of Micro- and Nanoplastics for Environmental Monitoring Purposes: the LIAISON project updates
<u>35</u> PS.48	Giulia Maria Itri Università degli Studi Mediterranea di Reggio Calabria	Recycling Spent Li-Ion Battery Materials into Pd-Based Catalysts for Biomass Upgrading
<u>36</u> PS.24	Maria Vittoria Mollo Università degli Studi della Campania Luigi Vanvitelli	Sol-gel synthesis of ZrO ₂ /Olive extract hybrids: FTIR and in vitro release study
<u>37</u> PS.25	Roberto Simonelli Università degli Studi della Campania Luigi Vanvitelli	FT-IR characterization of Alkali-activated waste (sawing sludges) materials
<u>38</u> PS.26	Meriem Goudjil Università degli Studi di Firenze	Efficient Photocatalytic Removal of Methylene Blue using Cobalt-doped CuO Nanoparticles
<u>39</u> PS.27	Zar Jan Università degli Studi di Messina	Sodium phyrophosphate decahydrate-Silca gel composites for Thermochemical Energy Storage
<u>40</u> PS.28	Silvia Sorbo Università degli Studi di Messina	Multi-Step Conversion of Orange Peel Waste into Value-Added Products via a Cascade Biorefinery Approach
<u>41</u> PS.29	Mirko Magni Università degli Studi di Milano	VisioNing: valorization of agro-industrial wastewater. From research bench to business.
<u>42</u> PS.30	Luisa Barbieri Università degli Studi di Modena e Reggio Emilia	Application of chemical technologies for waste inertization and recycling

Place Code	Presenting Author	Title
<u>43</u> PS.31	Luisa Barbieri Università degli Studi di Modena e Reggio Emilia	Engineering circular nutrient systems through material design and bio-assisted processes for environmental protection and soil restoration
<u>44</u> PS.32	Raffaele Longo Università degli Studi di Salerno	Chemical Recycling of Epoxy Composites in Mild Conditions
<u>45</u> FP.11	Beatrice Bonaldo Università di Trento	Sustainable Synthesis of Boron Carbide via Polyol-Based Precursors and Rapid Carbothermal Reduction
<u>46</u> PS.33	Francesco Parrino Università di Trento	Tailoring the structural and physico-chemical properties of starch-TiO ₂ nanocomposites through the incorporation of diverse antioxidants
<u>47</u> PS.34	Maria Enrica Di Pietro Politecnico di Milano	Novel ionic additives for safe and durable electrolytes in lithium-ion batteries
<u>48</u> PS.35	Omar Al Zeer Sapienza Università di Roma	Phase-guided design of layered Na _x (Mn,Ni)O ₂ cathodes: experimental phase maps and operando thermodynamics
<u>49</u> PS.36	Francesca Anna Scaramuzzo Sapienza Università di Roma	Sustainable and innovative materials for advanced energy storage devices
<u>50</u> FP.07	Matteo Battaglia Università degli Studi di Roma Tor Vergata	Performance study and characterization of mixed oxides for thermal energy storage applications
<u>51</u> PS.37	Seyedeh Maryam Hassani Vanhari Università degli Studi di Roma Tor Vergata	Rational Design of Phosphorus-Functionalized PBAs-Derived Electrocatalysts for Oxygen Evolution Reaction
<u>52</u> PS.38	Isabella Natali Sora Università degli Studi di Bergamo	Structural changes of La _{0.6} Sr _{0.4} Fe _{0.6} Mn _{0.2} Ni _{0.2} O _{3-δ} perovskite induced by reduction-oxidation cycles
<u>53</u> FP.05	Giuseppina Anna Corrente Università degli Studi di Messina	Bio-Based Polysaccharides for Low-Temperature Thermochemical Energy Storage
<u>54</u> FP.06	Simone Ghezzi Università degli Studi di Milano	Recovery, characterization and purification of LiPF ₆ extracted from lithium-ion batteries
<u>55</u> PS.39	Enrico Negro Università degli Studi di Padova	Improved Synthetic Route Towards Advanced “Core-Shell” Carbon Nitride Electrocatalysts for the Oxygen Reduction Reaction
<u>56</u> FP.04	Gioele Pagot Università degli Studi di Padova	Acetate-Driven Control of Zinc Deposition in Zn-I ₂ Redox Flow Batteries

Place Code	Presenting Author	Title
<u>57</u> PS.40	Paolo Sgarbossa Università degli Studi di Padova	Engineered organic-inorganic composite electrolytes for solid-state Mg batteries
<u>58</u> PS.41	Keti Vezzù Università degli Studi di Padova	Cation-Exchange Ionomers for Selective Lithium Recovery from Geologic Brines: Physicochemical Characterization and Binding Mechanisms
<u>59</u> PS.42	Riccardo Ceccato Università di Trento	Lead-free halide perovskites: synthesis and visible light photocatalytic applications
<u>60</u> PS.43	Sandra Dirè Università di Trento	Novel nanocomposites for thermal management: effect of interfacial interactions on thermal conductivity
<u>61</u> FP.20	Emmanuel De Gregorio Università di Napoli Parthenope	Tailoring Phosphoric Acid Doping in Electrospun Polybenzimidazole Membranes: From Adsorption Modeling to Proton Transport
<u>62</u> PS.44	Eleonora Pavoni Università Politecnica delle Marche	An Ab initio analysis of V-doped WSe ₂ as emerging materials for THz applications
<u>63</u> FP.08	Miryam Gulino Sapienza Università di Roma	PVD carbon and nitride coatings for application in metallic bipolar plates
<u>64</u> PS.45	Eugenio Lunedei CNR ISMN - Bologna	Temperature-dependent microspectroscopy of Egyptian Blue crystals and exfoliated nanosheets
<u>65</u> FP.21	Maria Trisolini Politecnico di Bari	An NMR-Based Approach for Monitoring the slow-growing bacterium <i>Xylella fastidiosa</i>

Unlocking Technology Potential - An Example from the Chemical Industry

N. C. Aust

BASF SE, 67056 Ludwigshafen, Germany

nicola.aust@basf.com

What makes a technology attractive for the chemical industry? At first glance, the answer appears straightforward: its successful application must enable the profitable production of chemicals that are competitive in the market. In addition, the sustainability of both process and product is playing an increasingly important role. However, even with these seemingly obvious criteria in mind, unlocking the full potential of a technology in an industrial context remains a significant challenge. To provide insights, electrosynthesis is chosen as a representative example.

Two well-established processes of BASF, a leading company in the chemical industry, are used to illustrate key factors for successful industrial implementation: chlor-alkali electrolysis¹ and the electrosynthesis of aromatic acetals².

A crucial factor in fully exploiting a technology's potential is the scale-up from laboratory to industrial production scale. General challenges associated with scale-up are highlighted using an additional example from organic electrosynthesis³.

Finally, an outlook is provided on how the potential for the future can be unlocked. In this context, a BASF project within the publicly funded cluster *Electrifying Technical Organic Syntheses (ETOS)*⁴ is highlighted, which is focused on the use of renewable feedstock linking technological advancement with sustainability objectives.

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⁴ <https://zukunftscluster-etos.de/en/>.

Bio-Inspired Materials for Cultural Heritage: Merging Nature and Technology in Sustainable Conservation Science

C. Graiff,^{1,*} L. Bergamonti¹

¹ Dipartimento SCVSA, Parco Area delle Scienze, 17/A, 43124 Parma, Università di Parma

*claudia.graiff@unipr.it

Cultural heritage lignocellulosic materials like paper, textiles and wood are continuously threatened by environmental and biological factors, leading to structural weakening and aesthetic damage. Traditional chemical treatments can slow degradation, but toxicity concerns and strict EU regulations require sustainable alternatives.

Bio-inspired nanocellulosic materials are attracting growing interest from researchers due to their properties, such as renewability, sustainability, and eco-friendliness. The purpose of this presentation is to provide an overview of the most recent applications of these innovative bio-nanomaterials in the field of cultural heritage.

Cellulose nanocrystals (CNCs) can be obtained by chemical and/or mechanical extraction from various natural lignocellulosic sources, as well as agricultural and textile waste. Their nanoscale dimensions, high mechanical strength, and biodegradability enable deep penetration into fragile structures, reinforcing cellulose fibers without altering appearance or texture. Laboratory tests, including tensile measurements before and after accelerated aging, show that CNCs significantly improve mechanical performance and effectively consolidate degraded materials. Their high degree of functionalization allows tailoring properties, for example, to obtain materials with antibacterial and antifungal activity against common biodegrading agents in lignocellulosic artworks.

The new CNC-based bio-inspired materials offer a promising and eco-friendly solution for conserving lignocellulosic cultural heritage, combining scientific rigor with environmental responsibility.

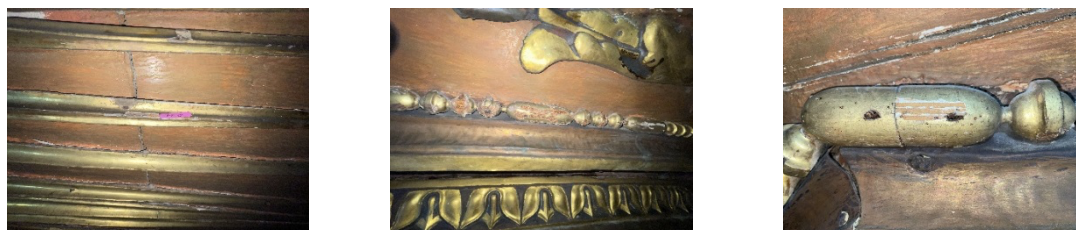


Figure 1. Application of bio-inspired treatments on selected areas of the Baldacchino artwork.
(per gentile concessione della Fabbrica di San Pietro in Vaticano)

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Mechanically Triggered Reactivity in Polymer Materials: From Pathway Control to Mechanochromic Functionality

J. A. Berrocal,^{1,2*}

¹ Institute of Chemical Research of Catalonia (ICIQ), The Barcelona Institute of Science and Technology (BIST); ² Catalan Institution for Research and Advanced Studies (ICREA)

*jberrocal@iciq.es

Mechanical force provides a distinctive means to activate chemical reactivity within polymer matrices, offering opportunities to design advanced materials with responsive or diagnostic functions.¹ It follows that understanding how force couples to molecular structure and how polymer environments modulate the resulting reactivity is key to harnessing this potential. Such knowledge can lead to the development of force-responsive systems whose chemical outputs can be predicted, tuned, and integrated into functional materials.²

In this talk, I will describe how triarylmethane and diarylmethane mechanophores can be engineered to undergo force-induced transformations with high pathway selectivity.^{3,4} I will discuss how subtle molecular changes, i.e., bond type, leaving-group identity, and substituent electronics, combine with polymer matrix design to bias homolytic or heterolytic reactivity, enabling precise control over radical or ion generation in the solid state.^{3,4} These mechanistic principles underpin new classes of mechanochromic materials capable of full visible-spectrum color responses and local polarity sensing, with the potential to achieve stress mapping in polymer films. Together, these results illustrate how mechanochemistry can serve as a platform for next-generation functional polymeric and composite materials.

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Advanced polymer-based electrolytes for solid-state batteries: addressing energy density, safety and sustainability

C. Gerbaldi,^{1,*} G.A. Elia,¹ G. Meligrana,¹ M. Falco,¹ H. Darjazi,¹ L. Balducci,¹ F. Gambino,¹ R. Bajaj,¹ A. Jouve,¹ M. Milanese,¹ V. Sperati,¹ V.G. Martello,¹ H. Ali,¹ Y. Zhang¹

¹ GAME Lab, Department of Applied Science and Technology (DISAT), Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129, Torino, and National Reference Center for Electrochemical Energy Storage (GISEL) - INSTM, Via G. Giusti 9, Firenze, 50121, Italy.

*Email: claudio.gerbaldi@polito.it

Adoption of all-solid-state designs by polymer materials, ceramics, low-volatility additives, and hybrids thereof represent a promising solution towards next-gen, advanced alkali metal-ion secondary batteries; in addition to safety advantages, these offer higher energy density and longer runtime than traditional Li-ion cells^{1,2}. However, low ionic conductivity, low cation transport properties and issues in sustainable manufacturing processes must be overcome for market deployment. Herein, recent advancements in polymer-based electrolytes with high ionic mobility, designed for safe and efficient solid-state batteries, are highlighted. Polymer matrices include poly(ethylene oxide), poly(carbonates), poly(vinylidene fluoride), and various blends thereof. Sustainable techniques, including solvent-free extrusion and UV-induced photopolymerization, are used for solid electrolyte production. Incorporating room-temperature ionic liquids, low-volatility additives, and biosourced materials further improves electrochemical performance, achieving near-theoretical capacities at high C-rates with stable cycling at ambient conditions, also in combination with high-energy 4V class cathodes^{3,4}. Single-ion conducting polyelectrolytes are also particularly promising as they feature immobilized anions and free-to-move lithium counterions, resulting in a lithium transference number close to unity and resistance towards dendrite growth⁵. In terms of sustainable development, the aim is at exploring alternative recycling pathways for materials holding potential for a second life within the energy storage domain, particularly as components in advanced solid-state batteries⁶.

Acknowledgements

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Integration of smart functions in 3D-printed polymers: material design and process parameters optimization

F. Aliberti,^{1,*} R. Pantani,¹ L. Guadagno,¹

¹ Department of Industrial Engineering, University of Salerno, Via Giovanni Paolo II, 84084 Fisciano, Italy

*faliberti@unisa.it

3D printing is transforming the production methods of real components in different industrial fields, such as aerospace, aeronautical and automotive sectors. Reducing part assembly and manual interventions and related expenses, together with the possibility of just-in-time production of customised geometry and material-saving structures, are the main reasons for industrial interest in 3D printing technology¹. The present research activity aims to develop nanomaterials for smart applications incorporating several self-responsive properties (self-sensing, electro-thermal heating, and self-healing) by using 3D printing technology. This approach would combine the advantages of 3D printing with those of self-responsive materials that can give new functions to the final device. Two different matrices and two different nanofillers have been studied: on one hand, an amorphous and rigid polymer, Acrylonitrile Butadiene Styrene (ABS) filled with carbon nanotubes (CNTs), and on the other hand, a semi-crystalline, soft matrix, poly(Ethylene-co-MethAcrylic Acid (EMAA) filled with both carbon nanotubes (CNTs) and expanded graphite (EG). By comparing these two different systems, the role of the matrix and the filler was studied in correlation with the printing parameters. Filler orientation in the printing direction and the consequent electrical anisotropy are the results obtained for the rigid ABS nanocomposites. By exploiting these results, devices with regions at different Joule heating performances and strain sensors with tunable sensitivity have been produced. For the EMAA nanocomposites, the piezoresistive response and the electro-thermal heating have been exploited in combination with the self-healing function. Once the damage was detected via the self-sensing function, the Joule heating effect was used to repair the damage (electro-healing). The auto repair function was verified for damages ranging from hundreds of micrometers to a few millimeters. Self-healing function induced by electrical stimulus without changing the chemical composition of the material was also successfully imparted to ABS nanocomposites, demonstrating the general validity of the self-healing approach.

Acknowledgments

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DNA as Drug Carrier: a Hydrophobic β -Cyclodextrin Channel in a Supramolecular Structure via Molecular Dynamics study

G. Raffaini ^{1,*}

¹ Department of Chemistry, Materials, and Chemical Engineering "Giulio Natta", Politecnico di Milano, Piazza L. Da Vinci 32, Milano, 20131, Italy

*giuseppina.raffaini@polimi.it

DNA as carrier of drugs is potentially significant for their transport and release within cells. β -cyclodextrins (β CDs) complexed with therapeutic compounds represent promising drug delivery systems. The molecular mechanisms governing the formation of these supramolecular complexes involving double-stranded DNA remain poorly understood. We employed molecular mechanics and molecular dynamics simulations to examine the formation of inclusion complexes between β CDs and quercetin (an antioxidant flavonoid with anticancer properties), and their subsequent adsorption and self-aggregation on double-stranded DNA. The adhesion process of these inclusion complexes results from intermolecular interactions between the hydrophobic drugs included in β CD cavities, which create a uniquely ordered hydrophobic channel that wraps along the DNA architecture, like ivy climbing a tree trunk. This structure is further stabilized by hydrogen bonds between β CDs, forming a long-range ordered supramolecular structure over time, akin to a thread enveloping the DNA, masking the negative charges of the phosphate groups on the DNA structure itself (Figure 1). This theoretical study offers insights into the concept of a supramolecular hydrophobic channel encasing double-stranded DNA, potentially improving applications in drug and gene delivery.

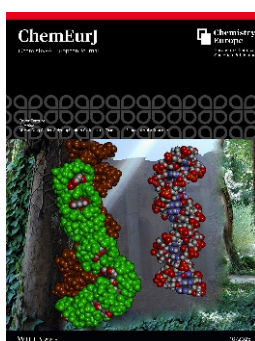


Figure 1. Cover Feature: <https://doi.org/10.1002/chem.202502895>.

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From Collection to Detection: How Materials Shape Clinical Volatilomics

R. Capuano,^{1,2}

¹ Department of Electronic Engineering, University of Rome Tor Vergata, Rome, Italy

² Interdepartmental Center for Volatilomics, “A.D’Amico” (CIVAD), University of Rome Tor Vergata, Rome, Italy

*capuano@ing.uniroma2.it

Over the past two decades, volatile organic compound analysis (VOCs) of biological fluids has gained increasing scientific relevance as a tool for assessing individual health status, leading to the emergence of a newly recognized omics discipline: volatilomics.

Numerous studies have demonstrated that VOCs emitted by the human body can reflect metabolic alterations, making them promising candidates as early biomarkers for disease screening and for pathology investigation¹. Strong evidence supporting the potential of VOC analysis for clinical monitoring, its translation into routine practice still faces several challenges largely due to the extremely low concentrations at which these compounds occur, often at ppt levels. Two critical aspects must be carefully addressed. At the sampling phase, device materials must be carefully selected to minimize background interference from off-gassing contaminants². Second, at analytical stage, particularly when sensor-based detection is employed, the careful selection of sensing materials becomes crucial to enable selectivity and in pushing the limits of sensitivity toward trace-VOC detection^{3,4}.

This contribution will discuss the impact of sampling and sensing materials on analytical performance, highlighting critical pitfalls, current technological solutions, with the goal of bridging the gap between laboratory promise and real-world clinical application

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Dual-purpose hybrid and mixed oxides: from catalysis to multifunctional polymer composites

C. Imparato,^{1,*} A. Bifulco,¹ I. Climaco,¹ E. Finocchio,² C.D. Varganici,³ S. Gaan,⁴ A. Aronne¹

¹ Department of Chemical, Materials and Production Engineering, University of Naples Federico II, Naples, Italy; ² Department of Civil, Chemical and Environmental Engineering, University of Genoa, Genoa, Italy; ³ "Petru Poni" Institute of Macromolecular Chemistry, Iasi, Romania; ⁴ Swiss Federal Laboratories for Materials Science and Technology (Empa), St. Gallen, Switzerland

*claudio.imparato@unina.it

Multicomponent and hybrid oxide-based materials with tailored surface properties can be synthesized *via* sol-gel for different catalytic processes. Examples include TiO₂-organic structures, active in the degradation of organic pollutants through reactive oxygen species stabilized at their surface owing to interfacial charge transfer complexes¹, and Si-Nb-P oxides, useful for acid-catalyzed biomass conversion reactions, such as hydrolysis and dehydration of sugars, thanks to the tunable strength and distribution of acid sites².

When introduced into a polymer matrix (e.g., epoxy resin), these materials disclose new functions, giving rise to multi-purpose composites (Figure 1). Specifically, TiO₂-rosin hybrid particles, containing a biowaste as organic ligand and modified *in situ* with hydrophobic silanes, provide epoxy coatings with low surface wettability, promising antimicrobial activity and improved fire resistance³, therefore suitable as protective layers and biocide-free antifouling coatings. Also, binary (Si-P, Si-Nb) and ternary (Si-Nb-P) oxides, added to epoxy polyesters with a phosphine oxide as co-reagent, enable thermomechanical reprocessing, by catalyzing dynamic bond exchange through transesterification⁴. At the same time, the mixed oxides support flame retardancy and smoke suppression, revealing the potential of acidic solids for the development of fire-safe covalent adaptable networks.

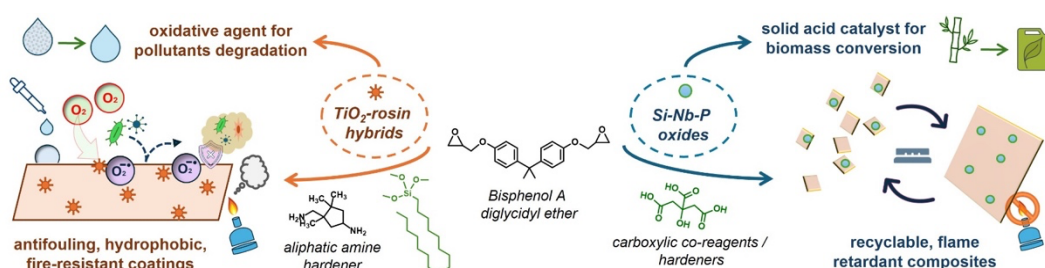


Figure 1. Main properties of some oxide-based materials and their epoxy composites.

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When 2D materials meet green solvents: hydrogen bonds in action at the Graphene Oxide-Deep Eutectic Solvent interface

G. Fioravanti,^{1,*} S. Di Muzio,² F. Ramondo³

¹ Dipartimento di Scienze Fisiche e Chimiche, Università dell'Aquila, via Vetoio, 67100 L'Aquila;

² Istituto di Fotonica e Nanotecnologie, Consiglio Nazionale delle Ricerche. P.zza L. Da Vinci 32, 20133

Milano; ³ Dipartimento di Chimica, Sapienza Università di Roma, P.le Aldo Moro 5, 00182 Roma

*giulia.fioravanti@univaq.it

Deep eutectic solvents (DESSs) have emerged as sustainable, tunable media for advanced materials design, characterized by low cost, low toxicity, and tunable physicochemical properties. Graphene oxide (GO) is a versatile 2D platform with high surface area, tunable oxygen-containing functional groups, and excellent dispersibility in various media. Understanding the molecular interactions at the GO-DES interface is essential to tailor physicochemical properties for applications in energy storage, catalysis, and green technologies¹. Here we present a combined experimental and molecular dynamics (MD) investigation of GO interactions with DESSs, namely ethaline (choline chloride and ethylene glycol, 1:2 molar ratio) and reline (choline chloride and urea, 1:2 molar ratio). A rigorously characterized GO (XPS, FTIR, Raman, DSC) was used to build a realistic atomistic model for simulations². Spectroscopic and thermal analyses, supported by radial distribution functions, reveal hydrogen-bond networks between GO oxygenated groups and DES components, leading to reciprocal structural and thermal modifications². The study provides a validated framework for rational design of GO-DES hybrid materials.

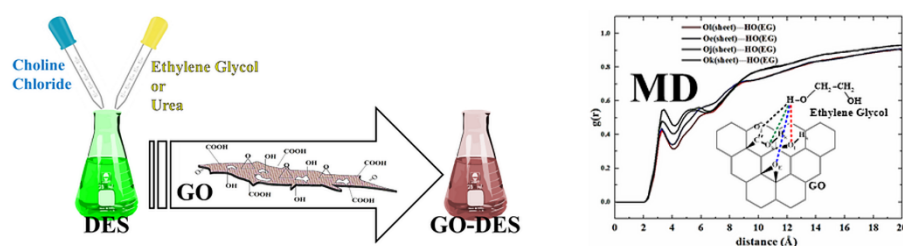


Figure 1. Schematic illustration of GO-DES composites preparation and molecular dynamics radial distribution functions obtained for GO-ethaline composite with graphical representation of distances among GO and ethylene glycol.

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Why TOPO Works: Intermolecular Interactions in Hydrophobic Deep Eutectic Solvents

M. E. Di Pietro,^{1,*} S. Rozas Azcona,² A. Mannu,³ A. Mele¹

¹ Dept. Chemistry, Materials and Chemical Engineering, Politecnico di Milano, Italy; ² Dept. Chemistry, University of Burgos, Spain; ³ Dept. Mechanical and Industrial Engineering, University of Brescia, Italy

*mariaenrica.dipietro@polimi.it

TOPO, the Italian word for “mouse”, is the acronym of trioctylphosphine oxide, a commercially relevant hydrophobic extractant.¹ Limited by its solid state under ambient conditions, its incorporation into liquid hydrophobic type V deep eutectic solvents (HDES) has greatly broadened its design space, yielding tunable systems where TOPO acts as a lone hydrogen-bond acceptor at the P=O site and its alkyl chains promote dispersive interactions. Despite the widespread use and remarkable extraction efficiencies of TOPO-based HDES, a detailed molecular understanding of the intermolecular interactions governing macroscopic performance remains lacking. Here, we investigate type V HDES composed of TOPO and phenols by combining ¹H-³¹P and ¹H-¹⁹F heteronuclear Overhauser enhancement (HOESY) NMR experiments with molecular dynamics (MD) simulations. By disentangling short- and long-range intermolecular contributions and carefully interpreting NMR data in these structured liquids, we identify key interaction patterns.² Elucidating and modulating these interactions is crucial for practical applications, as demonstrated for contaminant extraction in water remediation.³

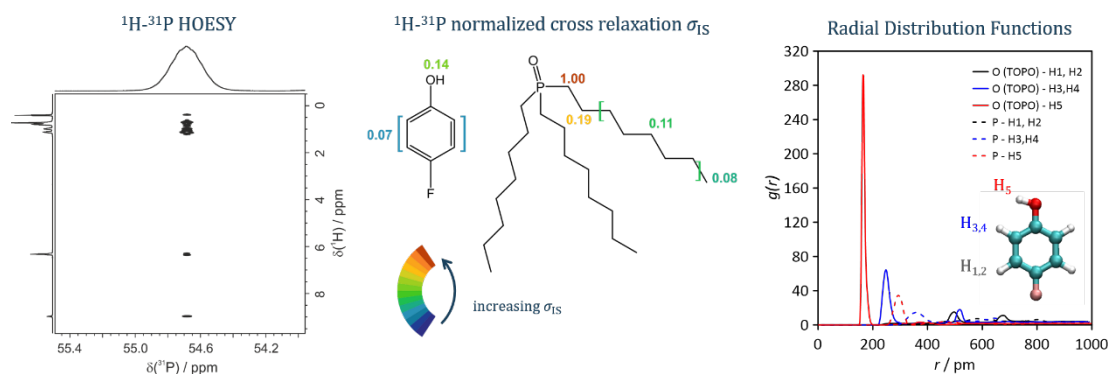


Figure 1. Experimental (HOESY and corresponding cross relaxations) and theoretical (MD radial distribution functions) results for the representative TOPO:4-fluorophenol 1:2 HDES.

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Reversible Aerogels for Heavy-Metal Capture and Reuse as Cross-Coupling Catalysts

D. Gentile,^{1*} D. Allevi¹, M. Galimberti¹, V. Barbera¹

¹ Department of Chemistry, Materials and Chemical Engineering “G. Natta”, Politecnico di Milano, Via E. Bassini 6, 20133 Milano, Italy

*davide.gentile@polimi.it

Water remediation technologies urgently require materials that are sustainable, efficient, and regenerable. In this study¹, we present a dynamic covalent aerogel derived from chitosan and formylated lignin that combines heavy metal adsorption with post-use catalytic functionality. The aerogel is formed through reversible imine bonds between chitosan and aldehyde-functionalized lignin, synthesized via a mild Reimer–Tiemann reaction². The resulting monoliths exhibit high structural integrity, solvent tolerance, and pH resistance (pH ≥ 7), together with remarkable adsorption capacities toward Cu²⁺, Pb²⁺, and Zn²⁺ ions (up to 32.8 mg g⁻¹). Density Functional Theory (DFT) calculations indicate that tridentate coordination is the dominant binding mode responsible for metal sequestration. Beyond remediation, the metal-loaded aerogels can be repurposed as efficient, recyclable heterogeneous catalysts for cross-coupling transformations under mild, green conditions, delivering high yields over multiple cycles. Finally, the dynamic covalent network enables complete component recovery and material regeneration, establishing a closed-loop strategy that integrates sustainable water detoxification with circular, bio-based catalysis.

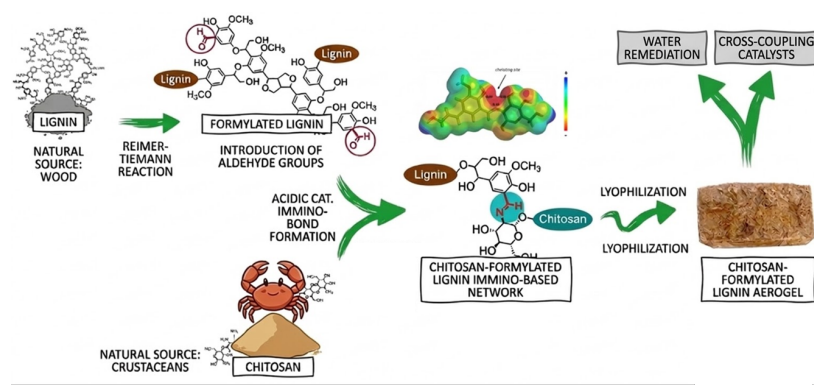


Figure 1. Schematic illustration of the preparation and dual-purpose deployment of chitosan–formylated lignin aerogels.

This work was supported by the Made in Italy-Circular and Sustainable (MICS) Extended Partnership (NextGenerationEU/PNRR, M4C2 Invest. 1.3, D.D. 1551/11-10-2022, PE00000004); the CELLS lab within the MUSA project (NextGenerationEU/PNRR, M4C2 Invest. 1.5); and the MadABio project (PRIN 2022 PNRR, D.D. 1409/14-09-2022, MUR).

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Integrating Halophyte-Based Phytoremediation of Saline Soils with the Production of High-Value Biochemical Products

B. Musio,^{1,*} A. Rizzuti,¹ V. Gallo,^{1,2} P. Mastrorilli^{1,2}

¹Department of Civil, Environmental, Land, Building Engineering and Chemistry (DICATECh),
Polytechnic University of Bari, Via Orabona, 4, Bari, I-70125, Italy

²Innovative Solutions S.r.l. - Spin-Off Company of Polytechnic University of Bari, Zona H 150/B, Noci,
70015, Italy

*biagia.musio@poliba.it

Soil salinization represents a major environmental constraint affecting agricultural productivity and ecosystem stability, particularly in coastal and arid regions. Among the sustainable strategies proposed to address this issue, phytoremediation using halophytic plants has gained increasing scientific interest.

Among the most promising species for the phytoremediation of saline soils are *Salicornia* spp. and *Crithmum maritimum*. *Salicornia*, a succulent halophyte belonging to the Amaranthaceae family, exhibits rapid growth and high biomass production in saline environments, making it particularly suitable for phytoextraction strategies aimed at reducing soil electrical conductivity. *Crithmum maritimum* (sea fennel), a perennial halophyte belonging to the Apiaceae family, also shows strong tolerance to saline substrates. This species contributes to soil phytoremediation primarily through ion uptake and stabilization mechanisms. Moreover, *Crithmum maritimum* has ecological and economic value, as it is traditionally used as an edible and medicinal plant rich in essential oils, phenolic compounds, and antioxidants.

An additional advantage of using halophytes in phytoremediation systems is the possibility of valorizing the produced biomass, thereby supporting a circular and sustainable approach in which soil restoration is combined with the production of renewable energy and high-value biochemical products. This integrated strategy contributes simultaneously to environmental restoration, resource recovery, and the development of sustainable bio-based value chains. The lignocellulosic fraction of halophyte biomass can be processed for the production of second-generation bioethanol through pretreatment, enzymatic hydrolysis, and fermentation. At the same time, both *Salicornia* and *Crithmum maritimum* are rich in bioactive compounds, including polyphenols and other antioxidant molecules, which can be extracted for potential applications in the food, nutraceutical, and pharmaceutical industries.

Herein, experimental results on the integration of phytoremediation with biomass valorization are presented and discussed, together with considerations regarding the overall sustainability of the process.

Upcycling of textile waste into nanocellulose-based aerogels for sustainable water treatment

A. De Santis,^{1,*} L. Riva,¹ G. Mascioni,¹ C. Gambarotti,¹ A. Truscello¹, C. Punta¹

¹ Department of Chemistry, Materials and Industrial Chemistry “Giulio Natta”, Politecnico di Milano, Italy

*arianna.desantis@polimi.it

The extraction of high-performance nanomaterials from textile waste represents a promising strategy for resource valorisation. Simultaneously, the textile industry constitutes a significant environmental concern due to the release of hazardous dyes and heavy metals into aquatic ecosystems, leading to biodiversity degradation and the necessity for costly wastewater treatment processes¹.

In this study, nanocellulose-based aerogels derived from three types of waste fabrics (cotton-based recycled fabric, viscose-based waste fabric, and a polyethylene terephthalate (PET)/cellulose blend) were developed and systematically evaluated for their effectiveness in the removal of heavy metals, dyes and emerging contaminants (PFAS) from contaminated water.

Various chemical pre-treatments were investigated to enhance the extraction of cellulose nanofibers (CNF) from textile waste^{1,2,3}. The resulting CNF were employed as fundamental building blocks for aerogel fabrication and were combined with a cross-linker and a co-crosslinker to obtain a stable formulation^{4,5}. Nanocellulose-based aerogels were subsequently produced through freeze-drying and thermal treatment. The resulting materials were thoroughly characterized, and their contaminant removal performance was assessed, showing outstanding sorption properties towards target contaminants.

This approach aims to promote a circular and environmentally sustainable strategy for water treatment. The upcycling of textile waste into high-performance nanomaterials establishes an effective circular approach, which not only mitigates environmental pollution but also supports the sustainable reuse of a waste as an innovative and environmentally responsible solution for wastewater treatment in the same process chain.

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Electrochemical Activation of Imidazolium-Based Covalent Organic Frameworks

C. Margarita,^{1,*} C. Bostan,¹ M. Bonomo,¹ F. Vetica,² M. Feroci¹

¹ Department of Basic and Applied Sciences for Engineering (SBAI), Sapienza University of Rome, 00161 Rome, Italy; ² Department of Chemistry, Sapienza University of Rome, 00185 Rome, Italy

*cristiana.margarita@uniroma1.it

Covalent organic frameworks (COFs) have emerged as porous organic materials valuable for a wide range of applications, owing to their high surface areas and ordered architectures.¹ Their modular construction enables the integration of well-defined active sites within periodic networks, offering a powerful platform for heterogeneous catalysis with advantages in catalyst recovery, stability, and reuse. Beyond their structural tunability and robustness, COFs incorporating redox-active functionalities such as imidazolium units represent promising candidates for electrocatalytic applications.² Within this context, the electrochemical generation of N-heterocyclic carbenes (NHCs) is a particularly attractive approach to access organocatalytic active species, widely used in synthetic chemistry, embedded in porous frameworks. While NHCs are conventionally obtained from azolium salts via deprotonation with strong bases, their formation via cathodic reduction has been extensively studied in room-temperature ionic liquids.^{3,4} In this work, we describe how combining the characteristic electrochemical reactivity of imidazolium ionic liquids with the operational advantages of COF-based materials can open new avenues for sustainable catalytic transformations.

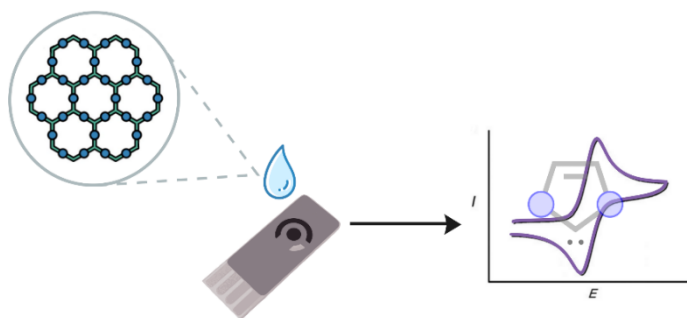


Figure 1. Electrochemical activation of imidazolium-based COFs.

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Innovative bioactive PLA-films for a sustainable packaging

A. Civitavecchia,^{1,*} E. Laudadio,¹ S. Sabbatini,¹ C. Minnelli,² S. Rinaldi,² P. Stipa,¹

¹ Department of Science and Engineering of Matter, Environment and Urban Planning (SIMAU), Università Politecnica delle Marche, Ancona, ITALY; ² Department of Life and Environmental Sciences (DISVA), Università Politecnica delle Marche, Ancona, ITALY

*a.civitavecchia@staff.univpm.it

The alarming and rapid increase in antimicrobial resistance (AMR) among pathogenic microorganisms has emerged as a complex global health crisis, driven by the critical emergence of multidrug-resistant bacterial strains¹.

In this context, innovative and functional materials able to reduce microbial proliferation and contamination using biodegradable and biocompatible polymers are in growing demand from food packaging and biomedical industries.

PLA is a polymer derived from renewable biomass sources and known for its many advantages, but it lacks intrinsic antimicrobial activity². For this reason, we investigate the synthesis and characterization of thin PLA films produced using solvent casting method and loaded with specific antibacterial natural molecules such as resveratrol, quercetin and chlorogenic acid. Due to their high biocompatibility and low toxicity, these molecules are ideal candidates for use in applications involving direct contact with food or human tissues. To demonstrate that controlled loading and subsequent release of these agents can provide a sustained and potent antimicrobial effect, while simultaneously preserving the film's structural integrity and mechanical properties, a multi-faceted approach based on quantum-mechanics simulations, experimental data, characterizations and *in vitro* tests has been adopted³ (Figure 1).

This work, among the sustainable and effective antimicrobial strategies, could offer upcoming innovation in material science, biomedical engineering, and public health initiatives.

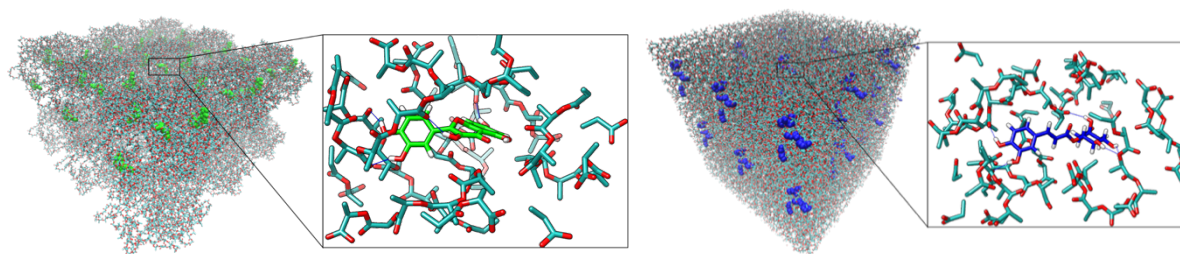


Figure 1. PLA film loaded with quercetin (left) and chlorogenic acid (right) in molecular dynamic simulations.

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Investigation on SiO₂/PEG hybrid biomaterials synthesized via the sol-gel route

A. D'Angelo,^{1,*} L. Vertuccio,² M. Fiorentino,² R. Simonelli,² M. Raimondo,¹ L. Guadagno,¹ M. Catauro²

¹ Department of Industrial Engineering, University of Salerno, Via Giovanni Paolo II 132, 84084 Fisciano, Italy;

² Department of Engineering, University of Campania "Luigi Vanvitelli", Via Roma 29, 81031 Aversa, Italy

*antoniodangelo2601@gmail.com

This study investigates the physico-chemical properties of inorganic–organic SiO₂/polyethylene glycol (PEG) hybrid biomaterials synthesized via the sol-gel route (see flowchart in Figure 1) with different PEG amounts (from 0 to 50 wt.%).¹

The interaction between the inorganic silica phase and PEG was investigated by Fourier-transform infrared spectroscopy (FT-IR). Moreover, deconvoluted FT-IR spectra in the 1500–500 cm⁻¹ range provided further information on the influence of PEG on the inorganic phase. Atomic force microscopy (AFM) has been used to study the nanoscale surface topography of the hybrids, revealing an increase in material porosity as a function of the PEG quantity and highlighting the crucial role of the PEG quantity as compatibilizing on the morphological features of silica-based blends. Furthermore, to evaluate their potential use as biomaterials, both biocompatibility, assessed by the MTT assay on eucaryotic cells, and bioactivity were evaluated. Eventually, tests on bacteria, performed using the Kirby-Bauer method, revealed high antimicrobial activity against both Gram-positive and Gram-negative strains.

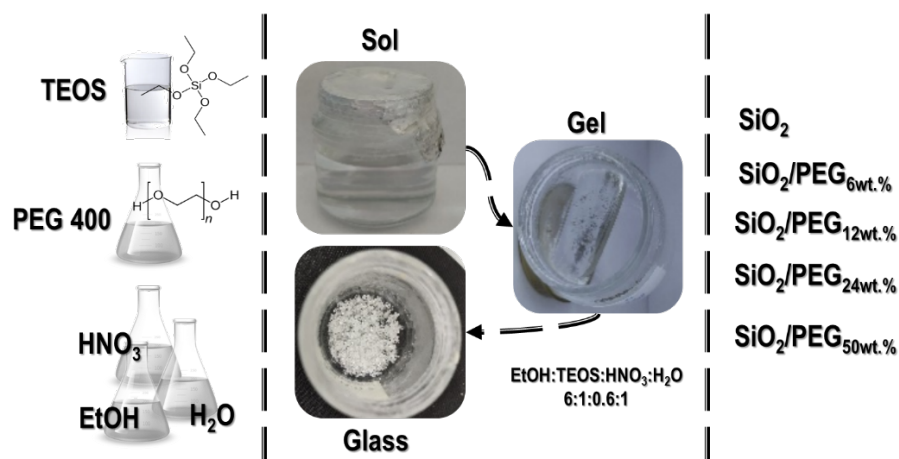


Figure 1. Sol-gel scheme of SiO₂/PEG hybrid biomaterials.

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Sustainable Self-Healing Waterborne Polyurethane Coatings for Enhanced Corrosion Protection of Metallic Artworks

Elodia Spinelli^{1,2*}, Federico Oliviero³, Zhanhua Wang⁴, Hesheng Xia⁴, Gennaro Gentile³,
Giovanna Buonocore¹, Marino Lavorgna¹, Silvia Licoccia^{2,3,5}

¹ Institute of Polymers, Composite and Biomaterials, National Research Council of Italy, Portici (NA), Italy

² Department of Chemical Science and Technologies, University of Rome Tor Vergata, Rome, Italy

³ Centre for Nanosciences, Nanotechnologies & Instrumentation (NAST), University of Rome Tor Vergata, Rome, Italy

⁴ State Key Laboratory of Advanced Polymer Materials, Polymer Research Institute, Sichuan University, Chengdu, China

⁵ Institute of Polymers, Composite and Biomaterials, National Research Council of Italy, Pozzuoli (NA), Italy

*elodia.spinelli@students.uniroma2.eu

Copper-based artworks are particularly susceptible to corrosion processes, which can compromise their structural integrity and historical value. In recent years, sustainable and nanostructured coatings have been successfully developed for cultural heritage protection. However, if the coating is accidentally damaged or scratched, its integrity is lost, exposing the artefacts to the surrounding environment and reducing their protection. Therefore, the development of multifunctional coatings capable of restoring barrier integrity while providing active corrosion inhibition is critical for long-term protection.¹ Waterborne polyurethane (WPU) coatings offer a promising approach due to their tunable structure and intrinsic self-healing potential.² In fact, these properties allow coatings to autonomously recover from mechanical damage, while their aqueous formulation reduces reliance on toxic organic solvents, minimizing environmental impact.³ In this study, WPU formulations previously developed at Sichuan University were optimized to improve both self-healing efficiency at reduced temperatures and corrosion protection of bronze surfaces. Polyethylene glycol (PEG) was incorporated to increase polymer chain mobility, facilitating the repair of surface scratches under mild thermal conditions compatible with metallic artworks. In parallel, benzotriazole was introduced into the PEG-modified matrix as an active corrosion inhibitor. Accelerated corrosion tests demonstrated that PEG-modified WPU coatings effectively preserved surface integrity, confirming their enhanced anticorrosion performance compared to unmodified formulations. These results highlight the potential of tailored WPU-based systems as environmentally friendly self-healing coatings for the long-term conservation of metallic artworks.

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Light-Induced Radical Grafting for Selective Surface Modification of Acrylate Photoresists in 2PL

D. Fontana^{1*}, E. Limiti¹, C. Bizzarri², F. Rossi³, G. Nunziata³, A. Rainer^{1,4}, E. D. Lemma^{1,4}

¹Department of Engineering, Università Campus Bio-Medico di Roma, Rome, Italy; ²Department of Chemical Science and Technologies, University of Rome Tor Vergata, Rome, Italy. ³ Department of Chemistry, Materials and Chemical Engineering "Giulio Natta", Politecnico di Milano, Milan, Italy.

⁴Institute of Nanotechnology, National Research Council (CNR-NANOTEC), Lecce, Italy

*dalila.fontana@unicampus.it

Modification of surface properties has greatly expanded the versatility of materials and structures, especially at the micro- and nanoscale. In the context of three-dimensional (3D) microenvironments for biomedical applications, coating with extracellular matrix proteins (ECM), such as fibronectin, via physi- or chemisorption is usually needed in order to be functional¹. Among fabrication techniques, direct laser writing, including two-photon lithography (2PL), enable the realization of highly controlled 3D microenvironments for cell biology. In recent years, functionality of 2PL materials and structures has benefited from the development of innovative photoresists², e.g., responsive materials, and from the optimisation of post-processing strategies and procedures³.

In this work, we show a UV-driven strategy enabling the radical grafting of maleimide derivatives (e.g., halogenated, propylic or biotinylated maleimides) to acrylate-based photoresists used for 2PL (i.e., trimethylolpropane ethoxylate triacrylate TPETA). Experimental evidence from fluorescence imaging, ToF-SIMS, FT-IR, and solid-state NMR suggests that the UV-mediated opening of the maleimide C=C bond leads to stable surface modification of 3d structures obtained via 2PL (Figure1). In turn, this can be exploited for facile and selective conferral of biologically functional properties to materials used in 2PL, including streptavidin and biotinylated ECM proteins.

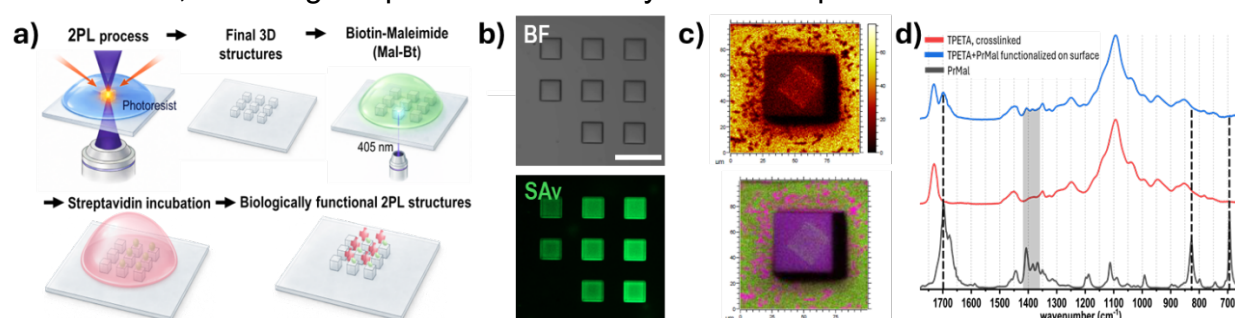


Figure 1. (a) Schematic overview of the functionalization mechanism. (b) 2PL-fabricated TPETA micro-squares showing selective streptavidin-TRITC (SAv-TRITC) fluorescence after functionalization. Scalebar 50 μm . (c) ToF-SIMS ion images of CN^- and CNO^- showing patterned SAv signals on the functionalized squares. (d) FT-IR spectra of the reaction between TPETA and propylmaleimide (PrMal).

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Tailoring Bilayer Graphtetrayne for Enhanced CO₂ Capture: Insights from Multiscale Simulations

L. Mancini,^{1,*} G. Giorgi,² Y. B. Apriliyanto³, A. Lombardi, N. Faginas-Lago

¹ Dipartimento di Chimica, Biologia e Biotecnologie, Università di Perugia, 06123, Perugia, Italy; ² Dipartimento di Ingegneria Civile e Ambientale, Università di Perugia, 06125, Perugia, Italy; ³ Department of Chemistry, Indonesia Defense University, Bogor 16810 Indonesia

*luca.mancini@unipg.it

Carbon-based two-dimensional materials are attracting growing interest as versatile platforms for gas separation and pollution control due to their high surface area, tunable porosity, and chemical stability¹. In this work, we investigate bilayer graphtetrayne, a recently proposed graphene-derived carbon allotrope², through a multiscale computational approach combining classical molecular dynamics with first-principles density functional theory. Classical simulations using an Improved Lennard-Jones³ potential efficiently explored the configurational landscape of stacked bilayers, while quantum-mechanical refinements provided accurate energetics and detailed characterization of the most favorable structures. This approach led to the discovery of a previously unreported intermediate bilayer stacking, thermodynamically more stable than conventional arrangements. The strong agreement between classical and quantum results validated the force field and confirmed the robustness of the predicted structure. From a technological perspective, CO₂/N₂ adsorption simulations showed pronounced selectivity toward CO₂ in the new stacking, driven by quadrupole- π interactions, CO₂ linear geometry, and accessible layered pores. These findings demonstrate that tuning bilayer stacking in graphtetrayne enables the design of 2D carbon membranes with enhanced CO₂ capture, bridging fundamental structural insights and practical applications.

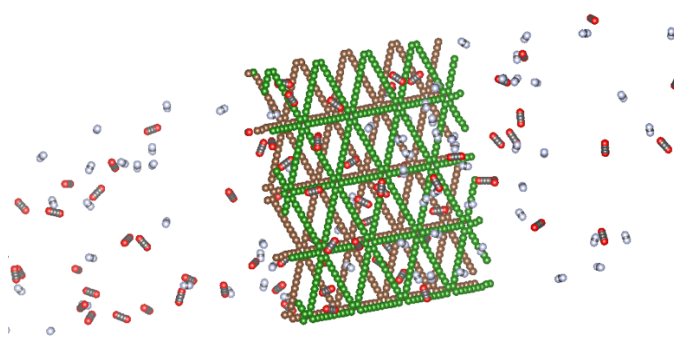


Figure 1. Final Configuration of the bilayer system.

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Pollen-based nano-plasmonic chips with MIP-NPs as receptors for Protein Detection at the attomolar levels

R. Pitruzzella,¹ A. T. Silva,^{1,2} J. Ribeiro,^{3,4} J. Mendes,⁴ L. C. Coelho,^{2,4} L. Pasquardini,^{1,5}
M. Seggio,^{6,*} C. Marzano,¹ F. Arcadio,¹ D. Cicatiello,¹ L. Zeni,¹ P. Jorge,^{2,4} N. Cennamo¹

¹Department of Engineering, University of Campania Luigi Vanvitelli, Italy; ²Faculdade de Ciências da Universidade do Porto, Portugal; ³iLoF - Intelligent Lab on Fiber, Rua de Godim; ⁴INESC TEC, Porto, Portugal; ⁵Indivenire srl, Italy; ⁶Department of Engineering, Telematic University Pegaso, Italy.

[*mimimorena.seggio@unipegaso.it](mailto:mimimorena.seggio@unipegaso.it)

In this work, a proof-of-concept for a point-of-care test (POCT) based on low-cost, small, disposable plasmonic chips for ultra-sensitive and selective protein detection was developed and tested. The POCT is based on a simple setup and a disposable sensor chip achieved by exploiting a sunflower pollen-derived nano-plasmonic transducer combined with biomimetic molecularly imprinted nanoparticles (MIP-NPs) engineered as synthetic receptors for proteins. Readout is performed via an extrinsic optical-fibre (OF) interrogation scheme, enabling compact, scalable operation, as outlined in Figure 1¹. The resulting sensor, engineered to detect bovine serum albumin (BSA) as a proof-of-concept target, achieves a limit of detection at the attomolar (aM) level, with high selectivity, consistent with ultra-trace, single-molecule-level capability, by merging a sustainable biotemplated nanoplasmonic chip with durable MIP-NP receptors¹. This approach increases Technology Readiness Level (TRL) through disposability, robustness, and cost efficiency, and offers a practical route to biomedical POCTs.

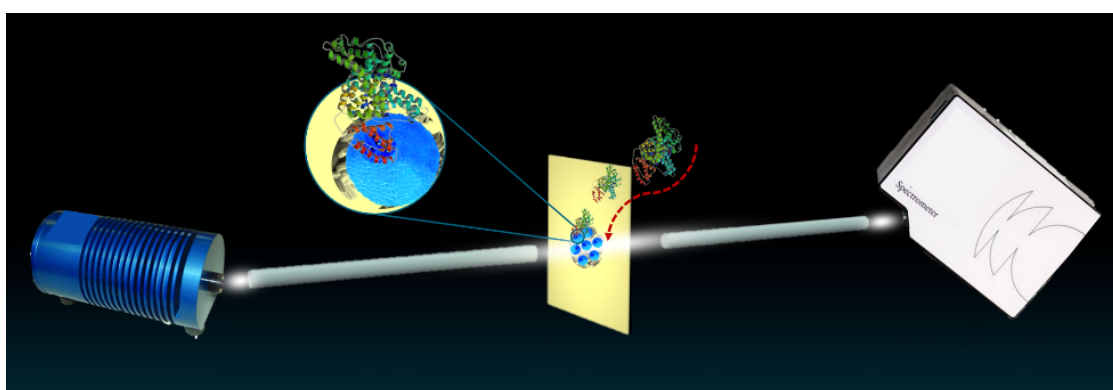


Figure 1. Schematic representation of the presented sensor system.

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TEMPO-functionalized nanogels: advanced nanoparticles for the mitigation of oxidative stress

A. Rossetti,^{1,2*} G. Nunziata,^{1,2} F. Pizzetti,^{1,2} E.G. Faggioli¹ A. Rainer,^{3,4} C. Punta^{1,2} A. Sacchetti,^{1,2} F. Rossi^{1,2}

¹ Department of Chemistry, Materials and Chemical Engineering “Giulio Natta”, Politecnico di Milano, piazza Leonardo da Vinci 32, 20133, Milan, Italy; ² National Interuniversity Consortium of Materials Science and Technology (INSTM), Florence, Italy. Local Unit c/o Politecnico di Milano; ³ Department of Engineering, Università Campus Bio-Medico di Roma, Via Álvaro del Portillo 21, 00128 Rome, Italy; ⁴ Fondazione Policlinico Universitario Campus Bio-Medico, via Álvaro del Portillo 200, Rome, 00128, Italy

*Email address: arianna.rossetti@polimi.it

Oxidative stress, characterized by an imbalance between reactive oxygen species (ROS) production and cellular detoxification, is a primary driver of numerous pathologies, including neurodegenerative diseases¹ and cancer². The nitroxyl radical 2,2,6,6-tetramethylpiperidin-1-oxyl (TEMPO) is a powerful antioxidant capable of scavenging reactive radicals and mimicking superoxide dismutase activity³. However, its therapeutic utility is hindered by rapid systemic clearance and challenging encapsulation into standard hydrophobic carriers due to its water solubility. Therefore, innovative drug delivery systems (DDSs) designed to target drugs to specific sites while harnessing the synergistic radical-scavenging activity of TEMPO offer a promising therapeutic approach in neurodegenerative diseases and cancer^{2,4}.

In this project, nanogels (NGs) were synthesized using the emulsification-evaporation method, utilizing polyethylene glycol (PEG) and linear polyethyleneimine (*l*-PEI). To incorporate the antioxidant activity, a specific linker with TEMPO was developed and either covalently linked to the polymer backbone during the NGs synthesis or grafted to their surfaces in a post-synthetic approach. The materials were characterized by FT-IR and NMR spectroscopy to confirm chemical functionalization, dynamic light scattering (DLS) to determine hydrodynamic size and ζ -potential, and atomic force microscopy (AFM) to assess morphology and size distribution. Antioxidant activity was evaluated using FRAP (Ferric Reducing Antioxidant Power) and ORAC (Oxygen Radical Absorbance Capacity) assays, while *in vitro* biocompatibility was assessed by MTT analysis. The proposed approach enabled the preparation of stable TEMPO-functionalized NGs, in which the radical retained its antioxidant activity when loaded onto the nanoparticles. These findings highlight the potential of TEMPO-NGs as versatile DDSs, able to integrate drug delivery with adjuvant antioxidant activity for the treatment of stress-driven pathologies, particularly within the CNS.

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A Dual-Mode Effusion Device: Vapour Pressure Measurements and Thin Film Deposition

J.M. Silva Ferraz¹, Marco Magi¹, L. Romagnoli², B. Brunetti², A. Ciccioli², S. Vecchio Cipriotti¹

¹ Department of Basic and Applied Sciences for Engineering (S.B.A.I.), Sapienza University of Rome, Via del Castro Laurenziano 7, Building RM017, 00161 Rome, Italy;

² Dipartimento di Chimica, Sapienza University of Rome, P.le A. Moro 5, 00185 Rome, Italy

*josemiguel.silvaferraz@uniroma1.it

Understanding the vaporisation and sublimation thermodynamics of materials at relatively high temperatures is essential for applications in optoelectronics and thin-film production. Traditional methods, such as Knudsen effusion and Langmuir vaporisation with the classical mass loss method, are often limited by their sensitivity. Quartz crystal microbalances (QCMs) offer a more sensitive alternative, allowing real-time measurement of small mass changes via shifts in resonance frequency^{1,2}.

We have developed an apparatus that combines Knudsen effusion and Langmuir vaporisation with an in situ QCM for mass flux detection, alongside conventional gravimetric analysis for validation. The system includes a high-temperature furnace, a vacuum-compatible QCM sensor, and a modular sample stage. While similar setups have been reported for specific applications^{2,3}, our instrument is, to our knowledge, the first dual-mode design capable of measuring both low-volatility liquid and solid over a wide temperature range without direct pressure gauges.

Preliminary tests with benchmark materials confirm the system's stability and reliability for vapour pressure measurements. This communication describes the design, construction, and initial tests of the apparatus, with an emphasis on its use for thermodynamic studies of vaporisation and sublimation. We also explore its potential for controlled thin-film deposition. Because the QCM provides continuous, precise feedback on mass flux, the apparatus can maintain stable deposition rates over extended periods, a key requirement for producing uniform films. This capability opens the possibility of using the system not only to characterise materials but also to deposit them directly onto substrates mounted within the vacuum chamber.

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Zwitterionic Surface Functionalization of Titanium as an Antifouling Strategy for Biomedical Applications

C. Celesti,^{1*} E. Piperopoulos¹, C. Gugliandolo,² V. Zammuto,² D. Iannazzo,¹ C. Milone¹

¹ Department of Engineering, University of Messina, Messina, Italy;

² Department of Chemical, Biological, Pharmaceutical and Environmental Sciences, University of Messina, Italy

*ccelesti@unime.it

Post-operative infections associated with bacterial adhesion and biofilm formation remain a major limitation in the long-term performance of titanium-based biomedical implants.¹ Although titanium exhibits excellent mechanical properties and biocompatibility, its surface lacks intrinsic resistance to microbial colonization.² In this work, a stepwise chemical strategy is presented to functionalize titanium surfaces with covalently bound zwitterionic moieties as a non-leaching antifouling approach. The modification involves surface hydroxylation, silanization with (3-aminopropyl)triethoxysilane, sulfonation with 1,3-propane sultone, and final quaternization to obtain a stable zwitterionic interface. Surface characterization confirmed the successful formation of highly hydrophilic interfaces, while *in vitro* assays against *Staphylococcus aureus* demonstrated a significant reduction in bacterial adhesion compared to untreated titanium. The observed effect is attributed to the formation of a strongly hydrated surface that inhibits non-specific bacterial attachment. These results highlight zwitterionic surface chemistry as an effective and antibiotic-free strategy for the development of advanced titanium-based materials with improved resistance to bacterial contamination.

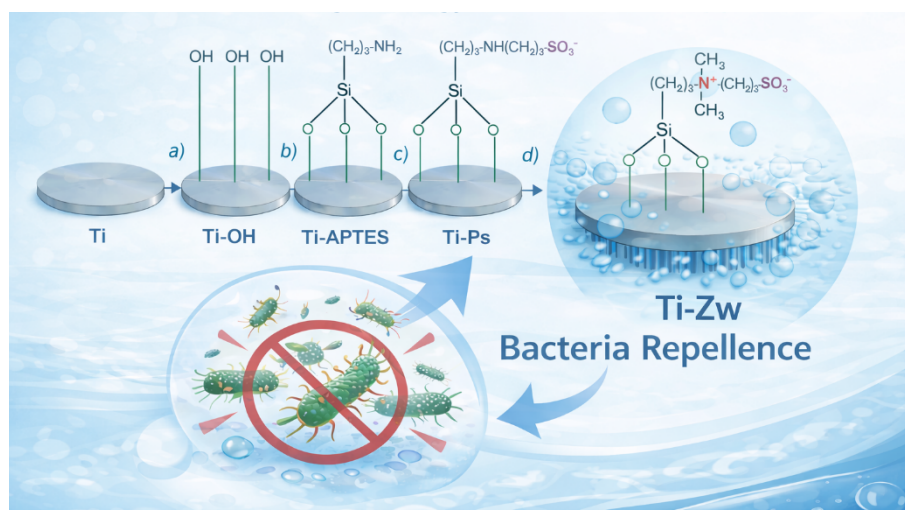


Figure 1. Titanium surface functionalization for antimicrobial activity.

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Shaping Antioxidants-loaded Nanoparticles Performance: How Surfactants Influence Stability, Activity, and Uptake in Human Skin Models

F. Baldassarre,^{1,4*} C. Boncristiani,² M. Ottolini,³ K. Eddahaoui,¹ C. Nobile,⁴ G.E. De Benedetto,⁵
V. Vergaro,² L. Valli,³ and G. Ciccarella^{1,3,4}

¹ National Interuniversity Consortium of Materials Science and Technology (INSTM), UdR Salento, University of Salento- Department of Biological and Environmental Sciences and Technologies (DiSTeBA), - Via Monteroni, 165 – 73100 Lecce (LE); ² Department of Experimental Medicine, University of Salento, S. P. 6 Lecce-Monteroni SNC, 73100 Lecce, Italy; ³ Department of Biological and Environmental Sciences and Technologies (DiSTeBA), University of Salento, S. P. 6 Lecce-Monteroni SNC, 73100 Lecce, Italy; ⁴ Institute of Nanotechnology, CNR NANOTEC, Consiglio Nazionale delle Ricerche, S. P. 6 Lecce-Monteroni SNC, 73100 Lecce, Italy; ⁵ Department of Cultural Heritage, University of Salento, Via D. Birago 64, 73100 Lecce, Italy

*francesca.baldassarre@unisalento.it

There is a growing demand for plant-derived antioxidants to replace synthetic ones in skincare applications ¹. A proof-of-concept study has been performed into the effect of surfactants on the properties of PLGA (poly-lactic-co-glycolic acid) nanoparticles, using lycopene as a challenging model compound from tomato peel (TP) extract ². The impact of two non-ionic surfactants, polyvinyl alcohol (PVA) and Tween 20, has been studied by evaluating: colloidal stability, lycopene retention and bioactivity over time, biological interactions on 2D and 3D keratinocyte and melanocyte cell cultures. Our results have emphasized the pivotal role of PVA in the prolongation of shelf-life, and of Tween 20 in facilitating the internalisation of nanoparticles by human skin spheroids. Future perspectives provide long-term stability tests and sophisticated transdermal permeation studies to support the industrial relevance of natural antioxidants-loaded nanoparticles in skincare formulations.

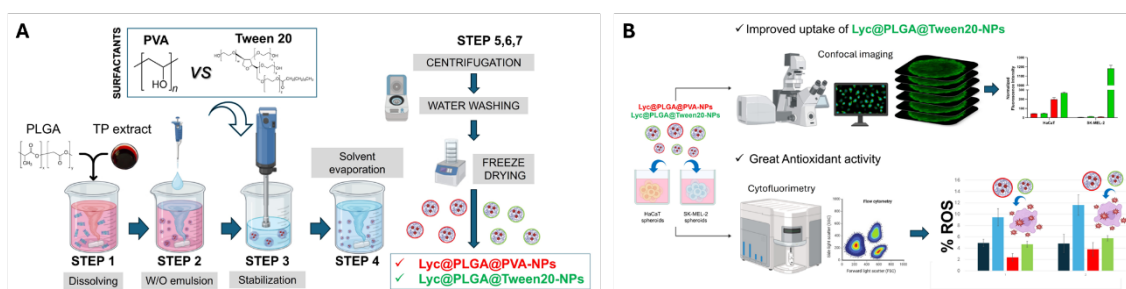


Figure 1. Synthesis scheme of PLGA nanoparticles loaded with TP extract (A) and workflow of cellular assays on human skin spheroids.

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Microfluidic Synthesis of Cerium Oxide Nanoparticles

B. Bruno^{1,2,*}, E. Limiti², F. Corsi¹, L. Ghibelli¹, A. Rainer², E. Traversa¹

¹ Università di Roma Tor Vergata, via della Ricerca Scientifica, 00133 Rome, Italy

² Università Campus Bio-Medico di Roma, via Alvaro del Portillo 21, 00128 Rome, Italy

[*beatrice.bruno@uniroma2.it](mailto:beatrice.bruno@uniroma2.it); b.bruno@unicampus.it

Nanostructured materials drive 21st-century technological innovation and materials design. Their potential to improve human well-being has intensified research on advanced nanomaterials and precise, scalable synthesis routes¹. Traditional methods often show batch variability and limited scalability, whereas microfluidics offers improved control, reproducibility, and efficiency². Cerium oxide nanoparticles (CNPs) are notable for redox activity, antioxidant behaviour, and biofilm inhibition. Acting as multifunctional nanozymes, they display both redox-dependent and redox-independent catalytic properties³. These features make them attractive for environmental, agricultural, and biomedical uses, including cancer therapy, antimicrobial treatments, biosurfactants, and biosensors⁴.

This study presents a continuous-flow microfluidic method to synthesize CNPs starting from cerium nitrate hexahydrate and using N,N,N',N'-tetramethyl ethylenediamine (TEMED) and Pluronic F127 as a precipitating and templating agent, respectively. A custom chip with three inlets, a spiral channel, and a serpentine section was designed to improve control over reaction parameters and to enhance mixing (Figure 1a). The resulting nanoparticles were thoroughly analysed by Dynamic Light Scattering (DLS), Transmission Electron Microscopy (TEM) (Figure 1b), X-Ray Diffraction (XRD) and Thermogravimetric Analysis (TGA). This work highlights microfluidics as a scalable and precise strategy for producing high-quality CNPs with increased product consistency.

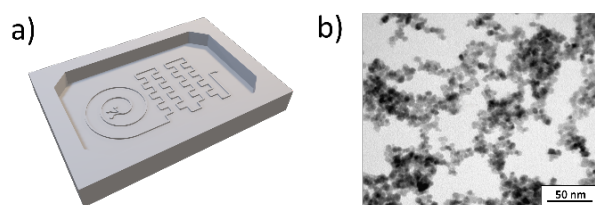


Figure 1. a) Design of the microfluidic chip; b) Image obtained by TEM microscopy of the CNPs.

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Bioactive Hydrogel Wound Dressings Incorporating Egg White Proteins and Polysaccharides Developed through Radiation

E. Muscolino^{1,3,*}, F. Gulino^{1,3}, S. Alessi¹, A. Girgenti², L. Palumbo², P. Picone², D. Nuzzo², D. Giacomazza³, C. Dispenza¹

¹ Dipartimento di Ingegneria, University of Palermo, Viale delle Scienze 6, 90128 Palermo, Italy;

² Istituto per la Ricerca e l'Innovazione Biomedica, Consiglio Nazionale delle Ricerche, Via U. La Malfa 153, 90146 Palermo, Italy;

³ Istituto di BioFisica, Consiglio Nazionale delle Ricerche, Via U. La Malfa 153, 90146 Palermo, Italy.

*emanuela.muscolino@unipa.it

Wound healing is a complex process involving the coordinated action of cytokines, growth factors, blood components, and the extracellular matrix.¹ Disruptions in these mechanisms, often linked to conditions such as diabetes, can impair healing and lead to chronic wounds. Persistent inflammation in chronic wounds prevents proper tissue regeneration and increases the risk of severe infection and possible amputation.²

Hydrogel wound dressings can be produced by radiation-induced crosslinking of polymers such as polyvinyl alcohol (PVA) or polyvinylpyrrolidone (PVP).³ This method eliminates the need for chemical initiators and simultaneously ensures sterilization. Radiation-crosslinked hydrogels are also transparent, an advantageous feature for wound monitoring. When combined with polysaccharides, such as k-carrageenan and xyloglucan, these materials may further enhance healing due to antioxidant fragments generated during irradiation.³ Besides, egg white proteins, including ovalbumin and lysozyme, have attracted attention due to their antioxidant and antimicrobial properties.⁴ These bioactive molecules can be incorporated into wound-dressing materials to reduce oxidative stress and bacterial contamination, thereby supporting the healing process.

This study aims to develop novel hydrogel formulations based on blends of synthetic polymers and polysaccharides incorporating egg white proteins and/or their derived peptides for advanced wound-dressing applications (Figure 1). The resulting hydrogels were evaluated in terms of rheological behavior, adhesion, fluid retention capacity, morphology, protein release, and antibacterial and antioxidant activity to assess their suitability as wound dressings.

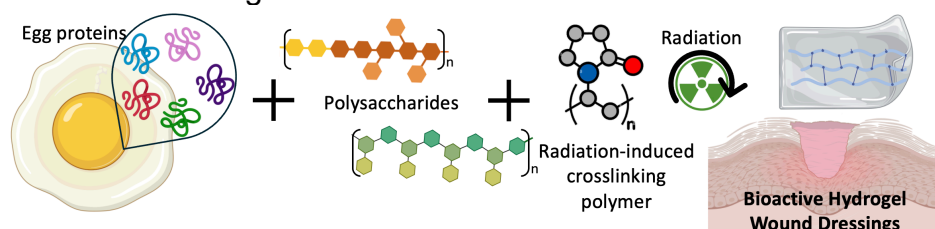


Figure 1. Schematic representation of wound dressing components.

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Polybutylenesuccinate-co-adipate (PBSA), a versatile, highly biodegradable matrix polymer for composites and nanocomposites.

Patrizia Cinelli^{1,3}, Steven Verstichel², Miriam Cappello¹, Marco Sandroni¹, Anna Silvia Citerinesi¹, Damiano Rossi¹, Camilla Ferretti¹, Maria Cristina Righetti³, Maurizia Seggiani¹

Dept. of Civil and Industrial Engineering, University of Pisa, Largo Lucio Lazzarino 1, 56122 Pisa, Italy;

²Normec OWS, Panterschipstraat 163, 9000 Gent, België; ³ National Research Council, Institute for Physical and Chemical Processes, Via G. Moruzzi 1, 56124, Pisa, Italy

*E-mail: Patrizia.cinelli@unipi.it

Biodegradable plastic are particularly relevant in those applications where post consume collecting and recycling are not feasible, and mechanical degradation can induce the production on micro or nanoplastic as in the agriculture sector. This work reports preparation, properties and biodegradability in different environments, from industrial compost to marine water, of composites and nanocomposites based on Poly (butylene succinate-co-adipate) (PBSA) or blends of PBSA and Poly(3-hydroxybutyrate-3-hydroxyvalerate) (PHB-HV) as polymeric matrix for production of composites and nanocomposites with filler derived from different biomasses such as insect exoskeleton, a by-product obtained from grinding the insect's post-protein extraction dry biomass, while nanocomposites were prepared with up to 5%-wt, nanocellulose (P5C) and nanosilica (P5S). Materials were produced by melt extrusion and injection moulding, characterized for thermal stability, morphology, and mechanical properties, and biodegradability in industrial compost, home compost, soil and marine water attesting for high biodegradability of PBSA based composites, when natural fillers are present in the material. This study confirm the valorising of biomass residue reducing the production cost of biopolyesters based composites without compromising mechanical properties for application as rigid items in agriculture or packaging, while promoting biodegradability.



Figure 1. Nano and bio composites PBSA based

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Dynamic covalent chemistry in biobased composites for additive manufacturing

E. Albertini¹, J.M. Capannelli¹, S. Dalle Vacche^{1,*}

¹ Department of Applied Science and Technology, Politecnico di Torino, Turin, Italy

*sara.dallevacche@polito.it

Thermosets, i.e. polymer materials forming a permanently crosslinked network upon curing, are widely employed due to their outstanding thermal and chemical stability. While their crosslinked architecture confers durability and structural stability, it also severely limits recyclability and biodegradability, posing a significant environmental challenge. Dynamic covalent chemistry addresses this limitation by enabling covalent adaptable networks (CANs), in which reversible covalent bonds allow network rearrangement or dismantling under an external stimulus. These materials, including vitrimers, where network topology rearranges without loss of crosslink density, retain the robustness of thermosets while enabling reprocessing and recycling.

In this context, we developed sustainable composite materials for additive manufacturing using renewable, plant-derived epoxy monomers combined with dynamic covalent chemistry to produce vitrimers with reduced environmental impact. Liquid Deposition Modeling (LDM) is a 3D-printing technique well suited for thermoset and vitrimer composites, in which objects are fabricated layer-by-layer by extruding a viscoelastic paste as a continuous filament, followed by curing to solidify the structure. A main challenge is achieving rheological properties that ensure printability and shape retention: the material must exhibit shear-thinning behavior for nozzle flow, along with sufficient yield stress and storage modulus at low shear stress to maintain shape fidelity after deposition and curing. We thus employed ultrafine and microfibrillated cellulose as rheology modifiers and reinforcing fillers, achieving good printability and shape retention, while maintaining reprocessability and recyclability^{1,2}.

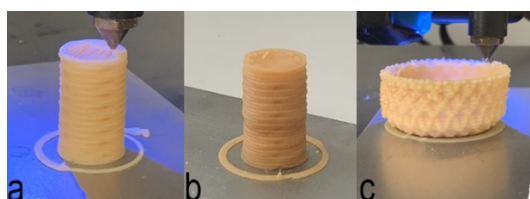


Figure 1. LDM 3D printing of a cellulose filled vitrimer paste: (a) cylinder during printing and (b) after curing; (c) printing of a complex object

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Tuning Structural Adaptability in One-Dimensional Coordination Polymers for VOC Capture

M. Lippi^{1*}, M. Goudjil¹, S. Camorali², C. Pelosi³, P. Rossi¹, L. Bernazzani³, P. Paoli¹, M. Cametti²

¹ Department of Industrial Engineering, University of Florence, via Santa Marta 3, 50136 Florence Italy; ² Department of Chemistry and Industrial Chemistry, University of Pisa, via G. Moruzzi 13, 56124 Pisa, Italy; ³ Department of Chemistry, Materials and Chemical Engineering "Giulio Natta", Politecnico di Milano, Milan, Italy

*martina.lippi@unifi.it

Coordination polymers (CPs) assembled from metal ions and organic ligands have emerged as versatile materials spanning a wide range of applications. Although one-dimensional CPs are often considered non-porous, they can nevertheless accommodate or exchange volatile molecules through pronounced framework flexibility, revealing an unexpected degree of structural adaptability.¹ Guided by this concept, we report the rational design and synthesis of a family of bispidine-based 1D coordination polymers displaying a wide range of topologies, including zig-zag chains, ribbon-like motifs, helical arrangements, and polycatenated networks achieved by systematically varying ligand functionalization, metal centers, and crystallization solvents (Figure 1).^{2,3,4} These materials show notable Volatile Organic Compounds (VOCs) uptake (adsorption) and guest-exchange behavior toward aromatic and chlorinated VOCs, among others. Particular emphasis is placed on their behavior under solid-vapor conditions, where adsorption/exchange processes induced by exposure to vapor-saturated atmospheres are directly coupled to marked phase transformations. These transformations were investigated using single-crystal and powder X-ray diffraction (SC- and P-XRD), thermal analysis (DSC, TGA-FTIR), and hot-stage microscopy, revealing different types of processes, including single-crystal-to-single-crystal, single-crystal-to-microcrystalline powder, amorphous-to-microcrystalline powder, and microcrystalline-to-microcrystalline transitions. The kinetics of these responses span a broad timescale, from hours to several weeks. Interestingly, the materials exhibited selective adsorption behavior in specific cases. Overall, this work highlights the marked structural flexibility and tunability of bispidine-based 1D coordination polymers, providing new insights into their dynamic behavior and reinforcing their potential as promising materials for selective VOC adsorption and separation.

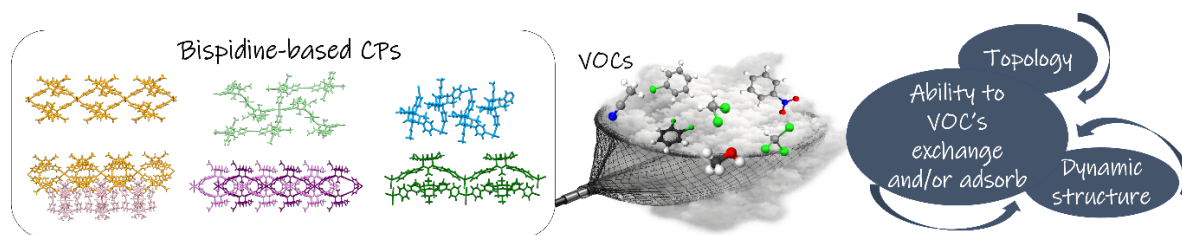


Figure 1. Schematic representation of different bispidine-based CP's topologies and their properties.

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Role of epoxy/anhydride stoichiometry in governing curing behavior and reprocessability of bio-based vitrimers

A. Marotta,^{1*} M. Salzano de Luna,¹ P. Cerruti,² G. Filippone,¹ V. Ambrogio,¹

¹ Department of Chemical, Materials and Production Engineering (DICMaPI), University of Naples Federico II, Naples (Italy); ² Institute of Polymers, Composites and Biomaterials (IPCB), National Research Council (CNR), Pozzuoli (Italy)

*angela.marotta@unina.it

Vitrimeric epoxy resins are polymer networks capable of undergoing associative bond-exchange reactions while maintaining the mechanical robustness typical of thermosets, enabling repair, reshaping, and reprocessing for sustainable long-lasting materials. The incorporation of bio-derived monomers further increases sustainability by introducing renewable functionalities into the polymer backbone without compromising the dynamic exchange mechanisms required for reprocessability.

In epoxy/anhydride systems, the amount and accessibility of exchangeable ester groups determine the rate of bond-exchange reactions, with higher densities promoting more efficient stress relaxation and improved reprocessability. Variations in the stoichiometric ratio between epoxy and anhydride components significantly influence network formation, affecting both the quantity and availability of dynamic ester linkages generated during curing. Networks enriched in accessible exchangeable sites exhibit faster exchange kinetics and enhanced reprocessing.

This study investigates how the epoxy/anhydride stoichiometric ratio influences curing behavior and vitrimeric properties in formulations based on bio-based epoxy monomers. Three formulations with increasing epoxy content were prepared to establish correlations between composition, network development, and reprocessing capability. Chemorheological analyses elucidated the effect of stoichiometry on anhydride and epoxy ring-opening kinetics and on the formation of dynamic ester linkages, while rheological measurements provided insight into the coexistence of glassy domains and covalent crosslinks.

Stress-relaxation experiments on fully cured samples confirmed the occurrence of exchange reactions and demonstrated the reprocessability of the materials. Overall, the epoxy/anhydride ratio emerges as a key parameter for tailoring network architecture and vitrimeric dynamics, offering guidelines for the design of epoxy/anhydride vitrimers with optimized reprocessing performance.

Effect of Nanosilica Aggregates/Agglomerates on Functional Properties of Poly(butylene 2,5- furandicarboxylate)-based Nanocomposites

M.C. Righetti,^{1,*} G. Molinari,¹ L. Ricci,¹ C.A. Massa,¹ P. Parlanti,² M. Gemmi,² A. Celli,³ M. Vannini,³ S. Filippi,⁴ M. Seggiani⁴

¹ Institute for Chemical and Physical Processes (IPCF), National Research Council (CNR), Via Moruzzi 1, 56124 Pisa, ² Center for Materials Interfaces, Istituto Italiano di Tecnologia, Via Piaggio 34, 56025 Pontedera, ³ Department of Civil, Chemical, Environmental and Materials Engineering, University of Bologna, Via Terracini 28, 40131 Bologna, ⁴ Department of Civil and Industrial Engineering, University of Pisa, Largo Lazzarino 1, 56122 Pisa, Italy

*mariacristina.righetti@cnr.it

Bio-based and biodegradable polymers are interesting materials able to positively contribute to the current environmental concerns in terms of plastic pollution and greenhouse gas emissions.

Furandicarboxylate-based polyesters have emerged as interesting new bio-based polymers. All the furandicarboxylate-based polyesters exhibit better mechanical and gas barrier properties in comparison to the homologous terephthalate-based polyesters¹. The properties of this class of polyesters can be fine-tuned by extending the aliphatic sequences in the chain, which can improve the processability, although the mechanical and barrier properties can worsen².

A technique useful to counterbalance this negative effect is the incorporation of nano-sized fillers to obtain nanocomposites. This study has been focused on the preparation of bio-based nanocomposites of poly(butylene furandicarboxylate) (PBF) with good mechanical and barrier properties.

The major challenge to develop nanocomposites for advanced technological applications is the capacity to understand the properties of these materials as a function of the matrix/nanofillers interphase.

The aim of the present study has been to investigate the role of nanosilica and its aggregation status on functional properties of PBF-based nanocomposites.

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Towards sustainable ceramic powder bed fusion: An LCA-based perspective

A. Sola,^{1,2,*} R. Taurino,^{3,4} A. Aversa,^{4,5} F. Bondioli,^{4,5} R. Rosa,^{1,2} A.M. Ferrari^{1,2}

¹ Department of Sciences and Methods for Engineering, University of Modena and Reggio Emilia, Italy;

² En&Tech Interdepartmental Centre, Reggio Emilia, Italy; ³ Department of Industrial Engineering, University of Florence, Italy; ⁴ National Interuniversity Consortium of Materials Science and Technology (INSTM), Firenze (Italy); ⁵ Department of Applied Science and Technology, Politecnico di Torino, Italy

*antonella.sola@unimore.it

Laser-based powder bed fusion (L-PBF) of ceramics is an emerging technique enabling customized, complex components for advanced chemical, biomedical, and aerospace applications. This study presents a life cycle assessment (LCA) aimed at identifying early environmental hotspots so that ceramic L-PBF can become “sustainable by design.”

Compared to traditional alumina disk production through pressing and sintering, ceramic L-PBF shows significantly higher energy use, which is a major driver of its environmental impact. Additional critical issues include the continuous argon flow required by current printers, originally designed for metals, and the increased footprint associated with the potential adoption of CO₂ lasers due to their slower rastering speed leading to longer build times.

The analysis suggests therefore that achieving sustainable ceramic L-PBF requires dedicated equipment that eliminates unnecessary burdens—such as argon consumption—and process optimisation that reduces build time and energy demand while limiting microstructural defects that might necessitate intensive post-processing, such as hot isostatic pressing.

Finally, a reliable LCA must also account for the printer and powder-handling hardware, whose substantial use of structural materials, especially steel, and electronics contributes appreciably to overall impacts but is often overlooked in the literature.

Volcanic ash: from Etna to applications in electrochemical sensors

M. Chelly,^{1,*} S. Chelly,¹ A. Consoli,² D. Puglisi,^{1,3} G. Neri¹

¹ Department of Engineering, University of Messina, Italy; ² Department of Chemical, Biological, Pharmaceutical and Environmental Sciences, University of Messina, Italy; ³ Department of Physics, Chemistry and Biology, Linköping University, Sweden.

* chelly.meryam@gmail.com

Etna is one of the most active volcanoes on the Earth. Explosive eruptions generate emissions of ash particles < 2 mm in diameter, consisting mainly of an aluminosilicate glass phase and a variety of other crystalline minerals. Due to its unique properties and large availability, a lot of applications have been proposed, but none deals with its electrochemical properties¹. The objective of this study is therefore to investigate the possible use of this natural material to develop electrochemical sensors.

A sample of Etna volcanic ash was first analyzed by different characterization techniques, SEM-EDX, XRD, XRF, FT-IR, Raman, for acquiring information about its chemical, morphological and microstructural nature. For carrying out the electrochemical tests, screen printed carbon electrode (SPCE) was used, by modifying the working electrode with the volcanic ash material. Preliminary electrochemical analysis by means of cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) was performed to assess the behavior of the fabricated Ash/SPCE in the presence of the $[\text{Fe}(\text{CN})_6]^{3-}$ redox probe. Results obtained (see Fig. 1), suggest the effective modification of the bare carbon working electrode by volcanic ash, and a boosting of the electrochemical properties compared to SPCE one.

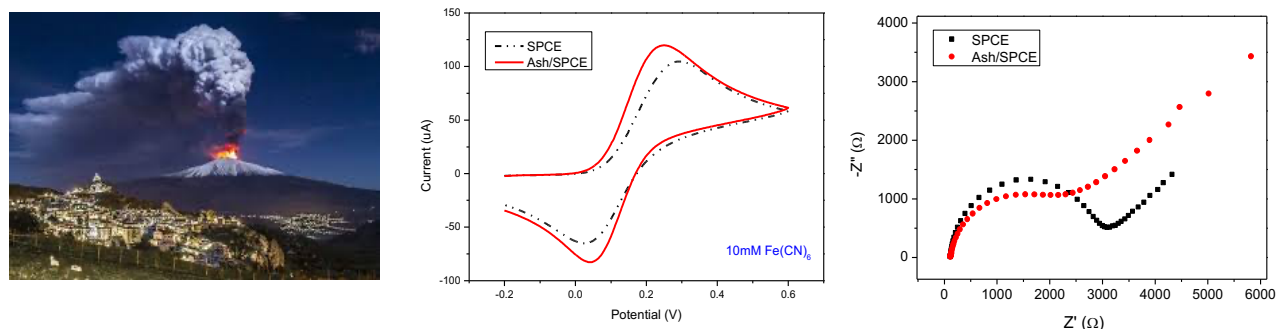


Figure 1. a) Etna view during an eruption; b) CV of $[\text{Fe}(\text{CN})_6]^{3-}$ for the SPCE and Ash/SPCE sensor; c) EIS of $[\text{Fe}(\text{CN})_6]^{3-}$ for the SPCE and Ash/SPCE sensor.

Work is currently in progress for implementing the analytical procedures to monitor important electroactive analytes in many relevant practical applications by using the novel developed Ash/SPCE sensor.

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Electrochemical Biosensor for Urea in Environmental and Biological Media

A. Ferlazzo,^{1*} G. Neri,² M.E. Fragalà,¹ S. Failla,¹ Antonino Gulino¹

¹Department of Chemical Sciences, University of Catania, Viale Andrea Doria 6, 95125 Catania, Italy

²Department of Engineering, University of Messina, C.da Di Dio, I-98166 Messina, Italy

* angelo.ferlazzo@unict.it

Modification of Gold electrode offers a versatile platform for constructing electrochemical biosensors aimed at detecting biologically and environmentally relevant molecules. Urea is a particularly important target, as its concentration reflects metabolic function and must also be controlled in food, pharmaceutical, and water-quality contexts.^{1,2} Urease enables selective electrochemical detection through the enzymatic conversion of urea into NH_4^+ and HCO_3^- . Therefore, in this study, we developed a potentiometric biosensor through the covalent immobilization of urease on Screen-Printed Gold Electrodes (SPGE), using 3,3'-dithiopropionic acid (N-hydroxysuccinimide ester, DSP), which provides a stable gold-sulfur anchoring and allows amide coupling with the enzyme.³ The resulting Ur-DSP/SPGE system was analyzed using FTIR spectroscopy, cyclic voltammetry, and electrochemical impedance spectroscopy to confirm successful surface functionalization. Urea detection was performed by open-circuit potentiometry over a 0–600 μM concentration range in aqueous media. The biosensor achieved a detection limit of 5.0 μM and exhibited strong temporal stability and selectivity. Its analytical performance was further assessed in cow's milk, human saliva, and tap water, where high recoveries demonstrated its suitability for real-sample applications.⁴

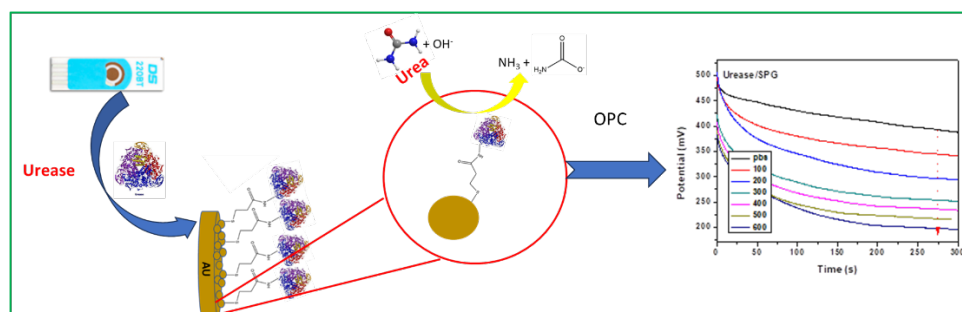


Figure 1. Schematic representation of the Ur-DSP/SPGE biosensor in urea detection.

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Synthesis and Characterization of Silica-Encapsulated Phase Change Materials Derived from Waste Cooking Oil

Rossi D.^{1,*}, Anguillesi I.¹, Iennaco A.², Leone M.S.², Mastroilli P.², Dell'Anna M.², Seggiani M.¹

¹ Department of Civil and Industrial Engineering, University of Pisa, Largo Lucio Lazzarino 1, 56122 Pisa, Italy. ² Dipartimento di Ingegneria Civile, Ambientale, del Territorio, Edile e di Chimica, Politecnico di Bari, Via Edoardo Orabona 4, 70125 Bari, Italy.*

damiano.rossi@unipi.it

Recycling Waste Cooking Oil (WCO) into functional materials provides a circular and low-carbon strategy that supports global energy-transition targets. In this framework, the present study introduces a sustainable route for producing bio-derived Phase Change Materials (PCMs) tailored for Thermal Energy Storage (TES)¹, offering a paraffin-free alternative with reduced environmental footprint. WCO was transformed into Hydrogenated Fatty Acid Methyl Esters (H-FAMES) through transesterification and complete hydrogenation², yielding a crystalline, thermally stable PCM core (Fig. 1a). The resulting H-FAMES were microencapsulated within SiO₂ shells via a TEOS-based sol-gel process, and the role of different surfactants in controlling emulsion stability and encapsulation performance was systematically explored (Fig. 1b). The bio-derived H-FAMES displayed a melting temperature of 35.3 °C and a latent heat of 195.9 J/g, while the microencapsulated PCM form maintained advantageous thermal behaviour (T_m = 33.9 °C; ΔH_m = 82.4 J/g) with an encapsulation efficiency of 43 %. The microcapsules, with an average diameter near 1.0 μm , exhibited low aggregation and excellent dispersibility. Differential Scanning Calorimetry (DSC) confirmed stable thermal cycling with negligible hysteresis over 50 cycles, and FTIR, SEM, and XRD analyses verified complete hydrogenation and successful silica encapsulation. Overall, this work demonstrates a viable approach for converting WCO into high-performance, sustainable PCMs, advancing circular-economy solutions for TES technologies.

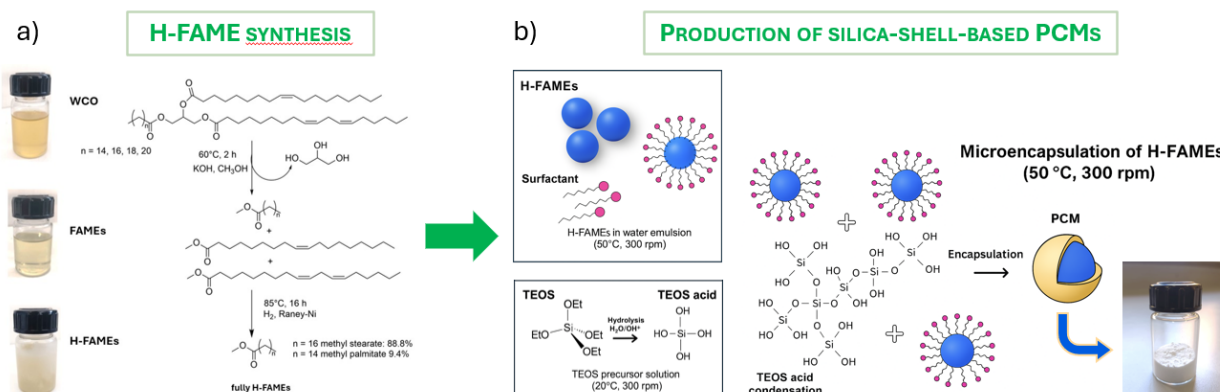


Fig.1. WCO transesterification to FAMES followed by full hydrogenation to H-FAMES (a); Encapsulation of H-FAMES within silica-shell-based PCMs (b).

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Combined NMR and HPLC-HRMS metabolomics for discriminating the response of susceptible and resistant olive cultivars to *Xylella fastidiosa* infection

A. Rizzuti,^{1,*} B. Musio,¹ A. Greco,¹ R. Ragone,¹ M. Trisolini,¹ R. Spanò,² A. Giampetruzzi,² M. Saponari,² P. Mastroianni,^{1,3} V. Gallo^{1,3}

¹Department of Civil, Environmental, Land, Building Engineering and Chemistry (DICATECh), Polytechnic University of Bari, Via Orabona, 4, Bari, I-70125, Italy

²Institute for Sustainable Plant Protection, National Research Council, Via Amendola, 165/A Bari, I-70126, Italy

³Innovative Solutions S.r.l. - Spin-Off Company of Polytechnic University of Bari, Zona H 150/B, Noci, 70015, Italy

*antonino.rizzuti@poliba.it

Bacterial infections caused by *Xylella fastidiosa* subsp. *pauca* ST53 (Xfp) in olives trigger the severe Olive Quick Decline Syndrome, one of the most severe threats to olive cultivation in the Mediterranean region. While the majority of the olive cultivars succumb to the infections by developing severe desiccation phenomena, only few exhibit resistance or tolerance responses. Current disease management strategies rely on vector control and the removal of infected sources, but these are only effective if these are timely implemented and on an area-wide base.¹ Therefore, the use of resistant or tolerant cultivars for the new plantations has been proposed as one of the most effective long-term mitigation strategies. Resistance refers to the ability of olive trees to limit the establishment and the rate of spread of the pathogen, whereas tolerance indicates the capacity to endure the damage caused by the pathogen without significant fitness loss.² Spectroscopy-based metabolomics has recently proven useful for investigating the biochemical changes associated with Xfp infection in olive trees.³⁻⁵ In this study, we applied a combined nuclear magnetic resonance (NMR) and high-performance liquid chromatography–high-resolution mass spectrometry (HPLC-HRMS) non-targeted metabolomics approach to investigate the metabolic alterations in xylem extracts from two olive cultivars, whose trees were grown under the same conditions, with contrasting phenotypes towards Xfp: FS17 (resistant/tolerant) and Arbequina (susceptible).⁶ The aim was to develop a robust metabolomics-based tool for effectively discriminating the metabolic response to infection and identifying potential biomarkers and metabolic pathways associated with resistance or tolerance mechanisms in olive trees.

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Biomass-Derived Catalytic Architectures: Chitin valorisation for the synthesis of modified N-doped carbons

Daily Rodríguez-Padrón¹

¹ Section of Chemistry for the Technology (ChemTech), Department of Industrial Engineering, University of Padova, Padova (PD), Italy

*daily.rodriguezpadrón@unipd.it

This study investigates the potential of utilizing fishery industry waste, which amounts to millions of tons annually, as a valuable source for biopolymers. The primary objective is to develop a flexible biorefinery model that integrates waste management, chemical processing of residues, and the scalable production of catalysts. Chitin, the second most abundant biopolymer on Earth, has been explored as a precursor for catalyst supports. Despite its potential, the use of chitin in innovative applications is often limited by its low solubility in most solvents, except for specific ionic liquids. In this work, we explore various valorization pathways using mechanochemical approaches to transform chitin into advanced catalytic supports. Our research team has recently demonstrated the successful conversion of chitin-rich bio-waste (shrimp shells) into metal-free catalysts for CO₂ fixation reactions.¹ Furthermore, we have developed new families of both noble and non-noble metal nanoparticles supported on chitin, which have shown promising catalytic activity in selective alcohol oxidation, reductive amination, hydrogenation, and C-C crosscoupling reactions.²⁻⁴

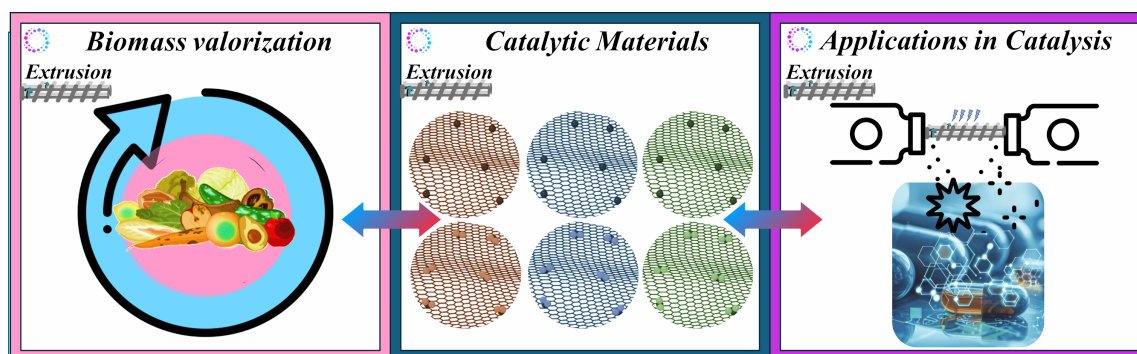


Figure 1. Schematic representation of the project objectives.

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From Coffee Waste to Sustainable Packaging: a Cascade Approach for Coffee Silverskin Valorization

C. Scapuzzi,¹ L. Navarini,² L. Baldi,¹ D. Romano,³ M. Peri,¹ D. Emide,³ G. Di Fabio,⁴ S. Farris,³ S. Lupinelli,⁵ C. Magni,³ A. Scarafoni,³ L. Verotta,¹ V. Romanucci,⁴ S. Marzorati,^{1,*}

¹ Department of Environmental Science and Policy, Università degli Studi di Milano, Milano, Italy;

² illycaffè S.p.A., via Flavia 110, Trieste I, 34147, Italy;

³ Department of Food, Environmental and Nutritional Sciences, Università degli Studi di Milano, Milano, Italy;

⁴ Department of Chemical Sciences, University of Naples "Federico II", 80126 Napoli, Italy;

⁵ ILSA S.p.A., Via Quinta Strada 28, Arzignano, 36071, Italy

* stefania.marzorati@unimi.it

Coffee production generates significant amounts of by-products, among which coffee silverskin (CS)—the thin tegument released during roasting—represents up to 4.2% (w/w) of coffee beans. Despite its abundance, CS is commonly discarded. However, it represents a promising resource, being rich in fibers, lipids, phenols, caffeine and proteins. The rECOBIOpack project explores the valorization of this residue through green extraction processes to develop bio-based food packaging materials. This approach supports circular economy goals by reducing waste towards the development of sustainable biomaterials¹.

Starting from CS supplied by illycaffè S.p.A., a cascade biorefinery strategy was applied. Supercritical CO₂ extraction was first employed at lab and industrial scales (ILSA S.p.A.) to isolate lipids in an environmentally friendly manner, avoiding any use of organic solvents². Lipids were enzymatically biotransformed to be added to improve packaging performance. From the delipidized biomass, phenolic fractions were separated and characterized for their antioxidant potential. Protein fractions were also extracted with different approaches (e.g. enzyme-assisted extraction and accelerated solvent extraction), and subsequently analyzed in terms of protein profile, extraction yield and suitability to be used in the packaging material. The remaining solid fraction was processed to recover cellulose, intended as the main polymer phase for material fabrication.

The integration of all CS-derived fractions into the cellulose matrix allowed the formulation of a biomaterial with tunable characteristics, designed to exhibit improved gas barrier properties, mechanical strength, and optical transparency, as well as antioxidant activities for food preservation. Economic and consumer studies assessed market viability and willingness to pay.

The rECOBIOpack project demonstrates how residues from the coffee industry can be upcycled into high-value, sustainable packaging solutions. By developing an eco-friendly material, the project aims to encourage responsible resource use to support the transition toward a more sustainable materials economy.

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Engineering circular nutrient systems through material design and bio-assisted processes for environmental protection and soil restoration

M. Napolitano,¹ G. Malavasi,² L. Barbieri¹

¹ Department of Engineering “Enzo Ferrari”, University of Modena and Reggio Emilia, Modena

² Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia, Modena,

* martina.napolitano@unimore.it

Sustainable nutrient management requires integrated material and biological strategies capable of reducing environmental pollution while recovering valuable resources. Conventional fertilizers often lead to nutrient losses, soil degradation, and ecosystem contamination¹. This contribution presents three complementary research lines based on circular design and bio-assisted process. The first project focused on the development of slow-release N-P-K composite granules derived from industrial by-products². Sterilized animal blood and bone meal were used as organic nitrogen source and calcium phosphate source, respectively, with pumice scraps as porous matrix providing structural stability and water retention. The resulting granules were engineered to modulate nutrient release kinetics (tested in 2% citric acid solution simulating the acidic conditions of the rhizosphere) and reduce leaching losses (tested in acetic acid to assess potential nutrient leaching under acid rain conditions). The second project addressed phosphorus bioavailability through biologically active carrier materials. Granules were produced using biochar and raw soybean meal, with pumice or zeolite as mineral carriers for phosphate-solubilizing bacteria. To assess whether microbially mobilized phosphorus remained available for plant uptake, soil tests using Diffusive Gradients in Thin Films quantified labile P fractions. Two formulations increased phosphorus availability by up to 50% compared to untreated P-deficient soil. These bioformulations are now being tested in greenhouse trials with *Brassica rapa* L. to evaluate plant growth response. The third project contributed to the study of the environmental remediation of a decommissioned industrial site, known for its historical production of explosives. Laboratory-scale studies on the bioremediation of nitrocellulose waste using multi-strain inoculum of microorganisms demonstrated effective degradation, absence of phytotoxicity, controlled NO_x emissions, and defined risk mitigation parameters. While the primary objective is contaminant removal and hazard reduction, the inorganic nitrogen released during degradation may support post-remediation soil restoration and reforestation. Collectively, these studies demonstrate how engineered and bio-assisted approaches can integrate waste valorization, nutrient circularity, and environmental remediation within a scalable soil protection framework.

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Multi-methods approach for room temperature immobilization of heavy metals cations and amphoteric moieties from industrial wastes

F. Genua^{1,*}, M. Giovini¹, C. Leonelli¹, M. Fattobene², R.E. Russo², M. Berrettoni², I. Lancellotti¹

¹Department of Engineering "Enzo Ferrari", University of Modena and Reggio Emilia, Via P. Vivarelli 10, Modena, Italy

² School of Science and Technology, University of Camerino, Camerino

*francesco.genua@unimore.it

Alkaline activation of aluminosilicate precursors, involving dissolution of reactive Si and Al species followed by polycondensation into a three-dimensional network is an efficient room temperature approach for stabilization/solidification (S/S) of hazardous heavy metals wastes. Although immobilization is effective for cationic elements, it is limited for amphoteric moieties¹ like CrO_4^{2-} , AsO_4^{3-} or SbO_4^{3-} . To overcome this limitation, the combination of a redox approach is proposed adding small amount of Na_2S and FeSO_4 (2.33 wt%) as reducing agents to convert Cr(VI) oxyanion into Cr(III) cation in an untreated Cr(VI)-rich industrial waste added in geopolymer formulation up to 20 wt%. The waste is characterized by high concentrations of Ni(II) too, sodium diethyldithiocarbamate (DTC, $\text{C}_5\text{H}_{10}\text{NS}_2\text{Na}$) was added as a chelating agent to promote Ni(ii)[DTC]₂ complexes. Preliminary XPS analysis and speciation tests using 1,5-diphenylcarbazide confirmed that the redox environment promoted reduction of Cr(VI) into Cr(III). Leaching tests in deionized water, analyzed using ICP-MS, showed a 95% reduction in Cr release for the FeSO_4 -added formulation while DTC improved Ni immobilization to a 93.4% reduction in Ni leaching. The proposed approach overcomes the limitation of geopolymers towards oxyanionic contaminants.

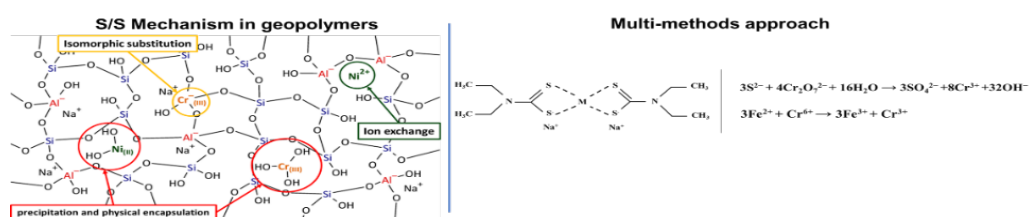


Figure 1. Schematic representation of the proposed immobilization strategy.

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Janus-Driven Carbon-Silver Nanohybrids for Biocidal and Flexible Electronic Applications

V. Barbera,^{1,*} E. Testa,¹ S. Raciti,¹ D. Gentile,¹ M. Mondella,¹ F. Goto,² G. Bussetti,² N. Bono,¹ D. Allevi,¹ A. Bottari,¹ G. Candiani,¹ M. Galimberti¹

¹ Department of Chemistry, Materials and Chemical Engineering “G. Natta”, Politecnico di Milano, Via Bassini 6, 20133 Milano, Italy; ² Department of Physics, Politecnico di Milano, piazza Leonardo da Vinci 32, Milan, 20133 Italy

*vincenzina.barbera@polimi.it

Carbon-enabled flexible electronics are rapidly moving from “smart” to “self-disinfecting”, yet combining electrical conductivity with reliable antimicrobial action still hinges on controlling metal–carbon interfaces under scalable, mild processing.

Here we introduce serinol-pyrrole (SP), a pyrrole-based dual-function molecular bridge that covalently grafts onto sp² carbon allotropes and simultaneously programs the in situ nucleation of silver nanoparticles through a mild, surfactant-free Tollens-type route, without external reductants.

The strategy is general across distinct carbon morphologies and is successfully translated to an aqueous high-shear mixing process, demonstrating industrially relevant scalability while preserving the structural and electronic integrity of the carbon phase. The resulting silver-carbon nanohybrids (CA-SP/Ag adducts) reach minimum bactericidal concentrations down to 7 µg mL⁻¹, show negligible mammalian cytotoxicity, and retain conductivity suitable for printable formulations. When incorporated into polymeric coatings and conductive inks, the materials achieve >99.9% bacterial reduction and stable piezoresistive response under mechanical deformation at markedly reduced silver loadings.^{1,2}

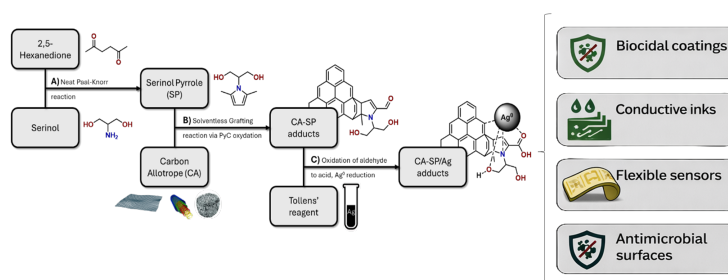


Figure 1. Block diagrams describing the process for the preparation of CA-SP/Ag adducts.

This work was supported by the Made in Italy-Circular and Sustainable (MICS) Extended Partnership (NextGenerationEU/PNRR, M4C2 Invest. 1.3, D.D. 1551/11-10-2022, PE00000004); the CELLS lab within the MUSA project (NextGenerationEU/PNRR, M4C2 Invest. 1.5); the EU Horizon Europe program (grant agreement No. 101070167, ECOTRON); and the MadABio project (PRIN 2022 PNRR, D.D. 1409/14-09-2022, MUR).

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Enhancing External Quantum Efficiency in OLETs by exploiting the transient electro-optical properties of luminescent radicals

E.Lunedei^{1,*}, M.Prosa¹, F.Reginato¹, S.Mattiello², G.Baroni¹, M.Bolognesi¹, F.Porcelli³, G.Mattioli³, Y.Hattori⁴, L.Beverina², S.Toffanin¹

¹ Institute of Nanostructured Materials (ISMN-CNR), Via P. Gobetti 101, Bologna 40129, Italy

² Department of Materials Science, University of Milano-Bicocca, Via R. Cozzi, 55, Milano 20126, Italy

³ Istituto di Struttura della Materia (ISM-CNR), Via Salaria km 29.300, Monterotondo 00015, Italy

⁴ Division of Materials Science Nara Institute of Science and Technology, Ikoma, Nara 630-0192, Japan

*Eugenio.Lunedei@cnr.it

Luminescent radicals gained considerable interest as emissive molecules in optoelectronics due to their intrinsic property (doublet excitons) to overcome the spin statistic limitation of the singlet emitters¹. When organic radicals are used in OLEDs, the observed tendency of these compounds to trap electrons though appears as a limitation for the device efficiency². In other class of devices, such as organic light-emitting transistors (OLETs), just the charge trapping turns out to be a key process to foster the light emission. We developed an unipolar n-type transistor architecture suitable for the implementation of organic radical emitters³ to exploit their doublet excitons and to study the mechanism governing the radiative recombination in this kind of device (Fig.1a). Transient Electroluminescence analysis of transistors incorporating the newly synthesized [2,6-dichloro-4-(2,6-dimethoxyphenyl)phenyl] (3,5-dichloro-4-pyridyl) (2,4,6-trichlorophenyl) methyl radical demonstrated the occurrence of a long-living emission ascribed to charge trapping mechanisms (Fig.1b), which was spectrally resolved. Complete 2D maps of both optical and electrical response of the device as a function of applied voltages (V_{GS} , V_{DS}) provided a comprehensive understanding of the processes governing the radical-OLET (Fig.1c). Trapping of electrons at radical sites was demonstrated to favour minority charges, *i.e.* holes, to be injected into the emissive layer. The improved balance of opposite charge carriers induced an increase of the charge recombination efficiency, which was up to three-fold higher than the maximum value obtained for OLETs based on benchmark singlet emitters. The device external quantum efficiency (EQE) reached a 10-fold enhanced value of 0.2%.

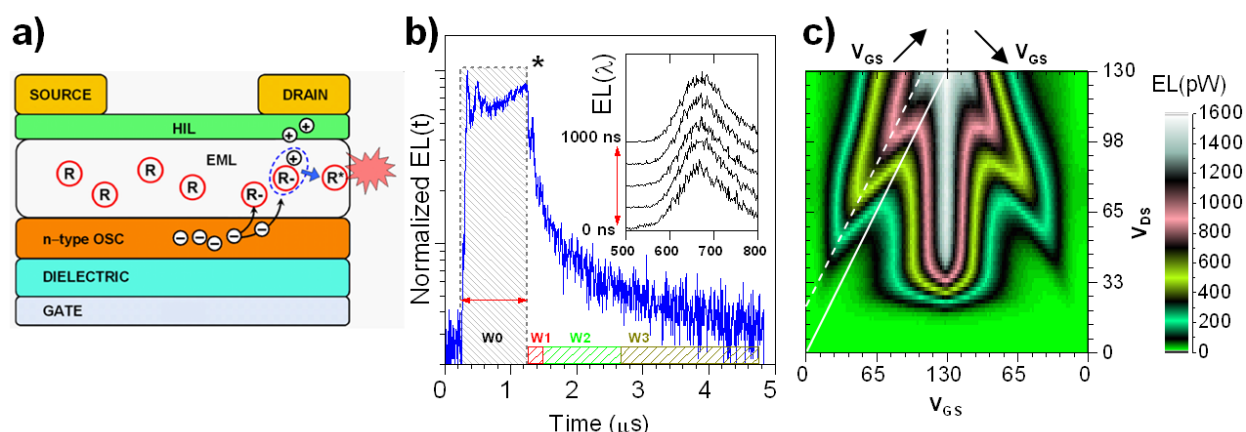


Figure 1 a) radical-OLET architecture; b) Transient Electroluminescence analysis and spectral evolution; c) EL(V_{GS} , V_{DS}) power map ($\lambda = 650$ nm) during forward and backward V_{GS} scan.

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Eco-friendly $\text{Eu}^{3+}:\text{YPO}_4$ – alginate luminescent water-based suspensions as inks for potential anticounterfeiting applications

C. Mortalò^{1,*}, E. Paradisi², F. Andreola², R. Capelli^{2,3}, L. Pasquali^{2,3,4}, V. Zin¹, S. M. Deambrosio¹, E. Miorin¹, M. Losurdo¹, C. Leonelli²

¹ National Research Council of Italy (CNR), Institute of Condensed Matter Chemistry and Technologies for Energy (ICMATE), Corso Stati Uniti 4, I-35127, Padova, Italy

² Department of Engineering “Enzo Ferrari”, University of Modena and Reggio Emilia, Via P. Vivarelli 10, I-41125 Modena, Italy

³ Department of Physics, University of Johannesburg, P.O. Box 524, Auckland Park 2006, Johannesburg, South Africa

⁴ CNR-Istituto Officina dei Materiali (IOM), Strada Statale 14, Km. 163.5 in AREA Science Park, Basovizza, 34149 Trieste, Italy

*cecilia.mortalo@cnr.it

There is a growing need for sustainable nanomaterials with well-controlled optical properties for security printing, bioimaging, and photonic technologies. Rare-earth-doped YPO_4 nanophosphors are especially attractive due to their high efficiency, chemical robustness, and well-defined emission features. ¹ Here, we present a simple and fully water-based route to produce luminescent inks by combining $\text{Eu}^{3+}:\text{YPO}_4$ nanophosphors with sodium alginate (SA), which acts simultaneously as dispersant and stabilizer. $\text{Eu}^{3+}:\text{YPO}_4$ nanoparticles (5 mol% Eu^{3+}) were synthesized via a rapid microwave-assisted hydrothermal process enabling additive-free crystallization in aqueous media. ^{2,3} Dispersions prepared using different SA grades exploit the carboxylate-rich polymer chains to achieve effective nanoparticle stabilization and tuneable rheology. Formulations containing 2 wt% SA and a $\text{Eu}^{3+}:\text{YPO}_4/\text{SA}$ mass ratio of 1:10 exhibit shear-thinning and anti-thixotropic behaviour. Rheological analyses, photoluminescence (PL) spectroscopy, and ζ -potential measurements reveal strong nanoparticle–polymer interactions that ensure long-term colloidal stability (≥ 30 days without agitation). PL spectra show an enhanced SA emission band (350–400 nm) while preserving the characteristic Eu^{3+} emission lines, evidencing a cooperative dual-emission response. ⁴ This contribution will elucidate the assembly mechanisms of $\text{Eu}^{3+}:\text{YPO}_4$ –SA systems in water and the resulting structure–property relationships governing flow and light emission. Overall, sodium alginate emerges as a sustainable dispersant for stable, additive-free luminescent suspensions, paving the way to next-generation green inks and solution-processed photonic materials for anticounterfeiting applications.

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Biobased electrospun fibers for the recovery of precious and rare earth metals from e-waste leachate solutions

V.Venezia,^{1,*} R. Grappa,¹ L.P. Di Bonito,¹ M. Orrico,¹ B. Silvestri,² B. De Gennaro,¹ F. Di Natale,¹ G. Luciani,¹

¹ Department of Chemical, Materials and Production Engineering (DICMaPI), University of Naples Federico II, Naples, Italy;

² Department of Civil, Architectural and Environmental Engineering, University of Naples Federico II, Naples, Italy

*virginia.venezia@unina.it

The rapid growth of electrical and electronic equipment has resulted in increasing amounts of waste electrical and electronic equipment (WEEE), which represents both an environmental concern and a valuable secondary source of metals. Besides hazardous components, WEEE contains significant quantities of base metals, precious metals such as Au and Pd [1], and critical raw materials including rare earth elements (REEs), which are essential for modern technologies such as electronics, catalysis, and renewable energy systems. Among the different recovery strategies, adsorption has gained attention due to its simplicity, efficiency, and potential selectivity. Biopolymer-based adsorbents derived from renewable resources have emerged as promising materials for REE recovery. Biopolymers such as cellulose and lignin contain abundant oxygenated functional groups that can promote metal binding through ion exchange and complexation mechanisms. Previous studies have shown that such materials can effectively interact with trivalent REE ions, including cerium (Ce^{3+}) and europium (Eu^{3+}), which are widely used in catalysts, polishing agents, phosphors and electronic devices [2]. In this work, electrospun fibers based on cellulose acetate (CA) and lignin (L) were developed as sustainable biosorbents for the recovery of valuable metals from model leachate solutions simulating electronic waste streams. SEM analysis revealed homogeneous fibers, while swelling tests confirmed high water uptake without compromising structural stability. Adsorption experiments showed a strong affinity toward precious metals, particularly Au^{3+} and Pd^{2+} ions. Indeed, a reductive adsorption process led to the formation of metallic Au^0/Pd^0 nanoparticles on the fiber surface, while negligible interaction with Cu^{2+} suggested good selectivity. In addition, under mildly acidic conditions ($\text{pH} \approx 5\text{--}6$), the fibers demonstrated the ability to capture REE ions such as Ce^{3+} and Eu^{3+} through coordination with oxygen-containing functional groups. These results highlight the potential of biobased electrospun fibers as sustainable and versatile mats for the selective recovery of precious metals and rare earth elements from complex aqueous streams.

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High-current density Binder-free Electrocatalysts for Efficient Hydrogen Production in AEMWE

J. M. V. Nsanzimana,^{1,*} G. Pagot,¹ K. Vezzù,¹ E. Negro,¹ V. Di Noto¹

¹ Department of Industrial Engineering, University of Padova, Via Marzolo 9, 35131 Padova (PD), Italy

*Email: jean.nsanzimana@unipd.it

It is very challenging to develop platinum-group-free metal and binder-free catalysts with high efficiency and durability in water electrolyzer industrial-relevant conditions. Hence, developing cost-effective materials based on earth-abundant iron-triad metal with excellent performance in an anion exchange membrane water electrolyzer (AEMWE), is very critical. Transition metals such as nickel are proven to easily form alloys with molybdenum due to their favorable thermodynamic properties, compatible electronic structures, comparable atomic radii, minimizing lattice strain, and the availability of various stable intermetallic phases.¹ These properties enable the synergistic interaction between nickel and molybdenum, enhancing the charge transfer and facilitating both hydrogen adsorption and desorption.² Despite these advantages, MoNi ECs face challenges in terms of stability and OER efficiency.

Through an engineering approach, a Ni-based binder-free catalysts with modulated chemistry by introducing iron-triad and high valence metal elements were developed as a durable binder-free EC in alkaline conditions. A chemical reduction, electroless plating, or hydrothermal synthesis methods were used, followed by either an annealing process or used without further treatment involving precious metal impregnation.³ The developed materials were tested in a conventional three-cell setup configuration, and the electrochemical testing was conducted in the AEMWE. The analysis of both physicochemical and electrochemical characterizations indicated that the in situ chemical reduction in an inert atmosphere at a high temperature and metal incorporation induced electronic modulation to Ni, and as a consequence, the advanced catalytic activity in AEMWE.

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Toward High-Performance NiFe Alloys Electrocatalysts for pH-Universal OER in Polymer Electrolyte Water Electrolyzers

W. Freitas,^{1,*} M. Montalto,¹ B. Mecheri,¹ A. D'Epifanio¹

¹ Department of Chemical Science and Technology, University of Rome Tor Vergata, Via della Ricerca Scientifica, 1, 00133, Rome, Italy.

*williane.freitas@uniroma2.it

The large-scale deployment of green hydrogen is essential for energy decarbonization, with polymer electrolyte membrane water electrolyzers (PEMWEs) representing a key technology. In this context, the oxygen evolution reaction (OER) remains the principal kinetic bottleneck of water electrolysis due to its complex four-electron, proton-coupled mechanism, which requires high anodic overpotentials. Although benchmark catalysts such as RuO₂ and IrO₂ exhibit excellent OER activity, their scarcity, high cost, and limited durability under anodic and extreme pH conditions constrain their large-scale implementation. Consequently, the development of cost-effective and stable alternatives based on earth-abundant transition metals or reduced platinum-group metal loadings has become a central research focus. Among these, NiFe-based electrocatalysts stand out for their high intrinsic activity, particularly in alkaline media, yet their long-term stability, especially in acidic environments, remains a significant challenge [1-3].

Herein, we propose a facile synthesis strategy to modify NiFe-based alloys with low iridium content to boost OER activity and performance durability in both acidic and alkaline electrolytes. The structure, morphology, chemical surface, and electrochemical properties of the NiFe alloys were investigated and correlated with their OER catalytic activity, as assessed by rotating disk electrode (RDE) analysis. Owing to the high OER activity indicated in the half-cell tests, the NiFeIr alloys were further tested on the anode side of a 5 cm² PEMWE single-cell setup operating in either acidic or alkaline electrolyte, with membrane electrode assemblies prepared using the catalyst-coated membrane approach. Incorporating Ir into NiFe alloys markedly strengthens both activity and durability, enabling the development of efficient pH-universal OER catalysts for advanced electrolysis applications.

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Nanostructured Pt Catalyst Layers Fabricated by PLD and iMAPLE for Low-Load PEMFC Applications

A. Occhicone^{1*}, G. De Marino¹, C. Ferone¹, G. Ausanio², O. Tarallo³, G. Roviello¹

¹ Department of Engineering, University of Naples Parthenope, Centro Direzionale, Isola C4, 80143 Napoli, Italy

² Department of Physics, University of Naples Federico II, Piazzale Vincenzo Tecchio, 80125, Napoli, Italy

³ Department of Chemical Sciences, University of Naples Federico II, Complesso Universitario di Monte Sant'Angelo, via Cintia, 80126, Napoli, Italy

*alessio.occhicone@assegnista.uniparthenope.it

The objective of this work is to develop low platinum membrane electrode assemblies (MEAs) for polymer membrane fuel cells (PEMFCs) using laser deposition techniques. The main objective is to reduce the Pt mass loading while maintaining the electrochemically active surface area (ECSA) and consequently the catalytic activity for the oxygen reduction reaction (ORR). The physical deposition methods investigated were pulsed laser deposition (PLD) and inverse matrix-assisted pulsed laser evaporation (iMAPLE). In this study, the process parameters (pressure, number of pulses, laser power) were optimized in order to correlate the operating conditions with the morphology, crystalline structure and size of the deposited Pt. Structural analysis by WAXD confirmed the presence of the *fcc* Pt phase in all samples with crystal sizes ranging from 3.6 to 6.1 nm. Operating in high vacuum (10^{-5} bar) and at higher laser power (200 W), average crystal domains of ~ 3.6 nm were obtained, which are within the optimal range (3-5 nm) for maximizing catalytic activity [1]. SEM images showed that the PLD deposits have a hierarchical structure consisting of submicron agglomerates (200-600 nm) composed of nanometric primary crystallites, in agreement with the XRD results.

In the case of iMAPLE, the more defined diffraction pattern and smaller peak broadening are consistent with the transfer of pre-crystallized nanoparticles, preserving their structural integrity during deposition. [2]. An innovative synthesis method based on a surfactant-free ethylene glycol/ethanol route for Pt nanoparticles [3] was optimized to obtain 2-4 nm particles with a final Pt loading of 1 wt%.

Overall, the work validates the possibility of using an alternative production system for the fabrication of highly efficient nanostructured catalyst layers, based on controlled physical deposition and compatible with strategies to drastically reduce Pt loading. These findings lay the groundwork for the integration of the developed materials into advanced, low-cost MEAs, with potential implications for the industrial scalability of PEMFCs and the economic sustainability of the hydrogen supply chain.

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The challenge of recycling spent lithium-ion batteries: an academy-industry joint project

M. Magni,^{1,*} A. Safdari,¹ S. Ghezzi,¹ K. Rajagopalan,¹ G. Cassardo,¹ G. Riva,¹
D. Maggioni,² P. Roustazadeh,^{1,3} A. Grassi,³ C. Bacco³

¹ *Dipartimento di Scienze e Politiche Ambientali, Università degli Studi di Milano, 20133, Milano*

² *Dipartimento di Chimica, Università degli Studi di Milano, 20133, Milano*

³ *Engitec Technologies SpA, 20026, Novate Milanese (MI)*

*mirko.magni@unimi.it

Lithium-Ion Batteries (LIBs) are ubiquitous electrochemical devices that span from portable electronics to electric vehicles. The tight dependence of this technology from many critical materials is forcing the scientific and industrial community to find out effective strategies to recover such materials from the constantly increasing numbers of spent devices. Looking at the stringent recovery rates stated in the specific Regulation, EU urgently needs efficient and (economically) sustainable hydrometallurgical processes for facing LIBs recycling issue.

Despite the relatively simple working principle, the lack of standards in LIBs manufacturing entails challenges for the recycling processes, especially for post-consumer devices that exhibit plenty of often-unknown features (crafting process, cathode and anode chemistries, shapes and dimensions, etc.). Thus, the development of a robust multi-step and adaptive process capable of running with LIBs of many types seems to be the most effective strategy.

The present research aims at developing an industrially relevant closed-loop hydrometallurgy process for LIBs recycling through a fruitful collaboration with the engineering company Engitec Technologies, partner of the Consortium of the European Battery Innovation project (IPCEI Batterie 2). The process starts with pre-treatment units that include mechanical operations, sorting/separation steps and chemical treatments aimed at recovering bigger metal parts, solvent, Li-based electrolyte, binders, etc. Then, the out coming black mass enters the real hydrometallurgical process aimed at the dissolution of metal oxides from positive electrodes (*i.e.*, leaching stage) followed by the recovery of the metal cations by precipitation, separation, refining, etc.

The speech will then focus on some of the operative units of the process line that represent open scientific challenges. By discussing the results, coming from a 4-years experimentation, the talk will show the multidisciplinary expertise required to carry out the research with the aim of triggering collaborative networking to better facing the big technological challenge behind the LIBs recycling issue.

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Low-temperature transition glycerol-based electrolyte toward sustainable zinc-ion batteries

D.Motta^{1*}, L. Sorrill², G. Zampardi², C. Barolo^{1,3}, F. La Mantia^{2,4}, M. Bonomo^{1,5,6}

¹ Department of Chemistry, NIS Interdepartmental Centre and INSTM Reference Centre, Università di Torino, 10135 Torino, Italy; ² Energiespeicher- und Energiewandlersysteme, Universität Bremen, Bibliothekstraße 1, 28359 Bremen, Germany; ³ Institute of Science, Technology and Sustainability for Ceramics (ISSMC-CNR), Via Granarolo 64, 48018 Faenza, Italy; ⁴ Fraunhofer Institute for Manufacturing Technology and Advanced Materials – IFAM, Wiener Str. 12, 28359, Bremen, Germany; ⁵ Department of Basic and Applied Sciences for Engineering (SBAI), Sapienza Università di Roma, 00139 Roma, Italy; ⁶ National Reference Center for Electrochemical Energy Storage (GISEL) – INSTM, Firenze 50121, Italy

*daniele.motta@unito.it

Aqueous zinc-ion batteries (ZIBs) are promising candidates for low-cost stationary energy storage because they rely on safer and more sustainable components than conventional lithium-ion batteries (LIBs). The use of aqueous electrolytes mitigates the flammability and toxicity issues associated with the organic electrolytes of LIBs, while zinc is more abundant and geopolitically accessible than lithium, making ZIBs attractive for large-scale applications¹. However, their practical deployment is still hindered by electrolyte-related challenges, particularly corrosion at the Zn anode due to hydrogen evolution reactions (HERs) that interfere with Zn plating/stripping (-0.76 V vs SHE), and proton co-intercalation into oxide cathodes, which causes structural degradation and accelerated capacity fading². Low-temperature transition mixtures, including deep eutectic solvents or merely eutectic mixtures, have recently been proposed as alternative electrolytes for ZIBs. These systems offer enhanced electrochemical and thermal stability, low flammability and volatility, ease of preparation, and often good environmental compatibility. In hydrated LTTMs, water actively participates in the hydrogen-bond network, improving transport properties without significantly compromising electrochemical stability³.

Building on previous work on supercapacitors⁴, we developed sustainable and cost-effective LTTMs based on ZnSO₄·7H₂O and glycerol, both inexpensive and widely available (glycerol being a biodiesel by-product). Through a comprehensive investigation, we correlated thermal behavior (*i.e.*, glass transition), transport properties, and electrochemical stability window. The 1:10 molar ratio showed efficient and uniform Zn plating/stripping on carbon cloth, as demonstrated through SEM/EDX analysis. As proof of concept, full-cell tests using a Zn anode and zinc hexacyanoferrate cathode demonstrated good power capability and long-term cycling stability, supporting the feasibility of these electrolytes for affordable stationary energy storage⁵.

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Synergistic Integration of Starch/IL Electrolytes and Manganese-Oxide-Modified Carbon Felt for Flexible and Eco-Friendly Energy Storage

C.Frezza,^{1,*} S. Romano,¹ D. Rocco,¹ M. Orsini,¹ G. Sotgiu,¹ S. De Santis,¹

¹ Department of Industrial, Electronic and Mechanical Engineering, Roma Tre University,
Via Vito Volterra 62, 00146 Rome, Italy

*chiara.frezza@uniroma3.it

The development of sustainable and flexible electronics requires energy-storage systems that combine environmentally friendly components with high electrochemical performance. Starch-based polymer electrolytes plasticized with an imidazole-based ionic liquid (IL) offer a biodegradable and conductive platform suitable for flexible devices. To enhance the overall performance of such bio-based systems, electrode engineering plays a crucial role. Here, we present a sustainable electrochemical device that integrates starch/IL electrolyte films with carbon felt electrodes modified with manganese oxide. The porous and conductive structure of carbon felt, combined with the pseudocapacitive contribution of MnO_x , significantly improves charge-storage capability. Structural, morphological, and mechanical characterization confirms the successful MnO_x incorporation and the suitability of the bioelectrolyte. Electrochemical evaluation demonstrates that coupling an IL-plasticized starch film with MnO_x -functionalized carbon felt yields a flexible, lightweight, and environmentally benign energy-storage system with promising performance.

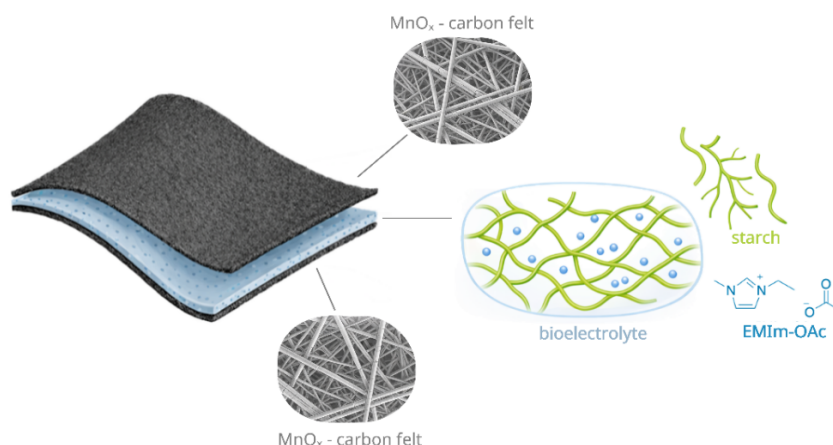


Figure 1. Schematic representation of the MnO_x - carbon felt/bioelectrolyte device

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Hydrophobic Eutectics-based Supramolecular Gels and Cellulose-based Nanosponges: Breakthrough Solutions for Water Remediation

L. Riva,^{1,*} G. Nicastro,¹ C. Carotti,¹ G. I. C. Righetti,¹ A. Mannu,¹ A. Rossetti,¹
F. Briatico-Vangosa,¹ C. Punta,¹ A. Mele,¹ M. E. Di Pietro¹

¹ Department of Chemistry, Materials, and Chemical Engineering “G. Natta”, Politecnico di Milano,
via Edoardo Bassini, 20133, Milano, Italy

*laura2.riva@polimi.it

Access to clean water is a core objective of the 2030 Agenda for Sustainable Development and the European Green Deal’s Zero Pollution Action Plan, making water remediation a major research priority. Conventional extraction methods, including dispersive liquid–liquid and solid–liquid microextraction (DLLME and DSLME), suffer from key drawbacks such as the use of volatile organic solvents and non-sustainable sorbents with limited adsorption capacity.

This work addresses these challenges through new sustainable materials based on hydrophobic non-ionic eutectic solvents (HES)¹. HES are chloride-free, easily prepared from natural precursors, characterized by 100% atom economy, and exhibit high sustainability. To extend their application beyond liquid–liquid extraction, two HES-based systems were developed: hydrophobic eutectogels (HEG) and HES-loaded cellulose nanosponges (HECS). HEG are supramolecular gels formed via rapid, thermoreversible self-assembly of low-molecular-weight gelators. HECS are hybrid materials combining HES with aerogel-like networks of derivatized cellulose² crosslinked using branched polyethyleneimine or gelatin and a co-crosslinker³, offering an attractive platform for sustainable water remediation.

Material properties are being investigated through morphological and mechanical characterization. Preliminary experiments demonstrate promising extraction performance toward endocrine-disrupting pollutants such as phthalates and bisphenol A (BPA). BPA removal and potential HES leaching are quantified using NMR and UV–Vis spectroscopy.

This systematic investigation enables fine control of material structure and performance, allowing adaptation to different remediation scenarios. Overall, the development of HES-based hydrophobic eutectogels and cellulose nanosponges represents a significant step toward greener water treatment technologies, providing safer, more efficient, and environmentally friendly strategies for contaminant removal while supporting global clean-water and green-chemistry objectives.

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Synthesis and characterization of polyurethane foams from waste cooking oil (WCO)

A. Iennaco,^{1,*} F. Derobertis¹, I. Anguillesi^{2,3}, D. Rossi², M. Seggiani^{2,3}, P. Mastroianni¹, M.M. Dell'Anna¹

¹ Dipartimento di Ingegneria Civile, Ambientale, del Territorio, Edile e di Chimica, Politecnico di Bari, Via E. Orabona 4, 70125 Bari, Italia.; ² Dipartimento di Ingegneria Civile ed Industriale (DICI), Università di Pisa, Largo L. Lazzarino 1, 56122 Pisa, Italia. ³ Consorzio Interuniversitario Nazionale per la Scienza e Tecnologia dei Materiali (INSTM), Via G. Giusti, 9, 50121 Firenze, Italia.

*a.iennaco@phd.poliba.it

Polyurethanes represent one of the most versatile families of polymers, enabling applications that range from flexible cushioning materials to rigid thermal insulation, coatings, and adhesives. Their production is generally based on the polyaddition reaction between polyols and polyisocyanates¹. Growing environmental awareness and the need to reduce petrochemical reliance have made renewable polyol sources a key research priority. In this study, waste cooking oil (WCO) was employed as a sustainable and widely available raw material for the preparation of bio-based polyols. With global WCO generation reaching 41–52 million tons annually², its valorization represents a promising route toward circular, low-impact polymer production. The polyol was produced from waste cooking oil via glycerolysis at 225 °C for 2 hours using NaOH as catalyst, then purified to remove excess glycerol and catalyst. ¹H NMR confirmed a polyol-rich mixture (67% monoglycerides, 30% diglycerides, 3% triglycerides). The resulting bio-polyol was reacted with a 68% bio-based aliphatic isocyanate (Desmodur® CQ N7300) in a closed mold, together with commercial catalysts, surfactants, and water as blowing agent, to obtain polyurethane foams. Different formulations were tested by varying the NCO/OH ratio. The resulting materials were analysed through infrared spectroscopy (IR) and scanning electron microscopy (SEM) to investigate their chemical structure and cellular morphology. Thermal stability was assessed using thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC). Density measurements and mechanical tests were conducted to classify the foams and distinguish rigid, semi-rigid, and flexible types.

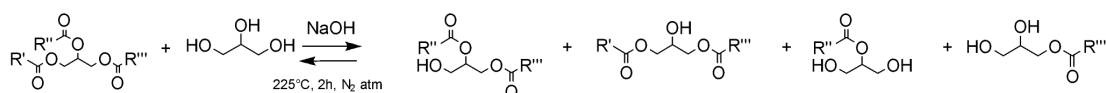


Figure 1. Scheme of the glycerolysis reaction of triglycerides.

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Ab initio characterization of transition metals: a comparative study to overcome inaccuracies in calculations

M. Petroselli,^{1,*} E. Pavoni,² E. Mohebbi,¹ A. Civitavecchia,¹ S. Sabbatini,¹ D. Mencarelli,² L. Pierantoni,² E. Laudadio,¹ P. Stipa¹

¹ Department of Science and Engineering of Matter, Environment and Urban Planning, Polytechnic University of Marche, Ancona, Italy; ² Department of Information Engineering, Polytechnic University of Marche, Ancona, Italy

*m.petroselli@pm.univpm.it

Atomistic simulations are recognized as a powerful tool to investigate properties of metallic elements at the atomic level.¹ However, when simulating these systems, significant challenges hinder the full potential of atomistic simulations, requiring careful calibration of the method used, based on the specific metal being analyzed.²⁻³ In this work, using Density Functional Theory (DFT), we compared the efficacy of three different exchange-correlation functionals (PBE, R²SCAN, and HSE06) in predicting the electronic, optical and mechanical properties of several transition metals belonging to groups 4B (Cr, Mo, W), 8B (Ni, Pd, Pt) and 9B (Cu, Ag, Au). The density of the states (DOS) calculation revealed that, while PBE and R²SCAN give results in strong agreement, the inclusion of exact Hartree-Fock exchange in the HSE06 functional introduces significant shifts in both the valence and conduction regions. In terms of optical properties, PBE and R²SCAN provide a more reliable reproduction of the experimental curves of metals with filled or almost filled d bands, while HSE06 performs better when dealing with localized d states. Finally, analyzing the mechanical properties in terms of Young's modulus, we observed that metals with a body-centered cubic (bcc) structure (Cr, Mo, W) have a higher elastic modulus value compared to those with a face-centered cubic structure (Ni, Pd, Pt, Cu, Ag, Au). All the results obtained in this work confirmed that, when determining the properties of the considered metallic elements, the electronic structure, bonding hybridization and electron promotion play a crucial role.

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Acetate-Driven Control of Zinc Deposition in Zn-I₂ Redox Flow Batteries

G. Pagot,^{1,2,3*} G. Crivellaro,¹ E. Negro,^{1,2,3} J.M.V. Nsanzimana,^{1,3} K. Vezzù,^{1,2,3} V. Di Noto^{1,2,3}

¹ Department of Industrial Engineering, University of Padova, and INSTM Via Marzolo 9, 35131, Padova, Italy; ² Centro Studi di Economia e Tecnica dell'Energia "Giorgio Levi Cases", Via Marzolo 9, 35131, Padova, Italy; ³ Gruppo Tematico ACee della Società Chimica Italiana and GISEL, Via Marzolo 9, 35131, Padova, Italy

*gioele.pagot@unipd.it

Zinc-polyiodide redox flow batteries (Zn-I₂ RFBs) are emerging as promising candidates for large-scale energy storage due to the high abundance and low cost of zinc together with the high solubility of ZnI₂ in aqueous media¹. However, their practical application is still limited by poor reversibility of zinc deposition and stripping processes, which lead to dendrite formation, side reactions, and capacity fading during cycling.

In this work², we propose an environmentally friendly electrolyte based on a mixed acetic acid/sodium acetate additive, acting simultaneously as a pH buffer and, more importantly, as a metal-complexing ligand to regulate Zn²⁺ coordination in solution. The effect of the additive was investigated through a combination of spectroscopic, electrochemical, and morphological studies, together with single-cell flow battery tests.

Spectroscopic results revealed that acetate ligands progressively replace iodide in the Zn²⁺ coordination sphere, promoting the formation of mixed [ZnAc(H₂O)_x]⁺ complexes while suppressing less electrochemically active [ZnI_x(H₂O)_{4-x}]^{2-x} species. Electrochemical measurements showed that moderate additive concentrations significantly improve the reversibility of the Zn/Zn²⁺ redox couple, increasing coulombic efficiency from ~20–40% in additive-free electrolytes to ~97–98%, while maintaining stable iodine redox behavior. Flow battery tests confirmed the beneficial role of the additive, with the optimal electrolyte composition delivering a coulombic efficiency of 98.2%, an energy efficiency of about 80%, and a volumetric energy density of 47.4 Wh L⁻¹. These results demonstrate that acetate-based additives represent a sustainable approach to control zinc deposition and significantly enhance the performance and durability of Zn-I₂ flow batteries.

Acknowledgments

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Bio-Based Polysaccharides for Low-Temperature Thermochemical Energy Storage

G. A. Corrente,^{1,*} M. A. Avila-Gutierrez,¹ Z. Jan,¹ E. Mastronardo,¹ L. Calabrese,¹ A. Beneduci,² C. Milone¹

¹ Engineering Department, University of Messina, C.da di Dio 98166, Italy; ² Department of Chemistry and Chemical Technologies University of Calabria Via P. Bucci 15D, Rende (CS) 87036, Italy

*giuseppinaanna.corrente@unime.it

The growing penetration of renewable energy requires efficient and sustainable thermal energy storage solutions to address supply-demand mismatches.¹ Thermochemical energy storage (TCES), particularly based on hydration-dehydration reactions, offers high energy density and long-term storage capability, but current systems relying on inorganic salts face issues such as corrosion, structural instability, and deliquescence.^{1,2} In this work, we explore natural polysaccharide gums: tara, guar, konjac, and xanthan, as bio-based alternatives for low- to medium-temperature thermochemical heat storage. These materials are abundant, non-toxic, and rich in hydrophilic functional groups, enabling strong and reversible interactions with water molecules. A comprehensive physicochemical characterization was performed using FTIR, TGA, DSC, and Dynamic Vapor Sorption (DVS) analyses to investigate structural features, thermal stability, hydration/dehydration energetics and moisture uptake/release behavior. Thermogravimetric and calorimetric analyses reveal a gradual and reproducible dehydration process, occurring mainly below 150 °C³, associated with an enthalpy changes and heat storage capacities in the range of 400-950 kJ kg⁻¹. All investigated gums exhibit significant hygroscopicity, an water uptake up to about 30 wt% at RH= 90% and T= 30 °C, and narrow hysteresis. Their relatively high energy density (max 390 KWh/m³) and low operating temperature enable efficient use of low-grade heat sources.

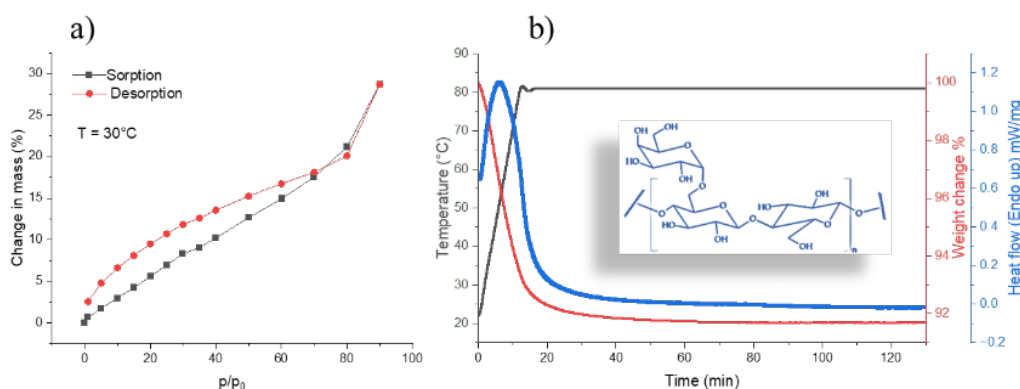


Figure 1. a) DVS measurements and b) Dehydration TG/DSC profile for the evaluation of the heat storage capacity of Guar gum. Inset: chemical structure.

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Recovery, characterization and purification of LiPF_6 extracted from lithium-ion batteries

S. Ghezzi,^{1,*} D. Maggioni², A. Grassi³, C. Bacco³, M. Magni¹

¹ Department of Environmental Science and Policy, Università degli Studi di Milano, via Golgi 19, 20133 Milano (Italy); ² Department of Chemistry, Università degli Studi di Milano, via Golgi 19, 20133 Milano (Italy); ³ Engitec Technologies Spa, via Paolo Borsellino e Giovanni Falcone 31, 20026 Milano (Italy)

*simone.ghezzi1@unimi.it

The growing volume of electronic waste (e-waste), particularly end-of-life (EoL) lithium-ion batteries (LIBs), poses significant environmental challenges. With EU regulations aiming for ambitious recovery rates of critical metals, such as lithium, by 2030–2031¹, the need for efficient, scalable, and environmentally friendly recycling methods of these devices is urgent.

LiPF_6 is currently the most used lithium salt for LIBs as an electrolyte, but it has various drawbacks regarding its stability, which usually contributes to the aging and eventually failing of the battery².

The purpose of this research has been to devise a repeatable recovery method of the lithium salt and, using ^{31}P NMR with the ERETIC software³, its quantification and the identification of its decomposition byproducts contained in an extract obtained from LIBs scraps.

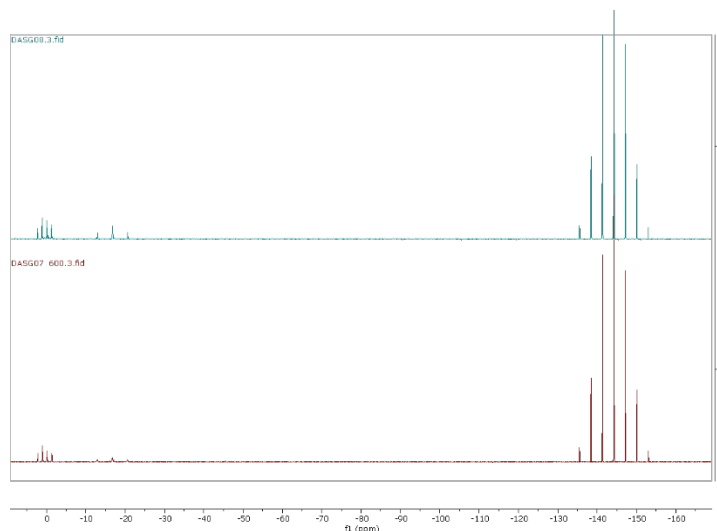


Figure 1. Two samples of LiPF_6 extracted from spent LIBs

Later, we will discuss a preliminary two-step purification process aiming to remove or reduce the percentage of the byproducts in the extract, with the purpose of reusing the LiPF_6 inside new batteries.

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Performance study and characterization of mixed oxides for thermal energy storage applications

Matteo Battaglia,^{1,*} S. Sau,² A.C. Tizzoni,² A. Spadoni,² N. Corsaro,¹ N. Roshan,³ C. D'Ottavi¹, S. Licoccia^{1,4}

¹ University of Rome Tor Vergata - Department of Chemical Science and Technologies, Via della Ricerca Scientifica 1, 00133 Rome, Italy; ² ENEA – Italian National Agency for New Technologies, Energy and Sustainable Economic Development, CR Casaccia, Via Anguillarese 301, 00196 Rome, Italy; ³ University of Rome Sapienza, Department of Chemical Engineering, Via Eudossiana 18, Rome, Italy; ⁴ Nast Center, University of Rome Tor Vergata, 00133 Rome, Italy

* matteo.battaglia@uniroma2.it

Concentrated Solar Power (CSP) technology is one of the most promising green technologies to reach net zero target by 2050, where solar energy can be used to produce electric energy through thermal conversion cycles, to produce high-temperature heat that can be used in industrial processes and to store large amounts of heat. In the search of suitable species to be used for thermal energy storage (TES), several materials have been investigated to identify suitable candidates characterized by being non-toxic, non-critic and sustainable.

This work focused on the development, characterization, and comparison of mixed oxides with different structures such as spinels (e.g. $\text{MnAl}_2\text{O}_4/\text{MnAl}_2\text{O}_{4-\delta}$) and perovskites (e.g. SrFeO_3). An extended study by TGA, XRD, BET and SEM analysis has been carried out for the highest-performing ones, studying also their behavior after pelletization. Key evaluation criteria included chemical and physical stability, the capability to store and release heat at the lowest temperature to be coupled to CSP. To maximize energy density and cyclic stability, these structures were further optimized through lattice doping and the use of inert substrates.

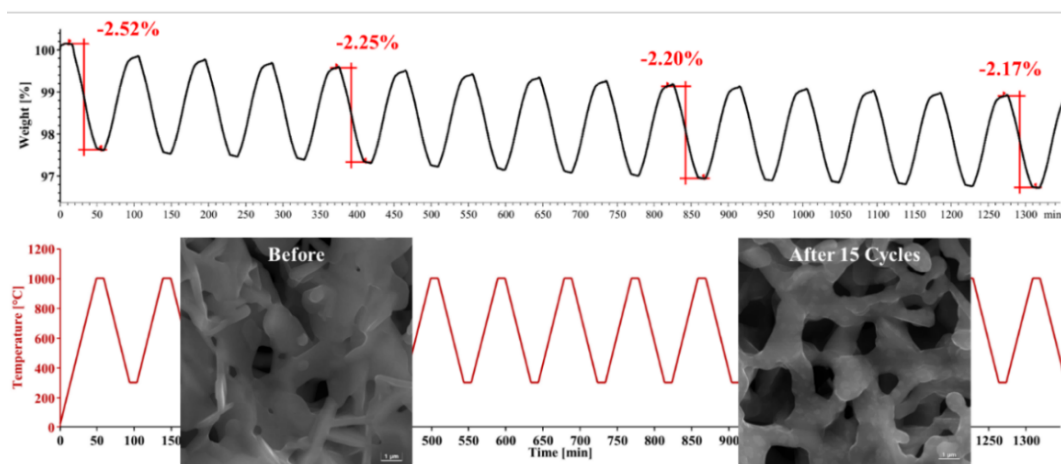


Figure 1. Stability test of SrFeO_3 (SFO_3) by Thermogravimetric Analysis (TGA): 15 cycles of reduction (300–1000°C) and oxidation (1000–300°C) under Air (30NmL/min). SEM particular characterization (50KX) pre and post test are shown.

Acknowledgments: the activities were carried out in the PTR 2025-27—Objective: Technologies—Project 1.2/WP4 National program LA 4.21.

PVD carbon and nitride coatings for application in metallic bipolar plates

M. Gulino^{1,2*}, C. Larosa², D. Zola², M. Feroci¹, M.L. Grilli²

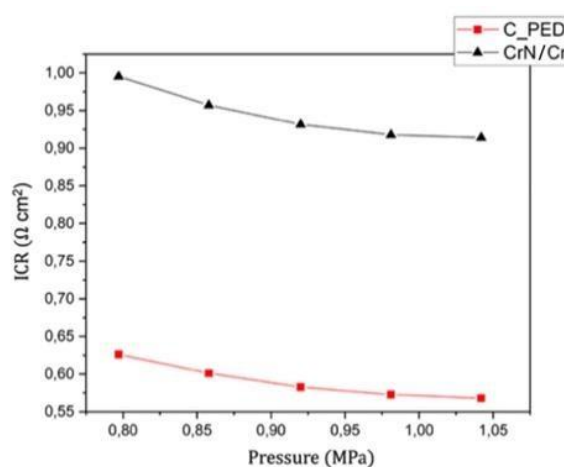
¹ Department of Basic and Applied Sciences for Engineering (SBAI), University of Rome La Sapienza, Rome, Italy; ² ENEA, Italian Agency for New Technologies, Energy and the Environment Department of Renewable Energies, Via Anguillarese, 301-00123 Rome, Italy

*miryam.gulino@uniroma1.it

Bipolar plates are critical components in proton exchange membrane fuel cell (PEMFC) systems. In these systems, replacing graphite bipolar plates (BPPs) with metallic alternatives such as stainless steel (SS) offers advantages in terms of lower density, higher mechanical strength, and improved cost-effectiveness. However, ensuring adequate protection of these metals against corrosion and passivation in the acidic and humid PEMFC environment is essential.

This study aims to compare the characteristics of protective coatings deposited by different physical vapor deposition (PVD) techniques onto stainless steel substrates.

Carbon coatings were deposited on AISI 304 and AISI 316L substrates using radiofrequency (RF) sputtering, ion beam sputtering (IBS), and pulsed electron deposition (PED), while nitride coatings were produced by RF sputtering. To enhance coating adhesion, various interlayers - including Cr, Si, Ti, Al, and W - were investigated. The coatings were characterized in terms of surface morphology using scanning electron microscopy (SEM) and stylus profilometer. Interfacial contact resistance (ICR) was measured using a dedicated setup under pressures of up to 104.20 N·cm⁻² (measurement configuration shown in Figure 1). Comparative results (Figure 2) indicated that C_PED samples (carbon coatings deposited by PED) exhibited lower ICR values than CrN/Cr samples (chromium nitride coatings deposited by RF sputtering), suggesting superior electrical performance for the PED-derived carbon coatings under the tested conditions.



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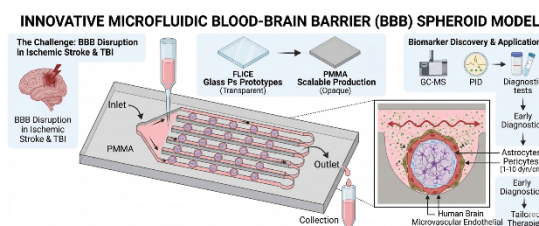
Microfluidic BBB Spheroids: Metabolomic Biomarkers for Brain Injury Detection

C. Boncristiani,^{1,2*} A. Di Gilio,³ A. Nardini,^{1,4} F. De Castro,⁵ J. Palmisani,³ R. Martínez Vázquez,⁴ F. Baldassarre,⁶ F.P. Fanizzi,⁵ G. Ciccarella^{2,5}, V. Vergaro¹

¹Department of Experimental Medicine, University of Salento, Centro Ecotecnico, Via Monteroni 73100, Lecce, Italy; ²CNR Nanotec Institute of Nanotechnology, Via Monteroni, 73100 Lecce, Italy; ³Department of Bioscience, Biotechnology and Environment, University of Bari, Via E. Orabona, 70125 Bari, Italy; ⁴Istituto di Fotonica e Nanotecnologie - CNR - Department of Physics - Politecnico di Milano, Piazza Leonardo da Vinci, 32, Milano, Italy; ⁵Department of Biological and Environmental Sciences and Technologies, University of Salento, Via Monteroni, 73100 Lecce, Italy; ⁶National Interuniversity Consortium of Materials Science and Technology (INSTM), UdR Salento, Via Monteroni, 165 – 73100 Lecce (LE)

* chiara.boncristiani@unisalento.it

Acute ischemic stroke and traumatic brain injury (TBI) rank among the top causes of morbidity and mortality, primarily due to blood-brain barrier (BBB) disruption that amplifies neuronal damage and undermines therapeutic effectiveness. To tackle this, we've engineered an innovative microfluidic platform leveraging high-throughput 3D multicellular spheroids (MCS) to replicate BBB behaviour in both physiological and ischemic scenarios, seamlessly paired with targeted metabolomics for pinpointing biomarkers¹. The platform features multiple independent incubation chambers equipped with growth wells, enabling standardized BBB MCS formation from human brain microvascular endothelial cells, pericytes, and astrocytes. We began with glass prototypes crafted via femtosecond laser micromachining (FLICE) for superior optical clarity and validation, then scaled to PMMA through micromilling and thermal bonding. This ensures reproducible, plug-and-play functionality with precise fluid shear stress (FSS) control at 1-10 dyn/cm², faithfully mimicking hemodynamic effects on BBB integrity. Guided by 3D computational fluid dynamics simulations in COMSOL Multiphysics, we optimized flow patterns, pressure gradients, and cell-like particle distribution for uniform well filling. An iterative cycle—design, simulation, prototyping with fluorescent microbeads, and refinement—guaranteed consistent spheroid size and shape for parallel production. High-field NMR and GC-MS, employing headspace/direct immersion SPME, profile intracellular and secreted metabolites plus VOCs from MCS under normoxia and hypoxia². Multivariate analyses like PCA via SIMCA uncover ischemia-specific signatures, including glycolysis shifts and oxidative stress markers, while integrated photoionization detectors (PID) provide real-time headspace VOC monitoring linked to BBB dysfunction. Our work propels chemical engineering toward precision neurology, delivering early TBI biomarkers to enable swift diagnostics and personalized therapies via organ-on-chip innovation.



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Enhanced metal ion recognition with bispidine-based fluorinated chemosensors

G. Marcolli,^{1,2*} P. Scampini,¹ S. Camorali¹, A. Rossetti^{1,2}, M. Cametti¹, A. Sacchetti^{1,2}

¹ Politecnico di Milano, Italy; ² National Interuniversity Consortium of Materials Science and Technology (INSTM), Italy

*giulia.marcolli@polimi.it

One of the major challenges for medical, environmental and pharmaceutical applications is the reliable and specific detection of analytes in complex mixtures. Proton Nuclear Magnetic Resonance (¹H-NMR) is often employed for this, because it is a powerful analytical technique to study molecular and atomic-level organization. However, its interpretation can be challenging due to signal overlap and low selectivity¹. To address this issue, chemosensing systems use specific molecular interactions to generate distinguishable signals and simultaneously detect multiple species². In this context, using ¹⁹F-labeled molecular probes for the coordination of analytes can be a powerful tool, as it generates unique ¹⁹F-NMR signals with minimal background interference¹. Additionally, metal-chelating fluorinated probes represent advanced materials designed for dual-mode imaging or stimuli-responsive theranostics³. In this work, bispidines were selected as a scaffold for metal chelation thanks to their rigid framework, conformational adaptability and multiple nitrogen donor atoms. Mannich reaction was employed to introduce both ¹⁹F-labelled probes (such as F, CF₃ and OCF₃) and additional nitrogen atoms to enhance coordination. Two types of scaffolds were then prepared: bidentate bispidines via a one-pot reaction, and tetradentate bispidines via a multi-step one. These compounds were tested to evaluate their ability to form coordination complexes with different metal salts, and the best-suited ones were tested for three possible applications: recognition of organic molecules in solution, studies of coordination competition between different metal salts and evaluation of ligand extraction capacity with two-phase mixtures.

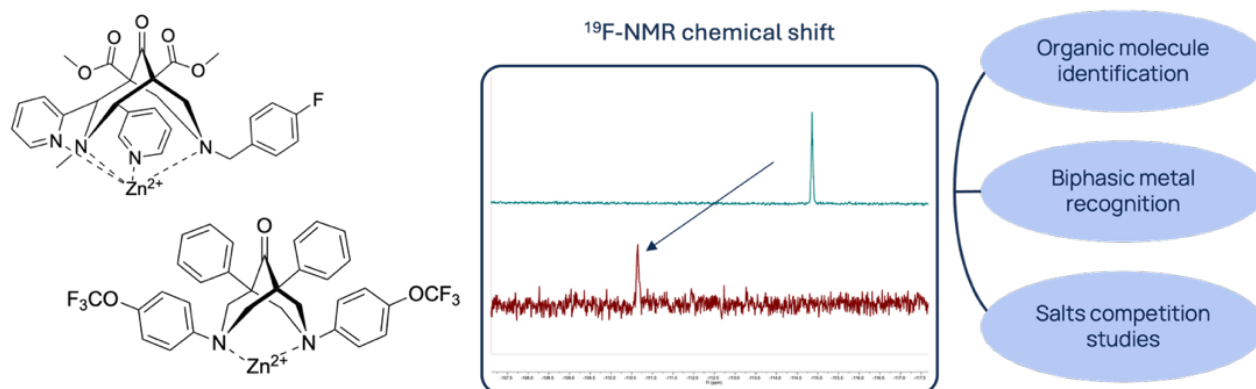


Figure 1: Graphical abstract

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Sustainable Synthesis of Boron Carbide via Polyol-Based Precursors and Rapid Carbothermal Reduction

Beatrice Bonaldo¹, Emanuela Callone¹, Riccardo Rovai³, Vincenzo M. Sglavo^{1,2},
Sandra Dirè¹

¹ Department of Industrial Engineering, University of Trento, Via Sommarive 9, 38123 Trento, Italy; ² INSTM Research Unit, Via G. Giusti 9, 50123 Firenze, Italy; ³ Industrie Bitossi SpA, Via Pietramarina 53, 50053 Firenze, Italy

*beatrice.bonaldo@unitn.it

Boron carbide (B_4C) is a ceramic material widely employed in structural, energy and armor components due to its hardness, low density and high chemical stability. The industrial production of B_4C is mainly based on carbothermal reduction of boric acid or B_2O_3 in an electric arc furnace with either coke or coal as carbon source at temperatures above 2000 °C^{1,2}. This process results in high energy consumption, poor stoichiometric control caused by boron volatilization, and significant residual free carbon in the final product, which negatively impact the mechanical and ballistic performance of the material.

To address these limitations, alternative low-temperature synthesis strategies based on sustainable carbon precursors have been recently explored. In particular, through condensation reactions of H_3BO_3 with polyols, preceramic polymers containing B–O–C bonds are obtained, which can be converted into the final ceramic at low processing temperatures (1000–1500 °C)³. However, the formation of residual free carbon that negatively affects densification behavior and the mechanical performance of the final product⁴ remains an unsolved issue.

This work presents a scalable synthesis strategy for B_4C that combines polyol-based precursor chemistry with rapid carbothermal reduction (RCR), promoting the formation of fine, highly uniform B_4C powders with low free carbon content.

The thermal decomposition behavior of the polyol-based precursors and the evolution of intermediate chemical species were investigated by coupled thermoanalytical techniques and FTIR spectroscopy. Structural and morphological characterization of the synthesized powders was carried out using XRD, SEM, FTIR and solid-state NMR spectroscopy. The results suggest that combining polyol-derived precursor with RCR offer a promising route for the efficient, chemically controlled and scalable route for the sustainable production of high-purity boron carbide powders⁵.

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Sustainable scale-up of fatty acids and polyphenols extraction from Spent Coffee Grounds

C. Corea^{1,*}, R. Hartmann², L. Riva¹, L. Gallo³, C. Punta¹

¹ Politecnico di Milano; ² Fraunhofer-Zentrum für CBP, ³ Coffeefrom Srl

*carmen.corea@polimi.it

Approximately 20 million tons of Spent Coffee Grounds (SCG) are generated each year as a by-product of the brewing process, therefore the identification of potential applications for SCG is of great importance to reduce the environmental impact of the entire supply chain. Despite source-dependent variations, generally dry SCG contains a non-negligible amount of bioactive compounds, including polyphenols and diterpenes ($\approx 3\text{--}5\%$), within a consistent share of lipids ($\approx 20\%$). It also contains cellulose and hemicellulose, lignin and proteins¹. This study focuses on the sustainable extraction and utilization of fatty acids and bioactive compounds.

The EthaNa process² represents an alternative approach to traditional extraction with organic solvents, since it is performed at ambient pressure and temperatures lower than 70°C , with the possibility to recycle the solvent. The application of this process to SCG has been investigated and optimized in terms of extraction yields to recover the fatty acid fraction in the pilot-scale plant of Fraunhofer CBP in Leuna.

Additionally, the potentiality of the process has been investigated at laboratory-scale by testing different solvents in sequence, including other organic solvents and NADES (natural deep eutectic solvents), aiming at a more selective extraction of polyphenols.

Fatty acid and oils find application in a variety of different fields³, and the solid residue can be further processed to obtain high-added value products⁴ or be used as it is in polymer compounding with better performances than SCG⁵.

Promising results have been observed, especially considering that the scale of the process allows an effective integration of this valorization step in the supply chain.

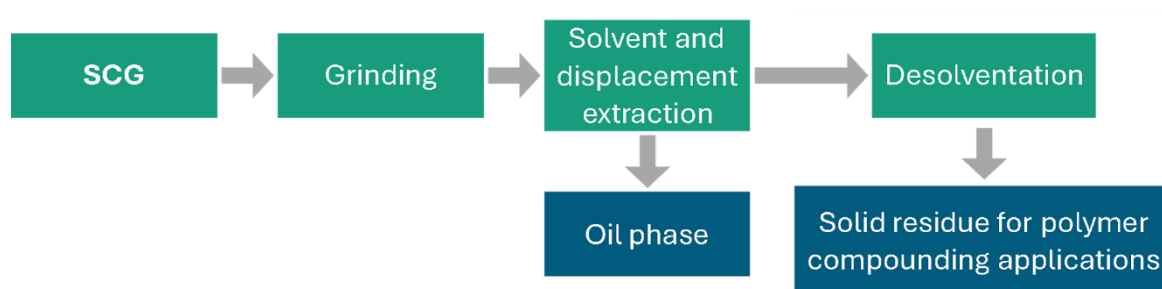


Figure 1. EthaNa Process Scheme

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ZrO₂/Orange Peel Extract Hybrids as Active Glass-Based Packaging Materials

M. Fiorentino,^{1,*} A. D'Angelo,² M.V. Mollo¹, L. Vertuccio,¹ I. Blanco,³ M. Catauro¹

¹ Department of Engineering, University of Campania "Luigi Vanvitelli", Via Roma 29, 81031 Aversa, Italy; ² Department of Industrial Engineering, University of Salerno, Via Giovanni Paolo II 132, 84084 Fisciano, Italy; ³ Department of Civil Engineering and Architecture DICAR, University of Catania, Via Santa Sofia 64, 95125 Catania, Italy

*marika.fiorentino@unicampania.it

The increasing demand for sustainable food packaging has driven the development of active materials capable of improving food preservation while reducing environmental impact¹. Zirconia-based hybrid glasses incorporating bioactive orange peel extracts represent a promising solution. The aim of this work is the synthesis Zirconia/orange peel extract (ZrO₂/OP8, 25, 33 and 50%) as suitable bioactive food and beverage packaging enable to release bioactive compounds. The bio-glasses were analyzed by Fourier transform infrared (FTIR) spectroscopy, differential scanning calorimetry (DSC), thermogravimetric analysis (TG), antimicrobial analysis, and *in vitro* release study. FTIR confirms the establishing of hybrid materials whereas thermal analysis underlines the stability of materials up to 300 °C with a main mass loss related to dehydration water. Particularly, the presence of FTIR bands of organic residues on ZrO₂/OP25% hybrid after heat treatment up to 800 °C highlights the highest stability of ZrO₂/OP25%. Moreover, this hybrid system exhibits the highest release efficiency. Antimicrobial tests further demonstrate that increasing the OP extract content enhanced the activity against Gram-positive bacteria. Based on these findings, further studies are required to assess the material performance under real application conditions and to optimize its functional properties.



Figure 1. Representative images of ZrO₂/OP systems from solutions to glass materials.

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Functionalized Graphene Oxide as a Neurogenic Trigger in Neural and Stem Cell Models

M. Catanesi,¹ M. G. Tupone,¹ F. D'Egidio,¹ Y. S. Moré,² A. D'Addario,^{2,*} A. Cimini,^{1,3} M. d'Angelo,^{1,3} G. Fioravanti²

¹ University of L'Aquila, Department of Life, Health and Environmental Sciences, Via Vetoio, L'Aquila, AQ 67100, Italy; ² University of L'Aquila, Department of Physical and Chemical Sciences, Via Vetoio, L'Aquila, AQ 67100, Italy; ³ Sbarro Institute for Cancer Research and Molecular Medicine, Department of Biology, Temple University, Philadelphia, PA 19122, USA.
* anna.daddario@graduate.univaq.it

Graphene-based nanomaterials are increasingly recognized as bioactive platforms capable of modulating cellular behavior, opening new avenues for regenerative medicine¹. This study investigates the neurogenic potential of functionalized graphene oxide (GO) and reduced graphene oxide (rGO) incorporated into polymeric hydrogel scaffolds, using a human neuroblastoma cell line (SH-SY5Y) and human amniotic fluid stem cells (hAFSCs) as in vitro models².

GO- and rGO-based composites were embedded within polyethylene glycol (PEG) and gelatin methacrylate (GelMA) matrices and characterized by spectroscopic and thermal analyses, confirming effective functionalization and homogeneous integration.

Biological assays demonstrated that graphene-based substrates support cell viability while promoting morphological changes associated with neuronal differentiation. SH-SY5Y cells cultured on rGO exhibited enhanced neurite outgrowth and synaptic-like structure formation. In hAFSCs, graphene-based scaffolds induced neuronal marker expression (MAP-2, PSD-95, Synapsin) accompanied by reduced SOX-2 levels, indicating loss of stemness. Notably, rGO elicited a stronger neurogenic response than GO, emphasizing the role of material physicochemical properties in directing cell fate².

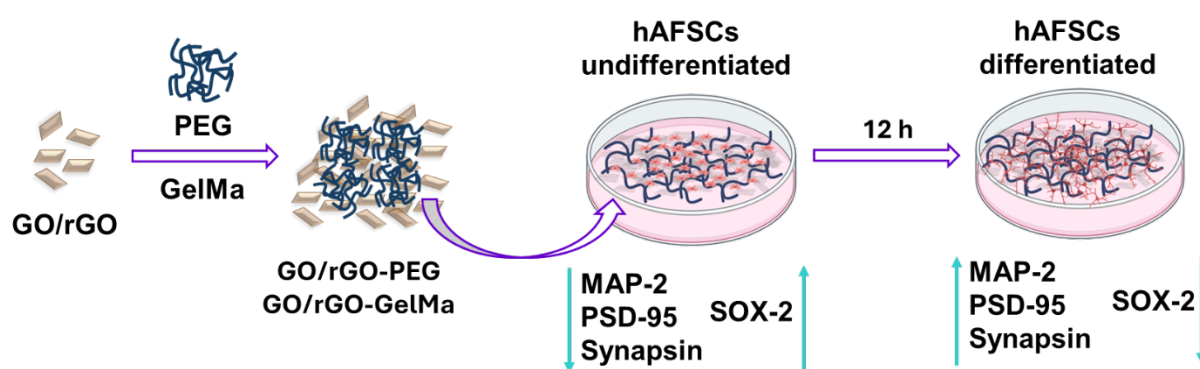


Figure 1. Schematic representation of GO/rGO-incorporated PEG/GelMA hybrid hydrogels engineered as scaffolds for neural differentiation of hAFSCs.

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Hydrophobic Eutectic Solvent-Loaded Cellulose Hydrogel for Microextraction of Emerging Pollutants from Water

R. Shrestha,^{1*} M. E. Di Pietro,² I. Anugwom¹

¹Separation Science, LUT School of Engineering Sciences, Lappeenranta-Lahti University of Technology, Finland; ²Department of Chemistry, Material and Chemical Engineering, "G. Natta" Politecnico di Milano, Milan, Italy

*rekha.shrestha@lut.fi

Hydrophobic eutectic solvents (HES), prepared from natural components are attracting interest as an eco-sustainable alternative to organic solvents in liquid-liquid extraction of emerging water pollutants¹. However, the challenging phase separation and partial cross-contamination limit their applicability. The post modification of polymeric adsorbents loaded with HES has undergone intense investigation in recent times addressing these challenges². Nevertheless, the use of fossil-based polymeric materials raises concerns regarding environmental sustainability and economic feasibility. Thus, the purpose of this research study was to explore HES-loaded cellulose hydrogels for the extraction of dyes and pesticides from water samples.

In this study, malachite green chloride was used as a model dye, and imidacloprid was used as a model pesticide. Cellulose hydrogels were prepared via phase inversion technique by co-dissolving microcrystalline cellulose (MCC) into a mixture of the ionic liquid 1-ethyl-3-methylimidazolium acetate ([EMIm][OAc]) and cosolvent DMSO. HES preliminarily screened in liquid-liquid extraction, and the most promising HES were loaded into cellulose hydrogels and further tested in solid-liquid extraction. The morphology of cellulose hydrogel was observed by using scanning electron microscopy and leaching of HES from hydrogel was determined by using ¹H NMR spectroscopy. The results showed that EE (extraction efficiency) of HES-loaded cellulose hydrogels increased compared to neat cellulose hydrogel. When HES based on (C8:C10) fatty acid was loaded into cellulose hydrogel, the extraction of malachite green chloride increased from 44.07% to 84.32%. Similarly, when cellulose hydrogel loaded with HES composed of thymol and octanoic acid, an increased extraction of imidacloprid from 8.16% to 74.28% was reported.

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Exploiting Metal Halide Perovskites for Photocatalytic Organic Transformations

D. Conelli,^{1*} G. P. Suranna,¹ R. Grisorio¹

¹ Dipartimento di Ingegneria Civile, Ambientale del Territorio Edile e di Chimica (DICATECh) Politecnico di Bari Via Orabona 4, 70125 Bari,

*Email address: daniele.conelli@poliba.it

Metal halide perovskites have emerged as promising tunable functional materials for visible-light-driven photocatalytic transformations, in which surface chemistry plays a crucial role in directing charge separation and radical generation.¹

Our research interest has recently focused on how surface-engineered metal halide perovskites enable different photocatalytic processes. Recent work demonstrated their activity in photoreduction and aerobic oxidation reactions, providing insight into surface-mediated radical pathways.²

Within this research line, this communication mainly deals with the photocatalytic arene bromination enabled by the Ag–Bi double perovskite $\text{Cs}_2\text{AgBiBr}_6$ under blue LED irradiation in air (Figure 1). Using HBr as an unconventional bromine source, the catalyst promotes the bromination of electron-rich arenes through surface-generated bromine radicals ($\text{Br}^\bullet$), which are regenerated at the catalyst surface during the photocatalytic cycle.

The system exhibits high photocatalytic efficiency, reaching product evolution rates up to $1060 \mu\text{mol g}^{-1} \text{h}^{-1}$ and affording mono-brominated arenes in yields up to 95%. The method is applicable to different substrates, and the catalyst maintains its activity over multiple cycles.³

These results confirm the potential of metal halide perovskites as platforms for surface-driven radical photocatalysis.

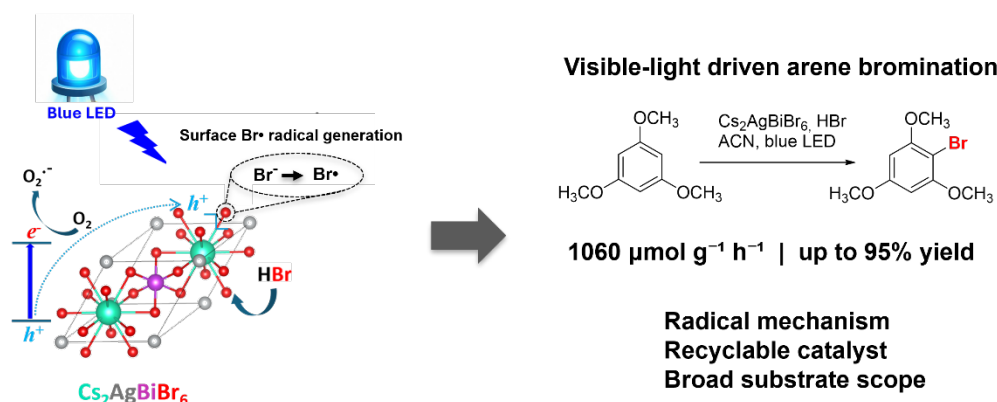


Figure 1. Visible-light-driven arene bromination over $\text{Cs}_2\text{AgBiBr}_6$ via surface $\text{Br}^\bullet$ generation.

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Biobased jet fuel from orange peel waste: limonene hydrogenation using Raney-nickel catalyst

F. Derobertis,^{*} P. Mastrorilli, M.M. Dell'Anna

DICATECh, Politecnico di Bari, Via Edoardo Orabona, 4, 70125 Bari

^{*}f.derobertis2@phd.poliba.it

The composition of conventional petroleum-based jet fuel consists of branched alkanes, cycloalkanes, and aromatic compounds. Due to the importance of the ecological transition, it is relevant to find bio-based alternatives to fossil source-based molecules. A representative example is p-menthane, a branched cycloalkane obtainable by hydrogenation of limonene.¹ The latter is a terpene and the main constituent of citrus essential oil which can be retrieved from orange peel waste. Considering a production of about 70 Mt of oranges annually worldwide for which the peel constitute up to 50% of the fruit weight, the valorization of these orange peels represents a great opportunity.²

Typically, limonene hydrogenation (Fig.1) has been carried out using molecular hydrogen and Pt, Pd or Rh as catalysts.^{1,3} In order to verify the feasibility of the reaction using another source of hydrogen and less noble metal as catalyst, in this study the reaction was performed using Raney-Nickel as catalyst, sodium borohydride as hydrogen source and methanol as solvent. The experimental tests were carried out in autoclave, using limonene purchased from commercial sources. A Design of Experiment was set to statistically assess the impact of: temperature (30 – 60 °C), catalyst amount (0.3 – 0.6 g), sodium borohydride amount (0.2 – 0.6 g), time (6 – 24 h) and solvent amount (10 – 20 mL). After, limonene was extracted from orange peel waste using green solvents and tested as substrate for the synthesis of p-menthane at the optimized reaction conditions.

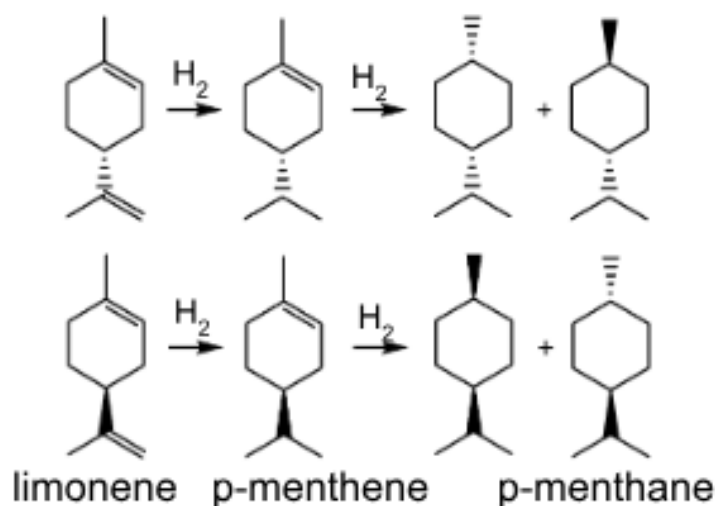


Figure 1. Hydrogenation of D,L-limonene

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Biomass-Derived Carbon Dots as Sensitive Fluorescent Probes for Mercury Detection.

R. Zribi,^{1,*} H. Zemzemi,^{1,2} R. Khiari^{3,4}, G. Neri¹, C. Espro¹.

¹ Dipartimento di Ingegneria, Università di Messina, Contrada di Dio Vill. S. Agata, I-98166 Messina, Italy;

² Laboratoire d'Application des Matériaux à l'Environnement, l'Eau & l'Energie LAM3E, Facultés des Sciences de Gafsa, Gafsa; Tunisia;

³ Department of Textile, Higher Institute of Technological Studies of Ksar Hellal, Ksar Hellal 5070, (TUNISIA)

⁴ Univ. Grenoble Alpes, CNRS, Grenoble INP, LGP2, Grenoble, F-38000 (FRANCE)

*razribi@unime.it

This study reports the synthesis of carbon dots (CDs) derived from date palm biomass via hydrothermal carbonization and their application as a fluorescent sensor for mercury (Hg^{2+}) detection. Date palm residues, an abundant agricultural by-product, were utilized as a renewable carbon precursor. The hydrothermal process was conducted under controlled temperature and pressure conditions to promote carbonization and surface passivation, leading to the formation of highly fluorescent carbon dots. The synthesized CDs were first doped with nitrogen and then characterized using spectroscopic and microscopic techniques to evaluate their structural, morphological, and optical properties occurred before and after the doping. The sensing performance of the N-CDs toward Hg^{2+} ions was investigated as presented in Fig.1. A fluorescence quenching effect was observed upon the addition of mercury ions, attributed to the interactions between Hg^{2+} and surface functional groups of the CDs, leading to non-radiative electron or energy transfer processes.

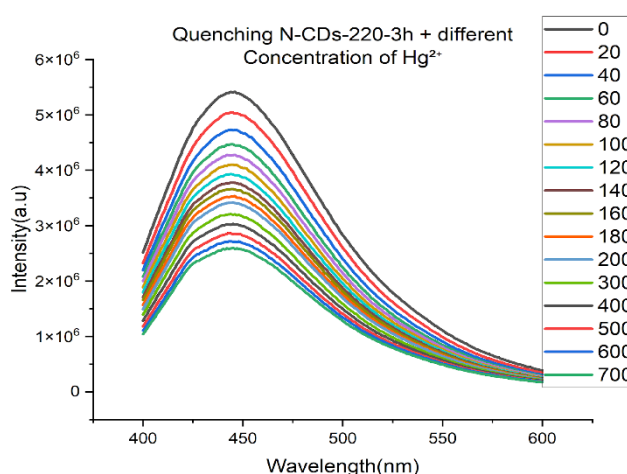


Figure 1. Response of N-CD to different concentrations of mercury ions.

The developed sensor demonstrated good sensitivity toward Hg^{2+} in aqueous media. These findings highlight the potential of biomass-derived carbon dots as low-cost, environmentally friendly fluorescent probes for heavy metal ion detection in environmental monitoring applications.

Homochiral-based Diastereomeric (Deep) Eutectic Systems (DIADES)

M. T. Barbero,^{1,*} M. E. Di Pietro,¹ M. N. Franchini,¹ G. I. C. Righetti,¹ A. Mariani,¹ S. R. Azcona,² S. Aparicio,² S. Nasrallah,³ M. Minceva,³ A. Mele¹

¹Department of Chemistry, Materials and Chemical Engineering "G. Natta" – Politecnico di Milano, Milano, Italy; ²Department of Chemistry – University of Burgos, Burgos, Spain; ³Department of Biothermodynamics – Technical University of Munich, Munich, Germany
*margheritateresa.barbero@polimi.it

Chirality is a fundamental property in biological systems, pharmaceuticals and materials science. Deep Eutectic Solvents (DES) are increasingly prepared combining natural homochiral compounds.^{1,2} Using only enantiopure substances as DES components leads to the formation of diastereomeric deep eutectic solvents (DIADES). Despite the potential significance of such systems, the chemical space arising from the combination of chiral components remains largely unexplored.

This work presents four DIADES formed by combining (+)-menthol, (–)-menthol, (+)-camphor, and (–)-camphor (Figure 1). A preliminary mapping of the chiral environment is carried out through NMR spectroscopy, DFT and MD simulations, whilst the mesoscopic structural heterogeneity is investigated by SAXS. Further information will be obtained by dissolving chiral solutes in these new media and investigating the molecular interactions and transport properties as a function of the absolute configuration of the components. Our findings provide a rational framework for understanding the solvation behaviour in these systems, directly connected to the individual stereochemical configurations, and establish a foundation for the strategic design of enantioselective media in advanced chemical applications.

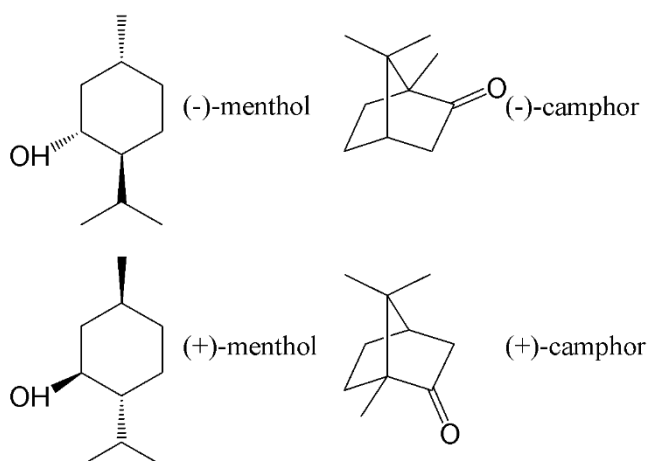


Figure 1. Chemical structures of the four chiral DES components.

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Phosphoric Acid Doping in Electrospun PBI Membranes: Kinetic and Electrochemical Evaluation

E. De Gregorio^{1,*}, C. Ferone¹, V. Naticchioni², O. Tarallo³, G. Roviello¹

¹ Department of Engineering, University of Naples 'Parthenope', Centro Direzionale, Isola C4, 80143 Napoli, Italy; ² Department of Energy Technologies and Renewable Sources, ENEA, Via Anguillarese 301, 00123, Roma, Italy; ³ Department of Chemical Sciences, Università degli Studi di Napoli Federico II, Complesso Universitario di Monte Sant'Angelo, via Cintia, 80126, Napoli, Italy

*emmanuel.degregorio001@studenti.uniparthenope.it

High-temperature proton exchange membrane fuel cells (HT-PEMFCs) operating between 120 °C and 200 °C offer significant advantages in terms of simplified water management, high CO tolerance, and enhanced system efficiency [1]. Among the available membrane materials, polybenzimidazole (PBI) represents one of the most robust non-fluorinated polymers due to its high thermal and chemical stability, as well as its capability to sustain proton conductivity in anhydrous conditions when doped with phosphoric acid (PA). In this study, electrospinning was employed to fabricate fibrous PBI membranes [2] characterized by a three-dimensional interconnected porosity and high specific surface area, both of which promote the interaction with PA and improve the overall doping kinetics. The acid uptake followed a pseudo-second-order kinetic model indicating that the mechanism is dominated by chemisorption [3] involving acid–base interactions between the PA molecules and the imidazole groups of the PBI backbone. Thermodynamic analysis revealed an endothermic process, with acid adsorption favored at higher temperatures, while equilibrium data fitted the Liu adsorption isotherm, confirming a heterogeneous distribution of active sites within the fibrous structure. Electrochemical tests were evaluated through impedance spectroscopy and polarization experiments under fuel cell-relevant conditions, revealing lower high-frequency resistance and improved proton conduction compared to dense cast PBI films.

Acknowledgements

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An NMR-Based Approach for Monitoring the slow-growing bacterium *Xylella fastidiosa*

M. Trisolini,^{1,*} S.S. Amoia², R. Ragone,¹ B. Musio,¹ A. Rizzuti,¹ A. Greco,¹ S. Todisco,¹ P. Mastrorilli,¹ M. Saponari,² V. Gallo¹

¹ Department of Civil, Environmental, Land, Building Engineering and Chemistry (DICATECh), Polytechnic University of Bari, Via Orabona, 4, Bari, I-70125, Italy; ² Institute for Sustainable Plant Protection, National Research Council, Via Amendola, 165/A Bari, I-70126, Italy

*m.trisolini1@phd.poliba.it

Xylella fastidiosa is a xylem-limited phytopathogen with a very slow growth in axenic conditions compared to other common plant pathogenic bacteria. As such, the optimization of culture media remains a major challenge for improving bacterial *in vitro* growth to enhance biological and molecular investigations. The development of robust analytical methods is essential for investigating its extracellular metabolism and supporting future studies on microbial interactions. In this work, ¹H NMR spectroscopy was used to characterize the metabolic profiles of the supernatant fractions recovered from bacterial liquid cultures of *X. fastidiosa* subsp. *pauca* ST53. Two media with marked differences in composition and growth-supporting properties, were used: (i) XFM, a minimal medium and (ii) PD3 a richer substrate commonly used to successfully grow a broad range of *Xylella* strains.¹

Culture supernatants were collected at five time points (0, 3, 5, 7, and 10 days), immediately centrifuged to remove bacterial cells, aliquoted, and stored at –80 °C until analysis. An operative protocol for NMR sample preparation was optimized in order to obtain reproducible and robust 1D ¹H NMR spectra. Different preparation conditions and pulse sequences were evaluated. CPMG provided better baseline quality and signal resolution than NOESY, especially for XFM samples, likely due to the presence of proteinaceous components such as bovine serum albumin.²

Preliminary qualitative analysis highlighted time-dependent metabolic changes in both media, with more pronounced spectral variations in PD3, consistent with its richer composition and faster expected growth rates. Overall, this study defines a robust NMR-based workflow for monitoring *X. fastidiosa* culture media and provides a first metabolomic comparison of XFM and PD3, laying the groundwork for future exometabolomic and footprinting analyses aimed at identifying metabolites involved in bacterial adaptation and microbial interactions³.

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Morphological and Structural Engineering of CeO₂ Nanoparticles

E. Alberti^{*,1}, S. Boveri¹, C. Canevali¹, M. D'Arienzo¹, S. Mostoni¹, R. Scotti¹, B. Di Credico¹

¹ Università Milano-Bicocca, Piazza dell'Ateneo Nuovo 1, Milano, Italy

*e.alberti9@campus.unimib.it

Nanostructured cerium dioxide (CeO₂) has gained interest due to its peculiar properties, such as its oxygen storage capacity driven by the reversible Ce³⁺/Ce⁴⁺ redox pair and the formation of oxygen vacancies¹. Understanding and controlling the physicochemical properties of this material are crucial for optimizing its reactivity.

The present study focuses on the synthesis and structural characterization of CeO₂ nanoparticles, exploring various synthetic strategies (Figure 1); at the beginning, microemulsion technique was investigated, followed by the development of precipitation synthesis as an eco-friendly alternative approach. Comprehensive material characterization enabled the determination of structural and optical properties like the crystalline phase and crystallite size, the estimation of the optical band gap, and the quantification of surface hydroxyl groups. To gain a deeper understanding of the material's behavior, the formation of paramagnetic species in selected synthesized samples, following targeted thermal treatments under various atmospheres (air, vacuum, and hydrogen), was investigated using Electron Paramagnetic Resonance (EPR) spectroscopy.

Based on these findings, hydrothermal treatments were then performed to evaluate the influence of parameters such as pH and reaction time on modulating the morphology and surface chemistry of nanoparticles. This precise engineering of the material's morphology and structural defects was aimed at tailoring the nanoparticles for evaluating their potential as highly efficient heterogeneous photocatalysts² for the complete degradation of recalcitrant organic pollutants in wastewater.

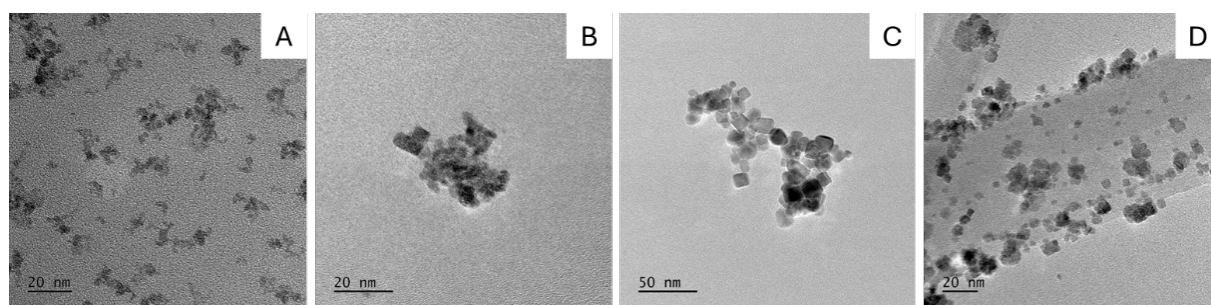


Figure 1. TEM Images of Ceria nanoparticles synthesized via microemulsion(A), precipitation(B), hydrothermal(C), nucleation on sepiolite(D)

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Temperature sensor based on expanded graphite/nylon composites

L. Vertuccio,^{1,*} M. Catauro,¹ R. Longo,² F. Aliberti,² L. Guadagno,² L. Schiavo,³ M. Oliviero,³ A. Sorrentino,⁴

¹ Department of Engineering, University of Campania "Luigi Vanvitelli", Via Roma 29, 81031 Aversa, Italy;

² Department of Industrial Engineering, University of Salerno, Via Giovanni Paolo II, 84084 Fisciano, Italy;

³ Institute of Polymers, Composites and Biomaterials, National Research Council, P.le E. Fermi, 1, 80055 Portici, Italy; ⁴ Institute of Polymers, Composites and Biomaterials, National Research Council, via

Previati n.1/E, 23900 Lecco, Italy.

* luigi.vertuccio@unicampania.it

Temperature sensing over wide operating ranges has gained significant interest across multiple disciplines within the sensing field. Various flexible temperature sensors based on polymer matrices combined with carbon nanomaterials have been developed and are widely employed to monitor physicochemical changes in industrial environments¹. Due to their excellent electrical, mechanical, and thermal properties, graphite nanoparticles are among the most investigated fillers for temperature-sensing applications^{2,3}. In this work, the temperature-dependent resistive behavior of expanded graphite (EG)/nylon 6 composites is investigated in the range from 20 °C to 120 °C. The electrical conductivity as a function of filler loading follows the classical percolation model, reaching a maximum value of 42 S/m at 40 wt% graphite amount, while the electrical percolation threshold is observed at concentrations below 10 wt%. A filler content of 20 wt%, well above the percolation threshold, was selected for temperature-response evaluation. Thermal characterization reveals a dominant positive temperature coefficient (PTC) behavior below 80 °C, attributed to matrix thermal expansion and the consequent increase in interparticle distances. Near the glass transition temperature, an opposite trend is observed. The temperature sensitivity is estimated at 0.175%/°C in the 20–80 °C range. The high reproducibility of the electrical response during thermal cycling confirms the suitability of the composite as a stable resistive sensor. The tunneling effect is mainly responsible for the electrical response of the graphite–nylon-6 nanocomposite to temperature stimulus.

Acknowledgements

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A new water-soluble Zn(salmal) complex as chemosensor for the enzymatic recognition of Phenylalanine

G. Consiglio,^{1,*} I. P. Oliveri,¹ E. Butera,² L. Maugeri,² G. Fangano,² S. Petralia²

¹ Dep. of Chemical Sciences, University of Catania, via Santa Sofia, 64, 95123 Catania; ² Dep. of Drug and Health Sciences, University of Catania, via Santa Sofia, 64, 95123 Catania.

*giuseppe.consiglio@unict.it

Hyperphenylalaninemia is a genetic disorder of phenylalanine (Phe) metabolism that may potentially lead to severe neurological damages.¹ A specific diet and monitoring the Phe levels in the blood is the unique therapy existing. A lot of effort has been made for the development of new sensing strategies and their integration on PoC (Point-of-Care).^{2,3} In this contest, the sensing strategy based on enzymatic recognition of Phe by *Phenylalanine Ammonia Lyase* (PAL), which convert the Phe to *trans*-cinnamic acid and ammonia, could be involved for the monitoring the Phe levels in the blood (Figure 1 A). Zn(salmal) complexes represent a class of chromogenic and fluorogenic chemosensors useful for a simple, fast and highly sensitive detection of several neutral and anionic Lewis bases, both in solution and in the solid state.⁴ Herein, the synthesis and characterization of a new water-soluble Zn(salmal) complex, **1**, as chemosensor for the detection of ammonia, and then Phe, in aqueous solution is reported.

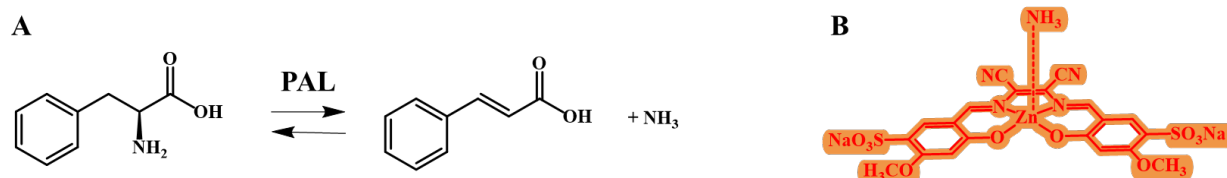


Figure 1. a) PAL enzymatic reaction with Phe; b) **1**·NH₃ molecular adduct

The ammonia amount is spectrophotometrically detected and quantified by **1** through the formation of **1**·NH₃ molecular adduct (Figure 1 B). **1** is conceived to perform sensing on phenylalanine levels for a rapid real-time therapy tuning. Excellent analytical performances in terms of sensitivity and specificity, robustness, and utility for phenylalanine sensing have been obtained.

This work has been funded by the project: Sens.AI: BioSENSori per la rilevazione di Aminoacidi su piattaforma IoT", Code: F/360079/003/X75, CUP progetto: B69J24000190005.

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Lanthanide-Driven Modulation and Glass-Induced Switching in Photoswitchable Macrocycles

G. Consiglio,^{1,*} S. Failla,¹ P. Dominika,² G. Forte,³ A. Gorczyński²

¹ Dipartimento di Scienze Chimiche – Università degli Studi di Catania, via Santa Sofia 64 – 95123 Catania - Italy; ² Faculty of Chemistry, Adam Mickiewicz University in Poznań, Uniwersytetu Poznańskiego 8, 61-614 Poznań, Poland; Dipartimento di Scienze del Farmaco e della Salute – Università degli Studi di Catania, via Santa Sofia 64 – 95123 Catania – Italy

*giuseppe.consiglio@unict.it

Integrating photoresponsive units into lanthanide complexes marks a leap in coordination chemistry, where lanthanide contraction acts as a precise lever for molecular engineering.¹ By synthesizing azobenzene-functionalized diazacorona ether macrocycles, this study demonstrates how the Ln³⁺ ionic radius reduction – from Lanthanum to Lutetium – dictates internal steric strain, tuning trans-to-cis isomerization via a "molecular dial" mechanism.² Beyond modulation, a glass-induced re-isomerization effect introduces a paradigm in surface-mediated catalysis; the cis isomer's reversion upon glass contact suggests that surface silanol groups (Si-OH) lower transition state energy through interfacial interactions.³ This spatial control, paired with robust visible and NIR emission, establishes a dual-functionality sought after in optoelectronic logic and ratiometric thermometry.⁴ Ultimately, harnessing the 4f subshell contraction allows for commanding complex photophysical behaviors, offering a blueprint for high-performance, surface-responsive smart materials.

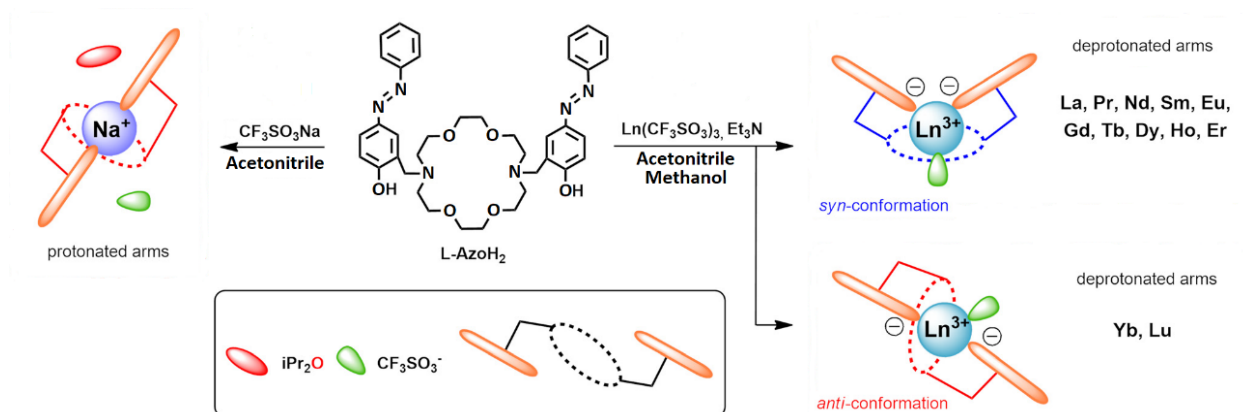


Figure 1. Scheme for the synthesis and conformations of the complexes.

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Sustainable Cellulose-Based Nanocomposite for Sensitive Electrochemical Detection of Environmental Pollutants

J. Belhaj, R. Zribi^{*}, G. Neri, C. Espro.

Dipartimento di Ingegneria, Università di Messina, Contrada di Dio Vill. S. Agata, I-98166 Messina, Italy;
^{*}razribi@unime.it

This study investigates the valorization of industrial waste, specifically almond shell residues, as a low-cost and sustainable raw material for the development of biodegradable, functional, and environmentally friendly nanocomposite materials. The biocomposite was fabricated through a multistep process. Initially, cellulose was extracted from almond shell residues via delignification and bleaching of the raw biomass. The recovered cellulose serves as a green material platform that meets both ecological and economic goals while offering strong potential for rapid industrial scalability. The research aims to promote the efficient utilization of abundant natural resources by developing a new generation of eco-friendly composite materials. The physicochemical properties of the extracted cellulose were enhanced through surface functionalization with zinc oxide (ZnO), followed by the incorporation of multiwalled carbon nanotubes (MWCNTs) to improve electrical conductivity and sensing capability toward tetracycline.

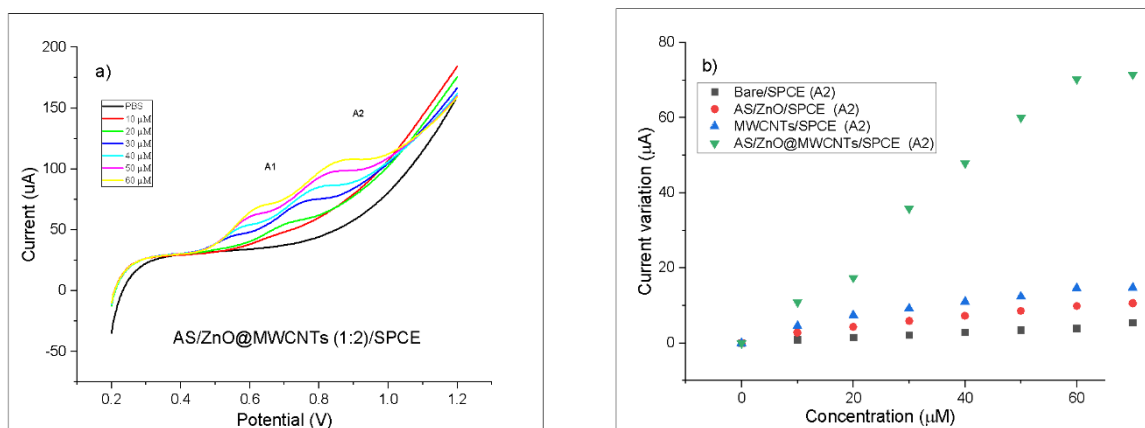


Figure 1. (a) LSV response of AS/ZnO@MWCNTs (1:2)/SPCE toward different tetracycline concentrations, (b) Calibration curve.

The resulting composite was then drop-cast onto the surface of commercial screen-printed carbon electrodes (SPCE), forming the basis of a highly sensitive electrochemical sensor as presented in Fig.1.

This sensor is designed for the detection and real-time monitoring of emerging environmental contaminants, including antibiotics which represent significant risks to public health in modern environments.

Nanotechnology meets circular bioeconomy: lignin nanostructured materials as active factory of metal nanoclusters for environmental sensing

A. Macagnano¹, V. Venezia², R. Grappa², S. Serrecchia^{1,2}, P. Papa¹, F. De Cesare^{1, 3}, G. Luciani^{2*}

¹ Institute of Atmospheric Pollution Research (IIA) of National Research Council (CNR), Montelibretti, 00010 Rome, Italy; ² Department of Chemical, Materials and Production Engineering (DICMaPI), University of Naples Federico II, Naples, Italy; ³ Department for Innovation in Biological, Agro-Food and Forest Systems (DIBAF), University of Tuscia, 01100 Viterbo, Italy

* luciani@unina.it

Lignin is gaining momentum as a renewable platform for the design of sustainable and high-performance materials due to the large abundance and unique properties related to its chemical richness. Indeed, its polyaromatic nature and the plethora of functional groups available in the backbone confer it the ability to interact with a great number of organic and inorganic moieties as well as an intrinsic red-ox behavior. In view of this peculiar chemistry, it can act as a reducing and stabilizing agent of precious metal clusters. At the same time, heterogeneity and poor reproducibility issues that may limit lignin technological valorization can be addressed by the design of lignin-based nanomaterials.¹

Herein, we introduce a novel, green and scalable approach for the design of multifunctional sensors for environmental and biomedical applications. Notably, lignin has been engineered as nanostructured material and exploited as active component of the sensor and as nanopatform for the in-situ production of precious metal nanoclusters able to enhance both activity and selectivity of the final material.² By integrating bio-waste valorization with urban mining practices for metal recovery and the development of advanced sensors, this study provide an holistic approach to sustainability.

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New Plastic Scintillators for Nuclear Medicine Applications

M. Lamacchia,^{1,*} M. Bonuso,² A. Burattini,³ M. Carruezzo,^{1,2,4} M.S. De Feo,⁵ G. De Vincentis,⁵ G. Franciosini,^{1,2} V. Frantellizzi,⁵ L. Frassi,⁶ M. Garbini,⁷ M. Magi,^{1,2} M. Marafini,^{1,7} V. Patera,^{1,2} F. Quattrini,^{1,6} A. Sarti,^{1,2} A. Schiavi,^{1,2} L. Testa,^{6,7} M. Toppi,^{1,2} G. Traini,¹ A. Vannucci,^{3,7} L. Mattiello²

¹ National Institute for Nuclear Physics (INFN), Rome I Section, Rome, Italy; ² Department of Basic and Applied Sciences for Engineering, Sapienza University of Rome, Rome, Italy; ³ Post-graduate School in Medical Physics, Sapienza University of Rome, Rome, Italy; ⁴ Italian National Institute of Health, Rome, Italy; ⁵ Department of Radiology, Oncology and Anatomic-Pathology, Sapienza University of Rome, Rome, Italy; ⁶ Department of Physics, Sapienza University of Rome, Rome, Italy; ⁷ "Enrico Fermi" Historical Museum of Physics and Research Centre (CREF), Rome, Italy

*martina.lamacchia@roma1.infn.it

Plastic scintillators are materials used for ionizing radiation detection and measurement. They stand out for their fast response, durability, and remarkable versatility in being shaped into different forms. Plastic scintillators essentially consist of two key components: 1) the bulk of the material, typically made from aromatic plastics like polyvinyltoluene (PVT) or polystyrene (PS); 2) fluorescent compounds (fluorophores) that efficiently convert the energy absorbed by the matrix into visible light, a process known as scintillation. Thanks to their unique properties, plastic scintillators are employed in a range of fields: High-Energy Physics; Fast Neutron Detection; Security & Monitoring; Medical Physics & Dosimetry. This project aims to develop high-performance plastic scintillators for total-body SPECT imaging and theranostic dosimetry. The main challenge addressed is the inherently lower performance of plastic scintillators compared to inorganic ones, due to the low atomic number of their components.¹ The approach involves the synthesis of new fluorophores and the integration of high-Z elements at higher concentration than the commercial limit (5%). New fluorophores were synthesized and patented,² with excellent yields and improved photophysical performance over commercial standards (light output, time resolution, and rise time). Besides thermal polymerization, photopolymerization and 3D printing³ were introduced to explore new manufacturing strategies. The results highlight the strong potential of these materials for advanced medical physics applications. Future work will focus on synthesizing new, more high-performing fluorophores and optimizing 3D printing to develop plastic scintillators on request for specific applications.

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Biomass engineering. Tuning the structure of BSF proteins for high performance bionanocomposites

M. Galimberti,¹ E. Testa,¹ E. Fasoli,¹ D. Gentile,¹ V. Barbera,¹

¹ Politecnico di Milano, Dipartimento di Chimica, Materiali e Ingegneria Chimica, Via Bassini 6, 20133 Milano

*maurizio.galimberti@polimi.it

The organic fraction of municipal solid waste (OFMSW) amounts to 1.3 billion tonnes each year. The black soldier fly (BSF) can effectively convert OFMSW.

In this work, the protein extracts of BSF larvae and pupae were transformed in bionanocomposites for packaging and for flexible electronics.

The proteome was characterized using SDS-PAGE and LC-MS/MS, revealing a prevalence of muscle proteins. Films were prepared by adding glycerol as a plasticiser, and their properties were characterised using calorimetric and infrared analysis. Polypeptide organisation was controlled by adjusting the pH of the protein solution and by annealing.¹

Flexible, electroconductive bionanocomposite materials were formulated by combining BSF proteins with conductive carbon black (CCB) pristine or functionalised with 2-(2,5-dimethyl-1H-pyrrol-1-yl)-1,3-propanediol (serinol pyrrole, SP), using water as a solvent and adding glycerol and carboxymethyl cellulose. High electrical conductivity (up to 0.9×10^{-2} S/cm at a filler content of 8% v/v (15% w/w)) was achieved as well as strain-sensing properties, biodegradability, and high surface hydrophobicity, upon performing a low-pressure cold plasma treatment.²

Amyloid-like aggregation of the BSF proteins was obtained, in alkaline environments, preparing amyloid fibrils. Bioplastic films were prepared by blending fibrillized BSF proteins with poly(vinyl alcohol) (PVOH) and glycerol. Thermal weldability and mechanical and gas barrier properties were in line with those of the traditional oil- and biobased plastics used for packaging applications.³

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Photoinduced Frontal Polymerisation for Wood Composites

H.M.Dizman¹, A.Vitale^{1,2}, R.Bongiovanni^{1,2*}

¹ Department of Applied Science and Technology Politecnico di Torino; ² INSTM – Politecnico di Torino Research Unit,

*roberta.bongiovanni@polito.it

Frontal polymerization (FP) is a self-propagating reaction in which a localized “polymerization front” is activated by an initial stimulus. The heat released by the exothermic reaction raises the temperature locally, enabling the polymerization to continue forward into the unreacted monomer, producing a steadily moving planar front. Photoinduced frontal polymerization (PIFP) is a hybrid approach that employs both a photo and thermal initiator, enabling light-triggered initiation followed by thermally sustained propagation, as sketched in Figure 1. PIFP is a bulk reaction (no solvent) and provides high reaction rate and high conversion, reducing processing time; energy consumption is low as there is no continuous heating or irradiation.¹ In this study biobased acrylic monomers were rapidly cured into bulk samples within seconds, the reaction was able to sustain itself after the light source was removed and to proceed in light hindered regions. Composites with up to 30%w/w of natural fillers such as wood powders and cellulose fibres were developed, showing promising performance as adhesives for wood bonding and repair applications.²

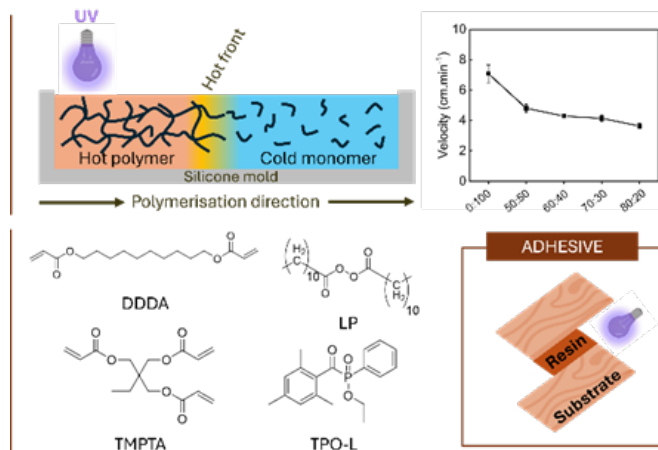


Figure 1. Photoinduced Frontal Polymerisation reaction

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Design, synthesis and characterization of bio-based ionic liquids as plasticizer for starch film

B. Malvagna¹, G. Sotgiu¹, M. Orsini¹, S. De Santis¹, D. Rocco¹, C. Frezza¹

¹ Department of Industrial, Electronic and Mechanical Engineering, Roma Tre University, Via Vito Volterra 62, 00146 Rome, Italy

*benedetta.malvagna@uniroma3.it

In recent years, increasing attention has been devoted to the development of biodegradable plastics derived from renewable and natural polymers in response to environmental concerns about conventional petroleum-based materials, which are often poorly recyclable. Among biopolymers, starch is particularly attractive due to its abundance, low cost, and complete biodegradability¹. However, its practical use is limited by high hydrophilicity and poor mechanical properties. To overcome these limitations, plasticizers are commonly employed to improve starch processability and performance. Ionic liquids have emerged as effective plasticizing agents, enabling the preparation of starch-based films with tunable physicochemical properties through the wide variety of possible cation–anion combinations². Such materials can find applications in sustainable packaging, biomedical fields, and solid-state electrolytes. In this work, bio-based ionic liquids are used as additives to enable the production of biodegradable plastic films that are biocompatible, non-toxic, and potentially bioactive³. Caffeine-based ionic liquids are prepared that stand out for their natural origin, structural versatility, and ability to improve both the mechanical and electrochemical performance of starch-based films (Figure 1).

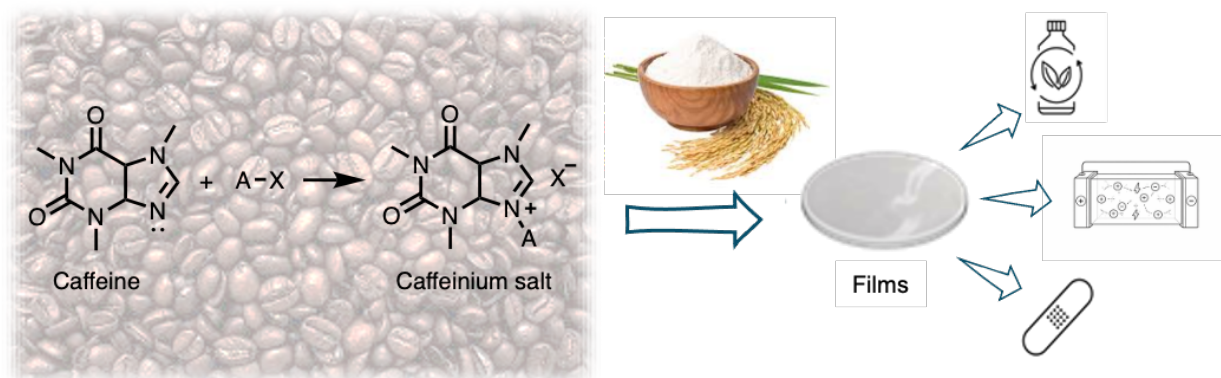


Figure 1. Synthesis of bio-based ionic liquids and starch film preparation

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Thermally weldable, degradable and high barrier sustainable flexible food packaging cast film from a novel furan based aromatic copolyester

N. Lotti,^{1,*} A. Coatti,¹ B. Semler², E. Bondi¹, M. Soccio¹, I. Solaberrieta³, A. Jiménez³, D. Puglia⁴, F. Dominici⁴, G. M. Guebitz²

¹Department of Civil, Chemical, Environmental and Materials Engineering, University of Bologna, Via Terracini 28, Bologna 40131, Italy; ²BOKU-University, Institute of Environmental Biotechnology, Department of Agricultural Sciences, Konrad-Lorenz-Strasse 20, Tulln an der Donau, 3430, Austria; ³Department of Analytical Chemistry, Nutrition & Food Sciences, University of Alicante, San Vicente del Raspeig, ES-03690, Spain; ⁴Department of Civil and Environmental Engineering, Università degli Studi di Perugia, Strada di Pentima 4, Terni 05100, Italy.
*nadia.lotti@unibo.it

In food packaging sector, plastics packages play a key role, protecting adequately food, extending its shelf life and thus reducing food waste, which is the main plagues of the modern era¹. Food waste indeed amounts to about one-third of all food produced worldwide², generating a food waste environmental impact higher than the one due to plastics waste². The innovation of food packaging materials has a substantial role in trying to solve this complex issue. In this scenario, 2,5-furandicarboxylic acid (FDCA) can be considered an interesting bio-based chemical building block to realize sustainable mono-material packaging, with excellent mechanical and gas barrier properties. Of particular interest, flexible films, which are more sustainable than rigid one, being very effective in protecting food with the minimum amount of material used and waste generated³. This contribution presents a new random aromatic furan-based copolyester properly eco-designed for the production of cast flexible films with required mechanical, barrier and thermal weldability properties. The cast film revealed to be enzymatically degradable.

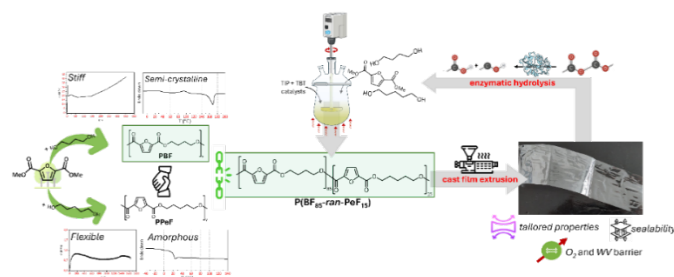


Figure 1. Experimental workflow, from copolymer synthesis and cast extrusion processing to the final enzymatic degradation study.

Acknowledgements: This project has received funding from the Bio Based Industries Joint Undertaking (JU) under grant agreement “GA101112541” project FURIOUS (Call: HORIZON-JU-CBE-2022).

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Design of novel furan-based copolyesters for sustainable antimicrobial medical packaging

G. Maccaroni^{1*}, G. Guidotti¹, M. Soccio¹, V. Siracusa², V. Sambri³, N. Lotti¹

¹ Civil, Chemical, Environmental and Materials Engineering Dept., University of Bologna, 40131 Bologna, Italy; ² Dept. of Chemical Science, University of Catania, 95125 Catania, Italy; ³ Dept. of Medical and Surgical Sciences, University of Bologna, 40138, Bologna, Italy

*giulia.maccaroni2@unibo.it

Globally, plastics account for approximately 33–36% of the overall packaging materials, the healthcare sector representing the major contributor to single-use plastic waste. This is particularly true in hospitals, where packaging and disposable medical devices are widely used to ensure sterility and patient safety¹. In detail, 60–70% of plastic hospital wastes consist of polypropylene (PP) and polyethylene (PE), mainly from items such as syringes, blood bags, bottles, tubing, and protective coverings^{1,2}. Poly(ethylene terephthalate) (PET) and Poly(ethylene terephthalate) Glycol-modified (PETG) are also employed for trays, blisters, and packages^{1,2}. Given the urgent need for sustainable alternatives to all these fossil-based materials, we explored a novel biocompatible, and potentially recyclable polymeric system with excellent mechanical and barrier properties and a potential intrinsic antimicrobial activity. The starting homopolymer was the bio-based and highly mechanical and barrier performant poly(butylene furanoate), PBF³, which has been copolymerized with Pripol 1009⁴, a commercial fatty acid capable of enhancing mechanical flexibility and imparting antimicrobial features, thanks to the presence of long PE-like side chains (Figure 1). This approach is expected to provide materials suitable for medical packaging and aims at maintaining high standards required in healthcare settings, while addressing the environmental impact of single-use plastics.

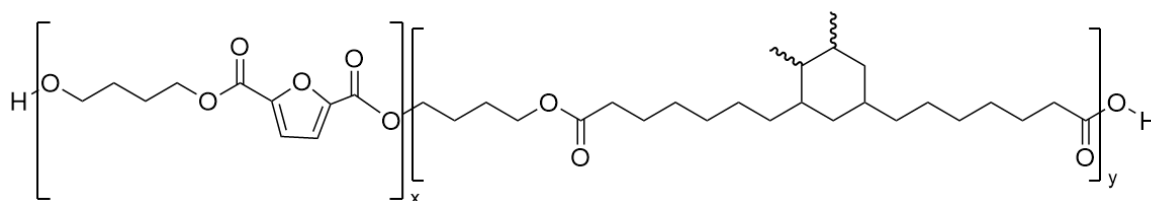


Figure 1. Chemical structure of P(BF_xBPripol_y) copolymers

Several random copolymers with different composition were synthesized by two-step melt polycondensation and characterized in terms of their molecular, thermal, surface wettability, mechanical and barrier properties. Antimicrobial performances were also tested, providing an integrated assessment of both functional and hygienic properties relevant for hospital use.

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Innovative Hybrid Red Mud-Metakaolin-Polydimethylsiloxane Geopolymers for Rapid Methylene Blue Adsorption

C. Migliaccio,^{1,*} G. Roviello,¹ O. Tarallo,² C. Ferone¹

¹Department of Engineering, University of Naples 'Parthenope', Centro Direzionale, Isola C4, 80143 Naples, Italy; ²Department of Chemical Sciences, University of Naples Federico II, Complesso Universitario di Monte Sant'Angelo, 80126 Naples, Italy.

*claudio.ferone@uniparthenope.it

This study presents the design and characterization of innovative hybrid geopolymers utilizing red mud (RM), metakaolin (MK), and polydimethylsiloxane (PDMS) to address industrial dye pollution through waste valorization. Structural characterization via XRD, FTIR, and SEM-EDX confirmed the successful integration of organic PDMS domains into a three-dimensional amorphous aluminosilicate network containing crystalline RM residues. Two distinct formulations were investigated to clarify the role of RM: RMMKSSH_p, where RM acts as a reactive precursor, and RMMKSSH_f, where RM serves as an inert filler. Batch adsorption tests revealed that RMMKSSH_f achieved complete methylene blue (MB) removal within 5 minutes, significantly outperforming the kinetic efficiency of both traditional geopolymers and commercial activated carbon¹, which required approximately 15 minutes for the same contact conditions. The process followed the Langmuir isotherm model ($R^2=0.986$) with a maximum adsorption capacity $q_{\max}$ of 31 mg/g, while thermodynamic parameters confirmed a spontaneous, endothermic, and predominantly physical mechanism governed by electrostatic interactions. Furthermore, the synthesis of millimetric spherical particles via suspension solidification method² enabled effective continuous-flow applications; the resulting breakthrough curves were accurately described by the Thomas model ($R^2=0.964-0.993$), establishing predictable dynamic performance. These findings demonstrate that utilizing RM as an inert filler enhances surface area (32.7 m²/g) and accessibility, providing a scalable, sustainable, and high-performance platform for advanced water purification systems.

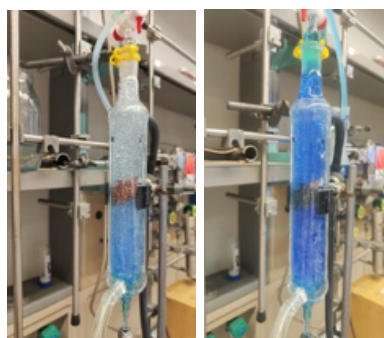


Figure 1. Real representation of the flow system pre- and post- MB adsorption.

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Processing and Characterization of PBSA/Biochar Composite Films for Biodegradable Mulching Applications

M. Seggiani,^{1,*} C. Pedrotti,¹ D. Rossi,¹ M. Sandroni,¹ A. Pucci,² A. Paoli,² P. Cinelli,¹

¹ Dept. of Civil and Industrial Engineering, University of Pisa, Largo Lucio Lazzarino 1, 56122 Pisa, Italy; ² Dept. of Chemistry and Industrial Chemistry, University of Pisa, Via Giuseppe Moruzzi 13, 56124, Pisa, Italy

*E-mail: maurizia.seggiani@unipi.it

The increasing demand for sustainable agricultural practices has driven the development of biodegradable alternatives to conventional polyethylene mulch films. In this context, this study investigates the formulation and characterization of biodegradable mulching films based on poly(butylene succinate-co-butylene adipate) (PBSA) reinforced with biochar as a functional bio-based filler. PBSA was compounded with wax-coated biochar at 2–8 wt.% through twin-screw extrusion and subsequently processed into films (40–100 μm thick) via blown film extrusion. Thermal analyses (TGA, DSC) showed a slight improvement in thermal stability upon biochar addition, while maintaining the crystallinity of the polymer matrix. FTIR spectroscopy and SEM observations confirmed good interfacial compatibility and homogeneous dispersion of biochar particles. Dynamic mechanical analysis demonstrated that the composites retained suitable tensile properties and glass transition temperatures for agricultural applications. Composting tests conducted according to ISO 20200 revealed progressive biodegradation, with higher biochar content slightly accelerating mass loss. Furthermore, biochar incorporation improved surface hydrophobicity and UV-blocking capacity, enhancing durability under field conditions. Overall, the results demonstrate that PBSA/biochar composite films combine biodegradability with improved functional performance, representing a promising and scalable alternative to conventional plastic mulches for sustainable crop production.



Figure 1. Processing workflow of PBSA/biochar mulch films.

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Manufacturing of sustainable biobased composites by means of Joule-heating-assisted curing with recycled carbon fibers

R. Longo,¹ L. Vertuccio,² F. Aliberti,¹ E. Calabrese,¹ L. Bonadies,¹ M. Raimondo,¹ R. Pantani,¹ L. Guadagno^{1,*}

¹ Department of Industrial Engineering, University of Salerno, Via Giovanni Paolo II, 84084 Fisciano, Italy;

² Department of Engineering, University of Campania "Luigi Vanvitelli", via Roma 29, 81031, Aversa, CE, Italy

*lguadagno@unisa.it

The application and advancement of thermosetting composites are constrained by several interrelated environmental challenges, including the persistent reliance on fossil-derived resins and the substantial energy requirements associated with fiber production—particularly carbon fibers—as well as composite manufacturing processes. This study addresses these three key issues by proposing the design of a high-performance bio-based resin and the fabrication of thermosetting composites reinforced with recycled carbon fibers through advanced, energy-efficient processing techniques. By leveraging the electrical conductivity of recycled carbon fiber mats, the composites were directly cured using Joule heating, enabling internal heat generation within the component and achieving temperatures of approximately 180 °C—adequate to ensure a high degree of curing of the selected thermosetting resin¹. The thermal parameters, namely temperature and heating duration, were determined based on preliminary characterization of the bio-based epoxy resin. The composites produced through this innovative method exhibit a glass transition temperature exceeding 198 °C and achieve complete curing.

Acknowledgments

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Nanoclusters-functionalized electrode for selective H-bond interactions

F. Marcaccio,^{1,*} A. Curulli,² M. Feroci¹

¹ Dip. Scienze di Base e Applicate per l'Ingegneria (SBAI), Sapienza Università di Roma, via Castro Laurenziano, 7, 00161, Roma, Italy ² CNR ISMN, p.le Aldo Moro 5, 00185, Roma, Italy

*francesco.marcaccio2@studio.unibo.it

Carbon dots are well-known nanoparticles, recently recognized, obtained from carbon-containing substrates via either top-down or bottom-up pathways. In both cases, nanostructures with a carbon core and various functional groups on the surface are obtained, depending on the starting material and the selected synthesis method. Once synthesized, these nanoparticles can be surface-functionalized to achieve the desired interaction with selected substrates.

When the intended substrate-nanoparticle interaction is based on hydrogen bonds, the surface post-functionalization inserts H-bond donors and/or acceptors (HBD, HBA), which induce nanoparticles self-aggregation, yielding nanoclusters.¹

Despite this “supramolecular” aggregation, the nanoparticles are effective in modifying a carbon electrode surface in view of an efficient and selective molecular recognition.²

In this regard, we will report our recent results on the electrode functionalization with nanoparticles post-functionalized with bifunctional molecules, e.g. amino acids, in order to ascertain the effect of possible H-bonding on the electrochemical detection of selected substrates (Figure 1).

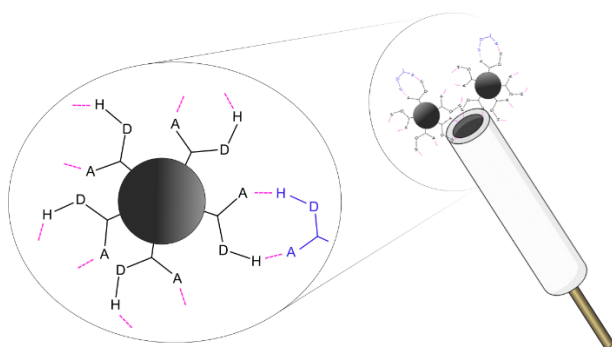


Figure 1. Electrode surface functionalization.

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Methacrylation of Fibrillar Marine Collagen: Production of Sustainable and Functional Hydrogels for Regenerative Medicine

S. Marzorati,^{1,*} M. Roncoroni,¹ G. Martinelli,¹ T. Chwojnik,¹ C. Scapuzzi,¹ L. Melotti,² A. Carolo,² D. Maggioni,³ M. Patruno,² M. Sugni¹

¹ Department of Environmental Science and Policy, Università degli Studi di Milano, Milano, Italy;² Department of Agronomy, Food, Natural Resources, Animals and Environment, University of Padua, Legnaro (PD); ³ Department of Chemistry, Università degli Studi di Milano, Milano, Italy;

* stefania.marzorati@unimi.it

Biomaterials derived from seafood by-products have been shown to represent a sustainable alternative to mammalian sources for biomedical applications, aligning with circular economy principles¹. In this study, native fibrillar collagen extracted from food waste of edible sea urchin was successfully methacrylated for the first time to produce structurally stable, photocrosslinkable hydrogels. A dedicated methacrylation protocol was developed to overcome the intrinsic limitations imposed by the supramolecular organization of intact glycosaminoglycane-decorated collagen fibrils, enabling effective functionalization while preserving their native architecture. Methacrylated collagen hydrogels were obtained via UV-induced photocrosslinking and further functionalized with sea urchin-derived polyhydroxynaphthoquinones to generate antioxidant composite hydrogels, thus accomplishing a full waste valorization strategy². The resulting biomaterials were comprehensively characterized in terms of ultrastructure, macroporosity, swelling behavior, water uptake, degradation kinetics under physiological and enzymatic conditions, antioxidant activity, and in vitro cytocompatibility using human dermal fibroblasts. Compared with non-methacrylated collagen scaffolds, methacrylated hydrogels exhibited enhanced structural stability, reduced swelling-induced deformation, and significantly increased resistance to degradation. Incorporation of antioxidants further improved hydrogel stability and conferred marked antioxidant activity, which was largely preserved after incorporation. In vitro assays demonstrated that the hydrogels supported cell viability and metabolic activity, while highlighting the influence of methacrylation degree on cytocompatibility. Overall, these findings demonstrate that methacrylated sea urchin collagen hydrogels, with or without antioxidant loading, constitute a promising class of sustainable and biomimetic biomaterials for regenerative medicine and tissue engineering applications.

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Purification of spent cigarette butts by natural deep eutectic solvents (NADES)

M.M. Dell'Anna,^{1,*} M.S. Leone,¹ A. Rizzuti,¹ A.R. Duarte,² A.R. Craveiro,² P. Mastrorilli¹

¹ Department of Civil, Environmental, Land, Building Engineering and Chemistry, Politecnico di Bari, 4 via Orabona, Bari, 70125, Italy; ² Department of Chemistry, NOVA School of Science and Technology, Largo da Torre, 2829-516 Caparica, Portugal

*mariamichela.dellanna@poliba.it

Spent cigarette butts represent very hazardous waste, since they contain several organic pollutants (arenes, polycyclic aromatic hydrocarbons, nicotine, heavy metals and so on)¹. Treating cigarette butts for recovering cellulose acetate is very attractive from both economic and environmental points of view. Nowadays, cellulose acetate can be retrieved from cigarette filters by using harsh and pollutant conditions, including the use of toxic solvents. In this presentation, a novel method of extraction of cellulose acetate from spent cigarette butts is proposed. This method is based on the use of the so-called deep eutectic solvents (DESs), that represent innovative and environmentally friendly solvents, having the advantages of both organic solvents and ionic liquids². DESs are composed of a hydrogen bond donor (HBD) and a hydrogen bond acceptor (HBA) (Figure 1) forming very strong hydrogen bonds. The effectiveness of the extraction procedures of cellulose acetate using different DESs is assessed by means of several analytical techniques performed on the purified samples compared to the polluted ones.

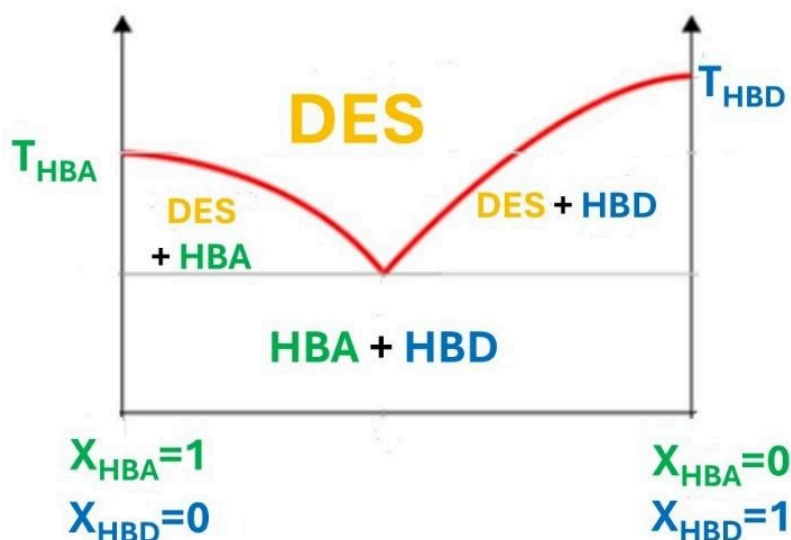


Figure 1. Eutectic diagram of deep eutectic solvents (DESs).

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Waste-to-wastewater-treatment: valorization of sewage sludge ash for contaminants adsorption

C. Punta,^{1,*} P. Pachaiappan,¹ E. Bontempi,² A. De Santis,¹ L. Riva,¹ A. D'Anna,³ M. Blazina³

¹ Department of Chemistry, Materials, and Chemical Engineering "G. Natta" and INSTM Local Unit, Politecnico di Milano, Piazza Leonardo da Vinci 32, I-20133 Milano, Italy; ² INSTM and Chemistry for Technology Laboratory, Department of Mechanical and Industrial Engineering, University of Brescia, Via Branze 38, 25123 Brescia, Italy; ³ MM SpA, Depuratore Milano San Rocco, Loc. Ronchetto delle Rane - 20141 Milano – Italy

*carlo.punta@polimi.it

Sewage sludge ash (SSA), containing 5–15 wt% phosphorus, is increasingly recognised as a strategic secondary resource for phosphorus recovery.¹ However, the residual solid fraction must be effectively valorised to ensure overall process sustainability. This study investigates fluidized bed mono-combusted SSA within a circular economy framework, coupling phosphorus extraction with the conversion of the treated ash into a functional adsorbent for wastewater treatment.²

Phosphorus was recovered through acid leaching, which simultaneously induced significant physicochemical modifications. The treatment increased the specific surface area from 1.51 to 16.18 m²/g and promoted marked phase and surface transformations, yielding an activated material (ASSA) with enhanced textural properties.

Adsorption performance was evaluated in batch experiments using four sulfonated anionic dyes and methylene blue as a cationic reference compound. Compared with raw SSA, ASSA exhibited substantially improved removal of anionic dyes, particularly at higher initial concentrations, while methylene blue uptake remained comparable. Isotherm and kinetic modelling revealed dye-dependent mechanisms and confirmed the influence of acid activation on adsorption behaviour.

A sustainability assessment performed with the ESCAPE tool indicates that ASSA may represent an environmentally competitive alternative to commercial activated carbons, despite its lower adsorption capacity. Overall, the results demonstrate the feasibility of an integrated waste-to-resource pathway, combining phosphorus recovery with the production of value-added adsorbents from sewage sludge ash within a circular valorisation strategy.

These results have been obtained within RHIGUS (Low Energy Technologies for Recovery of High-Grade Phosphorus) project, financed by MUR (PRIN 2022).

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Innovative hydrophilic ligands for the selective recovery of Am(III) from spent nuclear fuel

Giulia Marcolli^{1,2}, Margherita Grieco¹, Massimiliano Federico Silvio Tentorio¹, Giulia De Amicis¹, Elena Macerata¹ and Alessandro Sacchetti^{*1,2}

¹Politecnico di Milano, Italy; ²National Interuniversity Consortium of Materials Science and Technology (INSTM), Italy

alessandro.sacchetti@polimi.it

Managing highly radioactive waste remains a major challenge for the sustainable use of nuclear energy. Currently, spent nuclear fuel (SNF) reprocessing mainly recovers uranium and plutonium for reuse by PUREX (Plutonium Uranium Reduction EXtraction) process, but does little to reduce long-term radiotoxicity. In this perspective, a key difficulty lies in selectively separating americium from curium, two elements with very similar chemical and physical properties¹. The AmSel (Americium Selective Extraction)² process seeks to address this issue by selectively removing Am(III) from PUREX raffinate through liquid–liquid extraction.

In this work, we aim to improve the AmSel process by replacing the currently used sulfonated BTBP extractant with new hydrophilic ligands. The proposed extractant must be fully burnable at end of life, composed only of carbon, hydrogen, oxygen, and nitrogen, and capable of selectively extracting americium. The work focuses first on synthesizing the ligands and optimizing their preparation to obtain compounds soluble in acidic aqueous media. Ligands **1** and **2** are based on the phenanthroline scaffold and prepared as shown in Scheme 1. Starting from the oxidation of phenanthroline (compound **3**), and subsequently performing a Seyferth–Gilbert homologation, it is possible to obtain an alkynyl-functionalized phenanthroline. Reaction of this intermediate with 2-(2-azidoethoxy)ethanol or 2-[2-(2-azidoethoxy)ethoxy]ethanol produces ligands **1** and **2**, respectively.

The extraction performance is then evaluated through batch liquid–liquid extraction experiments using radioactive tracers (²⁴¹Am, ²⁴⁴Cm, and ¹⁵²Eu) to simulate the target elements present in the SNF. By varying ligand concentration and acidity, optimal operating conditions were identified. The results are encouraging, showing that compounds **1** and **2** are promising alternatives to the reference SO₃-Ph-BTBP extractant, with potential to further enhance the effectiveness of the AmSel process

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Deep Eutectic Solvent-enabled recovery of spent solar cells

Daria Ballardini^{1,*}, Stefano Nejrotti², Barbara Centrella², Francesca De Rossi³, Francesco Michelotti¹, Matteo Bonomo^{1,4}

¹ Department of Basic and Applied Sciences for Engineering-SBAI, Sapienza Università di Roma, Via del Castro Laurenziano 7, 00161, Rome, Italy; ² Department of Chemistry, NIS Interdepartmental Centre, INSTM Reference Centre, University of Turin, via Pietro Giuria 7, 10135 Turin, Italy; ³ Department of Electronic Engineering, University of Rome, Tor Vergata, Via del Politecnico 1, 00133, Rome, Italy; ⁴ National Reference Centre for Electrochemical Energy Storage (GISEL)-INSTM, Via Giusti 9, 50121, Firenze, Italy

*daria.ballardini@uniroma1.it

Lead halide perovskite solar cells (PSCs) have emerged as one of the most promising photovoltaic technologies, showing rapid improvements in power conversion efficiency and operational stability.¹ Despite their advances these devices contain several toxic and rare metals, whose recovery is crucial not only to cut wastes, but also to provide an additional source of them and lower the need for their extraction. Currently, pyrolysis and the use of strongly acidic solutions are the mostly used techniques; however, they are highly energy-intensive, costly and polluting, jeopardizing the sustainability of the approach.² Green solvents capable of selectively extracting metals from spent materials are being explored. Among these, deep eutectic solvents (DESs) have attracted increasing attention, being non-toxic, biodegradable, and tuneable, thus allowing their design to optimize their properties for leaching applications.³ In this work, a choline chloride-oxalic acid DES was selected for the recycling of spent perovskite devices. To mitigate high viscosity, water was added at selected molar ratios. Active material leaching was carried out heating at 40 °C with a 20 minutes soaking of the sample. SEM-EDX and UV-Vis analyses revealed that a DES:water molar ratio of 1:4 is the optimal composition, as it preserves the key DES properties required for efficient metal extraction while enabling recovery of the solar cell support, made of polyethylene terephthalate (PET), a crucial step toward minimizing waste and closing the materials loop in a circular economy. To demonstrate the versatility of the leached solution, we applied a circular approach that could repurpose this waste into a valuable solvent for a completely different application, *i.e.*, organic synthesis of photovoltaic-related compounds. Indeed, after having been used to treat the spent PSCs, the DES:water system was successfully employed as an active solvent to promote the acid-catalysed Nazarov cyclisation of the divinyl ketone 2,4-dimethyl-1,5-diphenylpenta-1,4-dien-3-one into the corresponding cyclopentenone, 2,5-dimethyl-3,4-diphenylcyclopent-2-en-1-one. Notably, the reaction was performed in the absence of any external acidic additive. Future efforts will aim to reutilize the PET substrate for new devices, with an optimization of the approach to preserve its conductive properties, as suggested by preliminary conductivity analysis.

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Green Asymmetric Synthesis: Electrodimerization of *p*-Fluoroacetophenone¹

Claudiu Bostan¹, Martina Bortolami¹, Cristiana Margarita¹, Fabrizio Vetica², Marta Feroci¹

¹Department of Basic and Applied Sciences for Engineering (SBAI), Sapienza University of Rome, Italy

²Department of Chemistry, Sapienza University of Rome, Italy
claudiu.bostan@uniroma1.it

The growing demand for chiral molecules necessitates the development of sustainable asymmetric synthetic strategies. Electrosynthesis represents a promising green alternative to traditional methods, leveraging selective redox reactions and high atom economy to eliminate the requirement for stoichiometric mediators². This work explores the electrochemical reduction of acetophenones to pinacol, a challenging transformation requiring dual stereocollective control—specifically, the simultaneous management of enantioselectivity and diastereoselectivity. To achieve precise stereocontrol, Glassy Carbon electrodes were functionalized with chiral nanoparticles (L-Pro-NPs) and amino acids, supplemented by the use of chiral additives in the electrolyte. Modification of the electrode surface was confirmed via cyclic voltammetry; notably, functionalization with L-Pro-NPs enhanced conductivity, whereas the L-Proline layer acted as an insulator, resulting in a significant decrease in current peaks. Optimization of the electrosynthetic process yielded exceptional chemical efficiency and high diastereoisomeric control. These results demonstrate the potential of electrochemical pathways as superior, environmentally respectful alternatives for the synthesis of complex chiral architectures, marking a significant advancement toward cleaner chemical manufacturing.

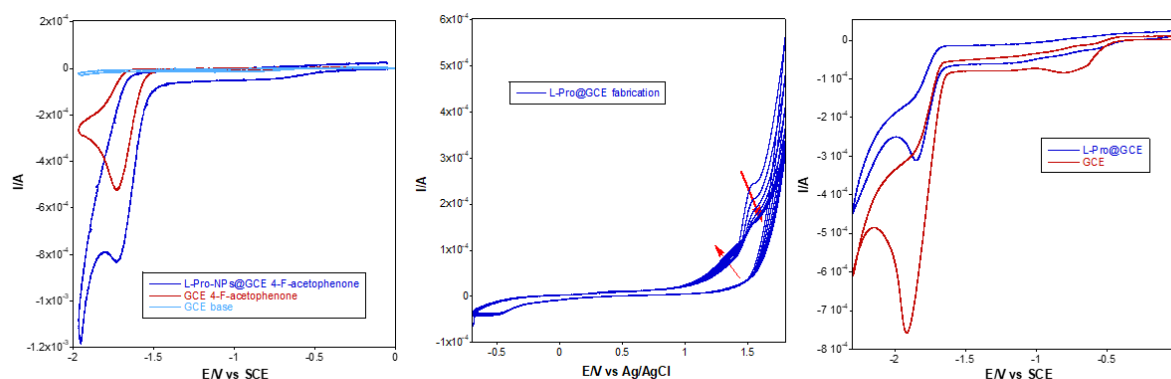


Figure 1. Left: Voltammetry of the ketone with the L-Pro-NPs functionalized GC electrode (in blue). Right: Voltammetry of the ketone with the L-Pro functionalized GC electrode (in blue). Center: The 10 cycles of L-Pro functionalization.

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Synthesis of Pt/CeO₂ from a leachate solution containing recycled platinum

A Varotto^{1,2*}, M. Feroci², U.P.Laverdura¹, and M.L.Grilli¹

¹Italian National Energy for New Technologies, Energy and Sustainable Economic Development (ENEA), Rome, Italy; ²Dept. Fundamental and Applied Sciences for Engineering (SBAI), Sapienza University of Rome, via Castro Laurenziano, 7, 00161, Rome, Italy

*alessio.varotto@uniroma1.it

Different types of CeO₂ supports were synthesized via a sol–gel method, and Pt/CeO₂ catalysts were subsequently prepared by impregnating the ceria supports with a platinum-containing leachate solution obtained from the hydrometallurgical processing of spent diesel oxidation catalysts¹. Ceria was selected for its ability to generate oxygen vacancies and for its high thermal stability². Platinum was employed as the active phase to promote the Dry Reforming of Methane (DRM), in which CH₄ and CO₂ react to produce a mixture of H₂ and CO (syngas).

Due to its strongly endothermic nature, the DRM reaction requires high operating temperatures, typically above 650 °C. A further challenge is the occurrence of side reactions. Among these, the most critical is the Reverse Water–Gas Shift (RWGS) reaction, in which part of the H₂ produced reacts with CO₂ to form additional CO and H₂O. This decreases the H₂/CO ratio, a key parameter for downstream processes such as Fischer–Tropsch synthesis.

Figure 1A shows the H₂/CO ratio (0.9), and figure 1B shows the CH₄ (95%) and CO₂ (96%) conversions achieved with the best-performing catalyst developed in this work³.

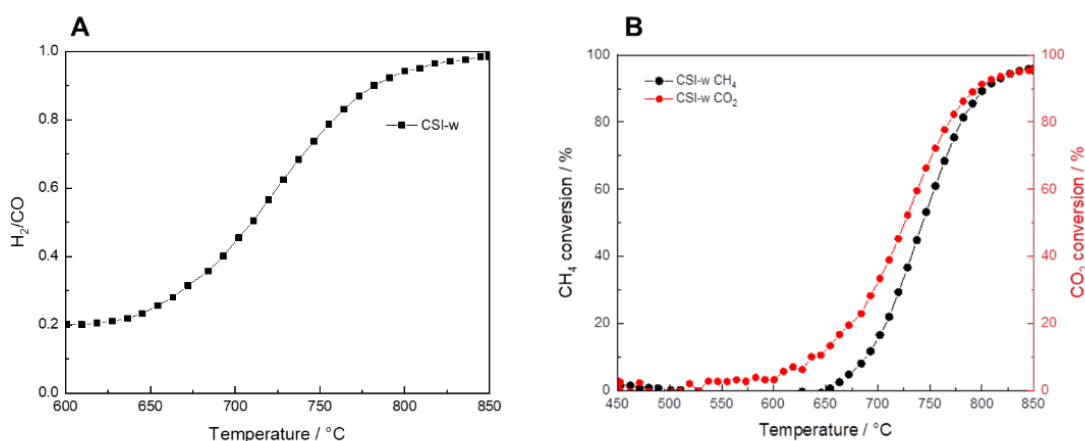


Figure 1. H₂/CO ratio (A), and CH₄ and CO₂ conversions (B) of CSI-w for the DRM reaction.

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Optical Detection of Micro- and Nanoplastics in Environment: the LIAISON project update

Larisa Lvova^{1*}, Chiara Capolungo², Damiano Genovese², Gabriele Magna¹, Marco Montalti², Enrico Rampazzo², Nelsi Zaccheroni², Manuela Stefanelli¹, Sara Nardis¹, Roberto Paolesse¹, Luca Prodi²

¹ Department of Chemical Science and Technologies, University of Tor Vergata, Via della Ricerca Scientifica, 000133 Rome, Italy; ² Dipartimento di Chimica "Giacomo Ciamician", Alma Mater Studiorum – Università di Bologna, via Selmi 2, 40126, Bologna (Italy)

*larisa.lvova@uniroma2.it

The increasing environmental pollution due to the intensive industrial, agriculture and urban emissions became nowadays a serious problem negatively influencing the quality of life and health of modern society¹. Plastics constitute 12% of total waste; 350 million tons of plastics are generated annually, only 10% is recycled, while the rest is dispersed in the environment². The micro- and nanoplastics (MNPs) are the most dangerous forms for biota and humans being ubiquitous and more bioavailable, and their detection and monitoring are important and challenging analytical task. Since existing protocols or MNPs assessment, are unsatisfactory and limited by high cost, complex instrumentation, necessity of sampling, transportation and impossibility of rapid on-site analysis³, the development of effective, low-cost, time-saving portable sensing devices for MNPs environmental pollution is highly requested⁴. Here we report on-paper based disposable optical chemical sensors prepared with hyaluronic acid functionalized with Nile Red (HA-NR) and with Rhodamine B (HA-RB) for screening and quantitative assessment of six MNPs: PVC, PMMA, PE, PP, PS, PET, and their mixtures in distilled and tap water. The possibility to discriminate MNPs with HA-NR fluorescent optodes, as well as the possibility to detect MNPs in tap water background in a range from 1 μ M to 0.1 mM with the lowest detection limit of 1.7 μ M and $R^2=0.995$ through HA-RB sensor was shown. The detailed discussion of these results will be provided in our presentation.

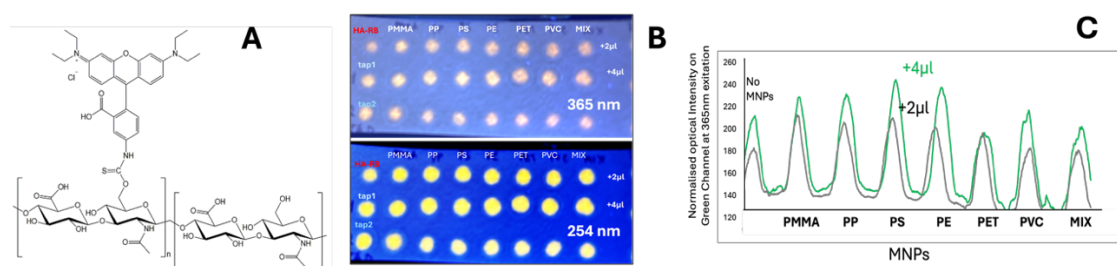


Figure 1. A: HA-RB structure; B: the spots of HA-RB in H₂O/1.8% (10 μ M) prepared on a filter paper support by drop casting method; C: the luminescence intensity variations on the Green channel at the excitation light of 365 nm.

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Sol-Gel synthesis of ZrO₂/Olive Extract Hybrids: FTIR and *In Vitro* Release Study

M.V. Mollo,^{1,*} M. Fiorentino,¹ A. D'Angelo,² D. Naviglio,³ M. Catauro¹

¹ Department of Engineering, University of Campania "Luigi Vanvitelli", Via Roma 29, 81031 Aversa, Italy; ² Department of Industrial Engineering, University of Salerno, Via Giovanni Paolo II 132, 84084 Fisciano, Italy; ³ Department of Chemical Sciences, University of Naples Federico II, Via Cintia 21, 80126 Napoli, Italy

*mariavittoria.mollo@unicampania.it

Olive leaf extract is rich in polyphenolic compounds with well-known antioxidant and antimicrobial properties, making it an attractive natural source of bioactive molecules for functional hybrid materials. The olive leaf extract was obtained through Naviglio extraction, a pressurized solid–liquid extraction technique that enhances the recovery of polyphenolic compounds while preserving their bioactivity. In this work, zirconia/olive leaf extract (ZrO₂/OLE 8, 25, 33 and 50 wt%) hybrid materials were synthesized via a sol–gel route and investigated as smart inorganic–organic systems capable of delivery bioactive species. The obtained hybrids were characterized by Fourier transform infrared (FTIR) spectroscopy to evaluate the interaction between the inorganic matrix and the organic extract. Colorimetric analysis was performed to assess optical variations induced by different extract loadings, while *in vitro* release tests were carried out to study the release behavior of the active compounds and UV–Vis spectroscopic analyses were employed to quantitatively determine the extract release over time. The results indicate successful incorporation of the olive leaf extract within the zirconia network, highlighting the potential of these hybrid materials for applications requiring sustained delivery of natural bioactive agents.

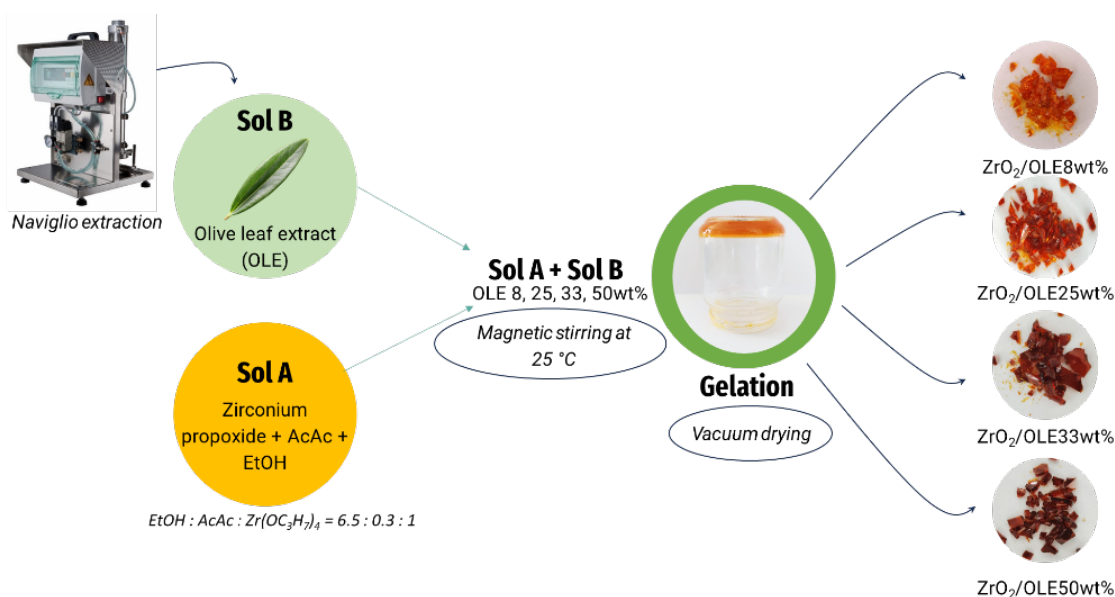


Figure 1. Flowchart scheme of ZrO₂/OLE hybrids synthesis

FT-IR characterization of Alkali-activated waste (sawing sludges) materials

R. Simonelli,^{1,*} A. D'Angelo,² M. Fiorentino,¹ L. Mollo,¹ S. Fasana,³ M. Catauro,¹ M. Zerbinatti³

¹ Department of Engineering, University of Campania "Luigi Vanvitelli", Via Roma 29, 81031 Aversa, Italy; ² Department of Industrial Engineering, University of Salerno, Via Giovanni Paolo II 132, 84084 Fisciano, Italy; ³ Department of Structural Geotechnical and Building Engineering, Politecnico di Torino, C.so Duca degli Abruzzi 24, 10129 Torino, Italy

*roberto.simonelli@unicampania.it

Nowadays Ordinary Portland Cement (OPC)¹ represents the most widely used construction material in the world due to its excellent performances. However, it has a fundamental drawback; it is responsible for the 8% of global carbon dioxide emissions.² This may be attributed to the employment of non-renewable resources and high temperature's processes (such as clinker production³).

In this context Alkali-activated materials (AAMs) can contribute to the reduction of environmental impact in construction industry. They configure as real sustainable alternative to OPC. AAMs are inorganic⁴ polymeric materials originating from the reaction of an alkaline activator with an aluminosilicate source (precursor).

In this study, five sawing sludge wastes (Figure 1) have been activated with NaOH 4 and 8 M. The resulting consolidated materials have been deeply characterized through Fourier-Transform Infrared Spectroscopy (FT-IR) to verify the occurrence of the reactions. Moreover, it provides information concerning the functional groups presence in the sawing sludges at hand. Since differences in sample appearance and features are due to the originating waste collection sites, integrity tests and pH measurements were carried out to investigate samples' stability. This research could provide a contribution to elaborate new promising binder formulations for a sustainable construction.



Figure 1. Sawing sludges images.

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Efficient Photocatalytic Removal of Methylene Blue using Cobalt-doped CuO Nanoparticles

M. Goudjil,^{1,*} A. Guerraoui,² A. Younes,³ A. Guerraoui,⁴ L. Hafsa,⁵

¹ Department of Industrial Engineering - University of Florence (Italy); ² Department of Physics - University of Batna (Algeria); ³ Research Center in Industrial Technologies (CRTI) – Algeria; ⁴ Faculty of Science et Technologies - University of Khenchela (Algeria), ⁵ Department of Matter Sciences – Laarbi Tebessi University (Algeria)

*meriem.goudjil@unifi.it

The photocatalytic degradation of organic dyes, such as methylene blue (MB), is widely used to evaluate the performance of semiconductor photocatalysts.^{1,2} MB is a persistent and stable cationic dye commonly present in industrial waste. Enhancing the solar-driven degradation of MB is therefore of practical significance.³ A series of CuO and cobalt-doped $\text{Cu}_{1-x}\text{Co}_x\text{O}$ ($x = 0.01, 0.03, 0.06$, and 0.09) nanoparticles was prepared via a template-free hydrothermal route and systematically examined for structural, optical, and magnetic properties. Powder X-ray diffraction (P-XRD) analysis confirmed a monoclinic single phase (C2/c) for both pristine and Co-doped phases, with an average crystallite size of ~ 20 nm. Co-incorporation was further assessed by EDS characterization, while SEM revealed typical flake-like and urchin-like morphologies. Band-gap narrowing was observed at intermediate Co content (2.35 eV for $\text{Cu}_{0.94}\text{Co}_{0.06}\text{O}$), improving visible-light absorption. Magnetic measurements revealed weak room-temperature ferromagnetic character, enabling magnetic recovery. Photocatalytic experiments under sunlight demonstrated that $\text{Cu}_{0.94}\text{Co}_{0.06}\text{O}$ achieved 82% of MB degradation within 75 min ($k = 0.0185 \text{ min}^{-1}$), ~ 2.2 times higher than pristine CuO. These results highlight cobalt-doped CuO as an efficient and magnetically recoverable photocatalyst for wastewater treatment.

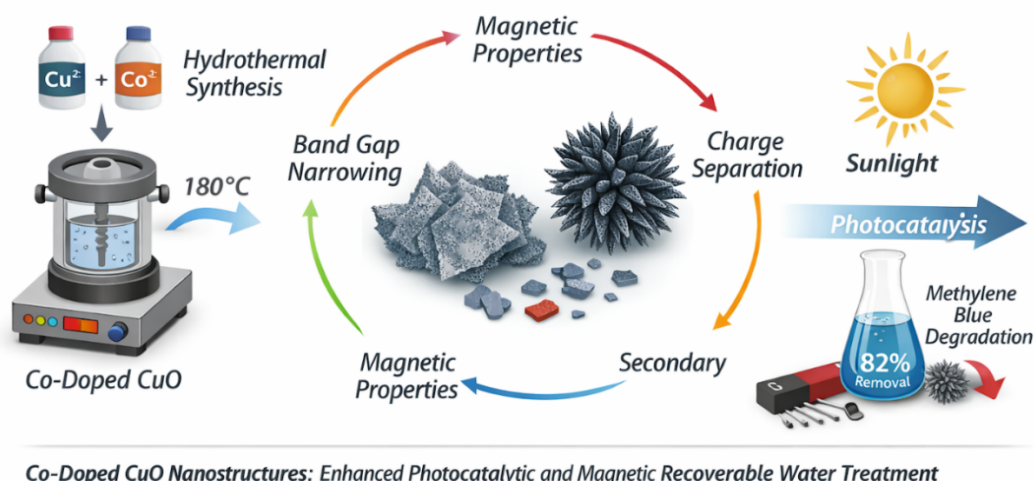


Figure 1. Schematic of hydrothermally synthesized Co-doped CuO nanoparticles designed for photocatalytic, sunlight-driven MB degradation.

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Sodium Pyrophosphate Decahydrate-Silica Gel Composites For Thermochemical Energy Storage

Zar Jan^{1*}, Giuseppina Anna Corrente¹, Emanuela Mastronardo¹, Luigi Calabrese¹, Candida Milone¹

¹ Department of Engineering, University of Messina, Messina, Italy

*zar.jan@studenti.unime.it

Thermal energy storage (TES) technologies are gaining increasing attention due to their potential to exploit waste heat and renewable energy sources to meet a significant share of heating and cooling demands across several industrial sectors¹. Among TES approaches, inorganic salt hydrates are promising candidates for thermochemical energy storage (TCES) because of their high theoretical energy density and ability to reversibly coordinate water molecules. However, challenges such as deliquescence and structural instability still limit their practical application. To address these limitations, we screened for a novel salt hydrate, sodium pyrophosphate decahydrate ($Na_4P_2O_7 \cdot 10H_2O$), which was a suitable material because it satisfies these challenges and has not been previously studied for this application. In this work pure $Na_4P_2O_7 \cdot 10H_2O$ was initially studied to understand its thermochemical behavior. Thermogravimetric analysis showed that water is totally loss in the range of temperature 40-120 °C and the heat stored in the dehydration process was 1.600 kJ/kg. The hydration/dehydration isotherm, (at 30 °C) has been measured by Dynamic Vapour Sorption, varying the RH% from 0 to 90%. The DVS analysis showed a large hysteresis between hydration and dehydration which indicates slow kinetics (Fig.1a). To reduce the hysteresis composite materials were developed by incorporating salt into mesoporous silica gel² (Fig.1b). The resulting materials were extensively characterized in terms of morphology, thermal behavior and water sorption properties.

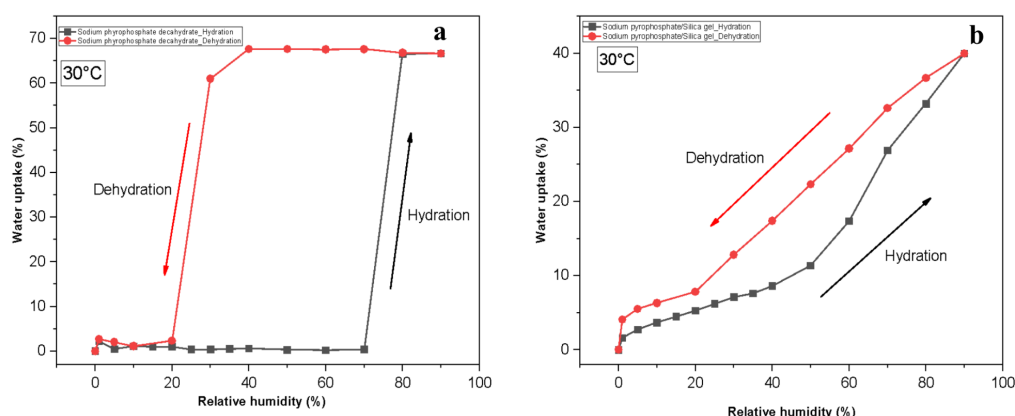


Figure 1. Isothermal hydration/dehydration at 30 °C of pure salt(a) and 30 $Na_4P_2O_7$ /SG composite (b)

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Multi-Step Conversion of Orange Peel Waste into Value-Added Products via a Cascade Biorefinery Approach

S. Sorbo,^a F. Mauriello,^b E. Paone,^b P. Calabrò,^b C. Espro^a

^a Department of Engineering, University of Messina, C.da Di Dio, I-98166 Messina, Italy; ^b Dipartimento di Ingegneria Civile, Energia, Ambiente e Materiali (DICEAM), Università degli Studi Mediterranea di Reggio Calabria, Via Zehender (già via Graziella) - Loc. Feo di Vito, I-89123 Reggio di Calabria (RC) Italy

srbslv97e59h224c@studenti.unime.it

Orange processing generates large quantities of peel waste, a moist and rapidly degradable biomass that can cause environmental and management issues, including odors, greenhouse gas emissions, and disposal costs. However, orange peel residues are rich in bioactive compounds and carbohydrates that can be recovered through appropriate valorization strategies.¹

This study proposes a cascade biorefinery approach to convert orange peel waste into multiple value-added products. Phenolic compounds are first extracted, yielding antioxidant-rich fractions with potential nutraceutical applications. The remaining biomass undergoes acid hydrolysis to produce fermentable sugars suitable for biofuels or biobased chemicals.²

The residual solids are then treated by anaerobic digestion to generate biomethane, while the resulting digestate can be applied as a soil amendment.³

Overall, this integrated process demonstrates a sustainable pathway for the valorization of orange peel waste within a circular bioeconomy framework.

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VisioNing: valorization of agro-industrial wastewater. From research bench to business.

M. Magni,^{1,2,*} D. La Cortea,² P. Scavone,² K. Rajagopalan,² S. Marzorati,¹ D. Meroni,³
F. Adani,⁴ C.L. Bianchi,³ S. Guzzetti,² E. Falletta^{2,3}

¹ *Dipartimento di Scienze e Politiche Ambientali, Università degli Studi di Milano, 20133, Milano;* ² *VisioNing srl, 20143, Milano;* ³ *Dipartimento di Chimica, Università degli Studi di Milano, 20133, Milano*

⁴ *Dipartimento di Scienze Agrarie e Ambientali, Università degli Studi di Milano, 20133, Milano*

**mirko.magni@unimi.it*

The escalating pollution caused by agro-industrial wastewater is an alarming environmental threat. Apart from the obvious water wastage, valuable nutrients within are also lost.¹ Besides that, processes able to treat emerging waste fluids, like the one coming from anaerobic digestion of biomass and biowaste, are still under scouting by many industrial actors, privates or corporates. The wastewater treatment sector and that of fertilizers' production account for over 3% and 1.2% of world's energy. Moreover, fertilizer costs are continually growing as they are related to the energy cost and population growth. This represents a significant economic damage to companies in the sector. The agro-industrial wastewater treatment market is witnessing a surge in interest towards efficient and sustainable technologies. In fact, technological innovation and the embrace of eco-friendly solutions are driving industry transformation. In this context, the mission of VisioNing is simple but ambitious: transforming wastewater from a problem to a resource with 100% circularity and sustainability.

VisioNing is a deeptech startup conceived and founded after a meticulous examination of the challenges in wastewater treatment. Combining synergistically spontaneous and low-energy demanding treatments, our process not only purifies wastewater but also recovers and reuses the nutrients it contains. While numerous wastewater treatment solutions exist, our combined technology offers dual benefits: energy efficiency and recyclability of water and added-value compounds in it. This empowers us to position ourselves as frontrunners in sustainability and innovation, pointing to a reduction in operational costs compared to traditional approaches. Having conducted in-depth research and developed prototypes at the University of Milan, we have now refined an operational and highly efficient pilot plant version.

Three pilots (500 L capacity, each) are operating, moved across several companies spread along the peninsula with different type of wastewater, and financed by the "Farming Future" investment fund of CDP Venture Capital SGR and ToSeed & Partners, confirming the preliminary results obtained in the Proof of Concept phase in terms of nutrients recovery and water purification.

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Application of chemical technologies for waste inertization and recycling

L. Barbieri,^{1,*} F. Genua,¹ I. Lancellotti,¹ C. Leonelli,¹ M. Napolitano,¹

¹ Department of Engineering “Enzo Ferrari”; University of Modena and Reggio Emilia, Modena

*luisa.barbieri@unimore.it

Inertization and waste recycling are key drivers of sustainability and the circular economy, transforming waste into resources, reducing landfill disposal, and cutting CO₂ emissions. Inertization stabilizes hazardous waste, making it safe, while recycling reintegrates materials into the production cycle, reducing the use of virgin resources. How the application of chemical principles can find a concrete basis in the field of technological processes and materials is briefly described below.

Immobilization via alkali activation: Alkali activation is an emerging synthetic pathway for the immobilization of inorganic waste. This chemical process involves adding highly concentrated alkaline solutions to aluminosilicate powders at room temperature. Compared to traditional processes used in the manufacture of ceramics and cement, this solid-state chemistry route reduces waste and emissions. Once activated with alkali, aluminosilicate precursors form cages similar to zeolites, which can encapsulate cations, anions and organic macromolecules present in the waste. Our work focuses on formulating and characterizing original matrices that can stabilize various types of industrial liquid and solid waste containing different contaminants¹.

Cold/hot waste treatment and bioremediation: Both room temperature granulation/pelletization and vitrification^{2,3} are used as consolidation techniques to produce new fertilizing systems with slow nutrient release, starting from mineral, animal, or vegetal waste and by-products, together with post- and pre-consumer scrap. The use of selected microorganisms to remediate a former industrial war site contaminated by nitrocellulose represents an opportunity to recover nitrogen compounds that can be reprocessed as nutrient components. Furthermore, the introduction of phosphorus-mobilizing microorganisms is part of a research project aimed at designing granular biostimulants based on volcanic residues and zeolitized tuffs, capable of enhancing the mobilization of poorly bioavailable phosphorus in soils.

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Engineering circular nutrient systems through material design and bio-assisted processes for environmental protection and soil restoration

M. Napolitano,¹ G. Malavasi,² L. Barbieri¹

¹ Department of Engineering “Enzo Ferrari”, University of Modena and Reggio Emilia, Modena

² Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia, Modena,
*luisa.barbieri@unimore.it

Sustainable nutrient management requires integrated material and biological strategies capable of reducing environmental pollution while recovering valuable resources. Conventional fertilizers often lead to nutrient losses, soil degradation, and ecosystem contamination¹. This contribution presents three complementary research lines based on circular design and bio-assisted process. The first project focused on the development of slow-release N-P-K composite granules derived from industrial by-products². Sterilized animal blood and bone meal were used as organic nitrogen source and calcium phosphate source, respectively, with pumice scraps as porous matrix providing structural stability and water retention. The resulting granules were engineered to modulate nutrient release kinetics (tested in 2% citric acid solution simulating the acidic conditions of the rhizosphere) and reduce leaching losses (tested in acetic acid to assess potential nutrient leaching under acid rain conditions). The second project addressed phosphorus bioavailability through biologically active carrier materials. Granules were produced using biochar and raw soybean meal, with pumice or zeolite as mineral carriers for phosphate-solubilizing bacteria. To assess whether microbially mobilized phosphorus remained available for plant uptake, soil tests using Diffusive Gradients in Thin Films quantified labile P fractions. Two formulations increased phosphorus availability by up to 50% compared to untreated P-deficient soil. These bioformulations are now being tested in greenhouse trials with *Brassica rapa* L. to evaluate plant growth response. The third project contributed to the study of the environmental remediation of a decommissioned industrial site, known for its historical production of explosives. Laboratory-scale studies on the bioremediation of nitrocellulose waste using multi-strain inoculum of microorganisms demonstrated effective degradation, absence of phytotoxicity, controlled NO_x emissions, and defined risk mitigation parameters. While the primary objective is contaminant removal and hazard reduction, the inorganic nitrogen released during degradation may support post-remediation soil restoration and reforestation. Collectively, these studies demonstrate how engineered and bio-assisted approaches can integrate waste valorization, nutrient circularity, and environmental remediation within a scalable soil protection framework.

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Chemical Recycling of Epoxy Composites in Mild Conditions

R. Longo^{1,*}, L. Bonadies¹, E. Calabrese¹, L. Guadagno¹, M. Raimondo¹, L. Vertuccio²

¹ Department of Industrial Engineering, University of Salerno, Via Giovanni Paolo II, 84084 Fisciano, Italy;

² Department of Engineering, University of Campania "Luigi Vanvitelli", via Roma 29, 81031, Aversa (CE), Italy

*rlongo@unisa.it

Chemical recycling of thermoset resins is highly relevant because it addresses one of the major challenges of composite material sustainability: the inability to remold or mechanically recycle crosslinked polymers.¹ By breaking down these resins into their original monomers or valuable chemical intermediates, this process enables material circularity and reduces reliance on virgin resources. Furthermore, it significantly lowers environmental impact by diverting waste from landfills and reducing greenhouse gas emissions compared to incineration. Beyond waste management, chemical recycling supports the recovery of high-performance raw materials, preserving their properties for advanced applications in sectors such as aerospace, automotive, and electronics, where durability and strength are critical. The goal of this research is to promote sustainable chemical recycling of thermoset epoxy composites by employing green solvents and low temperatures. A thermoset epoxy composite was produced using the Vacuum Assisted Resin Infusion (VARI) process, commonly applied for high mechanical performance Composites.² The composite showed a Young's modulus of ~7640 MPa, typical of structural materials. Chemical recycling tests on the developed composite were performed at three distinct temperatures (70 °C, 80 °C, and 90 °C) and at atmospheric pressure. FTIR and NMR investigations indicate that chemical bond cleavage occurs through the selective breaking of the C-N bonds within the crosslinked matrix structure, and allows the recovery of both the reinforcing phase and the epoxy matrix in the form of oligomers or monomers of the epoxy matrix. The final depolymerization efficiency is calculated by a new method through thermogravimetric analysis. It is observed that the depolymerization efficiency increased with the reaction temperature, reaching the maximum value of 81.3% at the highest investigated temperature (90 °C). Morphological analyses, electrical characterization, and AFM confirm this behavior. The results demonstrate that it is possible to use a low-temperature chemical recycling (90 °C) of thermoset composites using green solvents (a mixture of acetic acid and a small amount of hydrogen peroxide), therefore reducing the environmental impact and the cost associated with the chemical recycling processes.

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Tailoring the physico-chemical properties of starch-TiO₂ nanocomposites through the incorporation of different antioxidants

F. Parrino,^{1,*} N. Modena,¹ V. Zorzi,¹ S. Dalle Vacche,^{2,3} A. Vitale,^{2,3} R. Bongiovanni,^{2,3} L. Cipolla,⁴ S. Brocca,⁴ M. D'Arienzo,⁵ E. Callone,¹ R. Ceccato,¹ S. Dirè¹

¹ Department of Industrial Engineering, University of Trento, 38123 Trento, Italy; ² Department of Applied Science and Technology, Politecnico di Torino, 10129 Torino, Italy; ³ INSTM-Politecnico di Torino Research Unit, 50121 Firenze, Italy; ⁴ Department of Biotechnology and Biosciences, University of Milano-Bicocca, 20126 Milano, Italy; ⁵ Department of Materials Science, University of Milano-Bicocca, 20125 Milano, Italy

*francesco.parrino@unitn.it

Starch is a promising bio-material for sustainable food packaging applications, due to its abundance, low cost, and to the possibility of valorizing agri-food wastes.¹ However, intrinsic features such as water sensitivity and poor mechanical resistance, require modifications prior to use in this field.² In particular, the introduction of TiO₂ nanoparticles is reported to increase mechanical stability and confer photocatalytic properties, while the addition of antioxidants is often a viable way to prevent oxidative damages or suppress microbial growth. To this aim, the use of essential oils or natural extracts from rice straw, sunflower hull, or rosemary, has been proposed. However, the often unknown complexity of these mixtures makes impossible to correlate the chemical nature of the antioxidant species with the properties of the nanocomposites, posing serious hurdles during the steps of material development and optimization. In this contribution cinnamic, ferulic, and caffeic acid were used as antioxidants in starch based nanocomposites containing glycerol as the plasticizer and TiO₂ as the nanofiller. The films, obtained through solvent casting, were fully characterized by means of solid state NMR, X-ray diffraction and UV-vis spectroscopy. Customized water dissolution tests highlighted the water resistance of the films, while photocatalytic tests evidenced the capability of the antioxidants to prevent photoinduced oxidative damages. Results highlight the highly specific correlation between the structure of the antioxidants and the physico-chemical and functional properties of the nanocomposites.

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Novel ionic additives for safe and durable electrolytes in lithium-ion batteries

T. T. Borović,¹ M. E. Di Pietro,^{2*} Z. Novaković,¹ A. Roganović,¹ A. Mele,² S. Papović^{1*}

¹ Department of Chemistry, Biochemistry and Environmental Protection, Faculty of Sciences, University of Novi Sad, Republic of Serbia; ² Department of Chemistry, Materials and Chemical Engineering, Politecnico di Milano, Italy

*mariaenrica.dipietro@polimi.it

The development of high-energy density, safe and affordable energy storage devices is crucial for the energy transition. Lithium-ion batteries (LIBs) currently dominate the global energy storage market,¹ yet their safety and environmental impact remain significant concerns, mainly due to the use of highly flammable and toxic state-of-the-art electrolytes.² Improving electrolyte thermal stability and enhancing the overall safety of LIBs are therefore key priorities for the scientific community and society.

To address this challenge, we introduce novel zwitterionic additives for safer electrolytes. A series of zwitterion analogues (1-propylsulfonate-3-alkylimidazole and 1-butylsulfonate-3-alkylimidazole, with alkyl = methyl, ethyl or vinyl) were synthesized and comprehensively characterized.

The newly synthesized compounds were evaluated as additives in a commercial electrolyte consisting of 1.0 M LiPF₆ in a 50/50 mixture of ethylene carbonate and dimethyl carbonate. A comparative investigation of the physicochemical, thermochemical, and electrochemical properties of the additive-containing and baseline commercial electrolytes was carried out to assess the effectiveness of the proposed additives. The doped electrolytes preserved the key properties of the commercial electrolyte, including density, thermal expansion coefficients and adiabatic compressibility over a wide temperature range, while also exhibiting improved electrical conductivity and thermal stability. Galvanostatic measurements revealed increased electrode capacity upon addition of the sulfonate-containing zwitterions, together with improved capacity retention and Coulombic efficiency during extended cycling. Overall, this work highlights the potential of sulfonate-based zwitterionic additives to enhance both the safety and electrochemical performance of LIB electrolytes.

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Phase-guided design of layered $\text{Na}_x(\text{Mn,Ni})\text{O}_2$ cathodes: experimental phase maps and operando thermodynamics

O. Al Zeer,^{1,2,*} S. Vecchio Cipriotti,¹ S. Brutti²

¹ Department of Basic and Applied Sciences for Engineering (SBAl), Sapienza University of Rome;

² Department of Chemistry, Sapienza University of Rome

* omar.alzeer@uniroma1.it

Layered sodium transition-metal oxides (Na_xTMO_2) are among the most compelling cathodes for sustainable sodium-ion batteries targeting cost-driven stationary storage.¹ Yet, development in the Na–Mn–Ni–O space is still largely empirical, because experimentally validated phase fields and thermodynamic/thermal descriptors governing P2/P3/O3 stability, metastability and high-voltage degradation remain fragmentary.^{2,3} In practice, small variations in Na content and thermal history can shift the balance among polymorphs and multiphase assemblages, making optimization strongly non-intuitive. Here we propose an experimentally anchored, phase-guided workflow to build temperature-resolved ternary Na_2O – MnO_2 – NiO phase maps and translate them into actionable design rules for high-performance $\text{Na}_x(\text{Mn,Ni})\text{O}_2$ cathodes. Composition libraries will be synthesized via controlled solid-state routes (tuned Na excess, calcination dwell, quench vs slow-cool) to deliberately access layered single-phase regions and multiphase boundaries. Phase fields will be drawn by combining XRD/Rietveld refinement data, thermal analysis (DSC/TGA) and composition/morphology (SEM/EDX and ICP-OES). The link between phase stability and battery performance will be verified by screening representative compositions from distinct phase fields in Na half-cells by galvanostatic cycling, rate capability and electrochemical impedance spectroscopy. The main outcome is a thermodynamics-informed phase/performance atlas of the Na–Mn–Ni–O system, designed to replace trial-and-error with a reproducible compositional framework for robust layered cathode discovery in next-generation sodium-ion technology.

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Sustainable and innovative materials for advanced energy storage devices

F.A. Scaramuzzo,* L. Angeletti, S.H. Chenari, R.Y.S. Zampiva, M. Pasquali

Dipartimento SBAI, Sapienza Università di Roma, Via del Castro Laurenziano, 7 – 00161 Roma

*francesca.scaramuzzo@uniroma1.it

Lithium-ion batteries (LIBs) currently account for 78% of the world's battery energy storage system.¹ However, since the supply of lithium is becoming increasingly scarce, and at the same time material improvements are approaching saturation in LIBs technology, sustainable non-lithium-based alternatives need to be explored.²

Moving from its well-established experience in the development of innovative solutions for energy storage,^{3,4} ELEMeNT group is currently focusing on exploring advanced materials for sustainable and efficient beyond lithium systems, even exploiting alternative sources. Aiming to give an overview of our activities, here we will show some of our most recent results on (i) sustainable materials from agricultural waste for supercapacitors and (ii) advanced cathodes for zinc-ion batteries.

- i. Starting from rice husk, we synthesized carbon aerogels and graphene quantum dots that proved to be highly effective as electrodes for supercapacitors. Carbon aerogels display exceptional stability, with a capacitance retention up to 81.2 % after 10,000 cycles. As a subsequent step, we looked for a milder electrolyte and for mechanistic insight thanks to EC-AFM operando measurements.^{5,6}
- ii. V-based materials are widely exploited as cathodes for zinc-ion batteries for the various oxidation states and redox properties.⁷ We obtained vanadium oxides with different stoichiometry, finely tuning morphology and crystalline state. Besides a full physico-chemical characterization, the insertion/extraction of the Zn^{2+} has been optimized by changing the cycling conditions, electrode preparations and cell design. The devices based on the developed material proved to be robust, with long life cycle and good capacitance retention, particularly at high C rates.⁸

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Rational Design of Phosphorus-Functionalized PBAs-Derived Electrocatalysts for Oxygen Evolution Reaction

S.Maryam H. Vanhari,^{1,*} W. Freitas¹, M. Montalto¹, A. D'Epifanio¹, B. Mecheri¹

¹ Dept. Chemical Science and Technologies, University of Rome Tor Vergata, Via della Ricerca Scientifica, 00133, Rome, Italy.

*seyedehmaryam.hassanivanhari@uniroma2.it

The transition toward a hydrogen-based economy requires sustainable and economically viable routes for green hydrogen production. Among available technologies, anion exchange membrane water electrolyzers (AEMWEs) are considered promising for decarbonizing the energy system, as they enable hydrogen production from renewable electricity while operating under moderately alkaline conditions. However, the oxygen evolution reaction (OER) remains the main kinetic bottleneck due to its intrinsically sluggish multi-electron transfer mechanism. Therefore, the development of highly active and durable platinum-group-metal-free (PGM-free) electrocatalysts is essential.^{1,2} Herein, we report the optimisation of NiFe-based electrocatalysts derived from prussian blue analogues (PBAs), metal–cyanide coordination compounds that serve as promising precursors for highly active OER catalytic sites, owing to their high distribution of transition metals within a porous structure and their versatile functionalization with non-metals, such as phosphorus.³ The catalysts were synthesized *via* a mild aqueous precipitation method, followed by distinct phosphorus functionalization during thermal treatment at different conditions. The influence of the phosphorus incorporation strategy on the structural, morphological, and catalytic properties of the materials was systematically investigated through physicochemical and electrochemical characterization using a rotating disk electrode. Performance indicators, including overpotential, Tafel analysis, and stability metrics, confirm the beneficial effects of thermal treatment modulation and P-functionalization in forming and distributing Ni- and Fe-based phosphides within the catalyst's structure, thereby enhancing the OER activity of the materials in an alkaline electrolyte.

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Structural changes of $\text{La}_{0.6}\text{Sr}_{0.4}\text{Fe}_{0.6}\text{Mn}_{0.2}\text{Ni}_{0.2}\text{O}_{3-\delta}$ perovskite induced by reduction-oxidation cycles

I. Natali Sora^{1*}, R. Pelosato¹E, E. Di Bartolomeo², Anna Paola Panunzi², L. Duranti²

¹Department of Engineering and Applied Science, University of Bergamo, Dalmine, BG, Italy;

²Department of Chemical Science and Technologies, University of Rome Tor Vergata, Rome, Italy
isabella.natali-sora@unibg.it

The effect of 20 mol% B-site substitution on the structural behavior of $\text{La}_{0.6}\text{Sr}_{0.4}\text{Fe}_{0.8}\text{Mn}_{0.2}\text{O}_{3-\delta}$ (LSFM) perovskite under H_2 -reduction and air-oxidation cycles was investigated¹. As shown in Figure 1, LSFM reduction products under 5% H_2 at 850°C/2h are Ruddlesden-Popper (RP) phase + Fe^0 + MnO + residual perovskite. Under the same reduction condition, the perovskite phase is absent for $\text{La}_{0.6}\text{Sr}_{0.4}\text{Fe}_{0.6}\text{Mn}_{0.2}\text{Ni}_{0.2}\text{O}_{3-\delta}$ (LSFMNi) and the principal reduction steps are the formation of RP + NiFe phases. After cooling down to room temperature in reducing atmosphere, the sample was re-oxidized in air at 850 °C. The increase in the particle size of exoluted particles due to thermal treatment should be avoided to favor the restoration of the original perovskite phase.

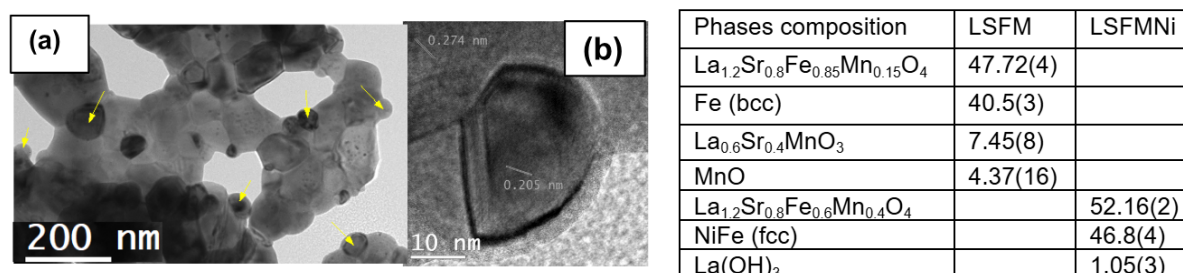


Figure 1. (a) TEM images of reduced LSFMNi: yellow arrows indicate NiFe exsolution. (b) Enlargement of a NiFe particle: 0.205 nm (111) $2\theta=43.67^\circ$. Phase compositions obtained by Rietveld refinement on XRD data of reduced powders (5% H_2 at 850°C/2h) are reported in the Table.

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Improved Synthetic Route Towards Advanced “Core-Shell” Carbon Nitride Electrocatalysts for the Oxygen Reduction Reaction

S. Boudjelida,^{1,2} P. Mattana,^{1,2} G. Pagot,^{1,2,3} K. Vezzù,^{1,2,3} V. Di Noto^{1,2,3}, E. Negro,^{1,2,3}

¹ Department of Industrial Engineering, University of Padova, and INSTM Via Marzolo 9, 35131, Padova, Italy; ² Gruppo Tematico ACee della Società Chimica Italiana and GISEL, Via Marzolo 9, 35131, Padova, Italy; ³ Centro Studi di Economia e Tecnica dell'Energia “Giorgio Levi Cases”, Via Marzolo 9, 35131, Padova, Italy

*enrico.negro@unipd.it

The development of advanced electrocatalysts (ECs) for the oxygen reduction reaction (ORR) is a key step towards the large-scale deployment of proton-exchange membrane fuel cells (PEMFCs). Achieving ORR ECs with a durability sufficient to meet practical application requirements remains highly challenging. Our research group has developed a synthetic route markedly different from those commonly reported in the literature.¹ The proposed ECs feature a “core-shell” architecture wherein a carbonaceous “core” is coated with a carbon nitride (CN) “shell”, whose C- and N-functionalities create “coordination nests” that stabilize the metal active sites.

A broad set of advanced analytical techniques is employed to characterize bulk composition, porosity, morphology, structure, surface composition, and chemical states. “Ex situ” electrochemical methods are used to identify ORR active sites (via CO stripping) and to evaluate ORR performance and reaction mechanisms by cyclic voltammetry with a rotating ring-disk electrode (CV-TF-RRDE). The ECs are further integrated into single PEMFCs and tested under various operating conditions, with particular attention to the effect of cathodic oxygen partial pressure and to the maximum power output of the device.

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Engineered organic-inorganic composite electrolytes for solid-state Mg batteries

P. Sgarbossa,^{1,*} F. Lanero,¹ G. Pagot,¹ V. Di Noto,¹ E.M. Dematteis,² M. Sgroi,² S. Rachidi,² E. Pregnotato,² M. Baricco,² A. Mazzucco,³ G. Capurso,⁴ N.D. Neehall,⁴

¹ Department of Industrial Engineering, University of Padova, via F. Marzolo 9, Padova I-35131, Italy; ² Department of Chemistry, NIS and INSTM, University of Turin, 10125 Turin, Via Pietro Giuria 7, 10125 Torino, Italy; ³ CRF S.C.p.A., Strada Torino 50, 10043 Orbassano (TO) - Italy; ⁴ Polytechnic Department of Engineering and Architecture, University of Udine, Via del Cottonificio 108, 33100 Udine, Italy

*paolo.sgarbossa@unipd.it

The realization of full solid-state magnesium batteries depends on solid electrolytes that simultaneously provide efficient Mg^{2+} ions transport, chemical compatibility with the electrodes, and adequate mechanical properties. Among the materials investigated for this purpose, complex hydrides have attracted considerable attention because of their structural versatility, diverse anion chemistry, and ability to accommodate defects. Nevertheless, crystalline borohydride exhibits limited Mg^{2+} mobility at ambient temperature, mainly due to strong electrostatic interactions and restricted diffusion pathways. In this study, we designed and developed innovative polymer-based composite electrolytes aimed at overcoming these intrinsic limitations. Both neutral and ionic functionalized polyketone¹ or polyphosphazene² polymers have been synthesized by conventional and microwave synthesis and combined with nanostructured magnesium borohydrides³ to engineer new composite electrolyte systems with improved ion transport. The mechanochemical preparation of these hybrid materials produces composites that reach ionic conductivities close to $10^{-4} \text{ S cm}^{-1}$ at room temperature, as revealed by impedance spectroscopy. The incorporation of hydride nanophases into polymer matrices represents a key strategy in the development of advanced polymer composite electrolytes, enabling improved mechanical robustness while preserving continuous pathways for Mg^{2+} migration.

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Cation-Exchange Ionomers for Selective Lithium Recovery from Geologic Brines: Physicochemical Characterization and Binding Mechanisms

K. Vezzù,^{1,2,*} G. Pagot,^{1,2} E. Negro¹, V. Di Noto^{1,2}

¹ Section of Chemistry for the Technology (ChemTech), Department of Industrial Engineering, University of Padova, Via Marzolo 9, I-35131 Padova (PD), Italy, ² National Interuniversity Consortium of Materials Science and Technology (INSTM), Via Marzolo 9, I-35131 Padova (PD), Italy

*keti.vezzu@unipd.it

A profound transformation of the global energy landscape is underway, driven by the need to reduce dependence on fossil fuels and expand renewable energy sources such as solar and wind. Because these resources are intrinsically intermittent, efficient energy storage systems are required to balance energy generation and consumption. In this context, lithium batteries (LiBs) have become one of the most promising technologies for storing renewable electricity and powering applications ranging from portable electronics to light-duty electric vehicles.

The rapid growth of LiB-powered vehicles has led to a sharp increase in lithium demand, placing pressure on conventional supply chains and contributing to rising prices. Lithium is currently classified by the European Union as a Critical Raw Material, prompting major efforts to identify alternative sources. Among these, geologic brines are particularly attractive due to their abundance and widespread availability. However, the selective and cost-effective extraction of Li^+ from brines remains challenging because of the much higher concentrations of competing cations such as Na^+ , Ca^{2+} , and Mg^{2+} .

In this work, a novel family of low-cost, chemically robust cation-exchange ionomers is introduced and systematically characterized in terms of cation-exchange capacity, morphology (scanning electron microscopy), and pore structure (nitrogen physisorption). Cation uptake kinetics are investigated using a synthetic brine containing Li^+ , Na^+ , K^+ , Ca^{2+} , and Mg^{2+} to determine the equilibrium binding behavior of each ion.

The study enables determination of key binding parameters, including the number of binding sites, cation coordination per site, and the maximum theoretical uptake, with particular focus on Li^+ . Correlations between ionomer physicochemical properties and binding behavior are established, providing guidelines for the design of improved materials for selective lithium extraction from geologic brines.

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Lead-free halide perovskites: synthesis and visible light photocatalytic applications

R. Ceccato,^{1,*} S. Dirè,¹ F. Parrino¹

¹ Department of Industrial Engineering, University of Trento, Via Sommarive 9, I-38123, Trento

*riccardo.ceccato@unitn.it

Among the novel materials developed for optoelectronic devices, like emerging photovoltaic technologies, perovskites have been extensively studied. In particular, the tuning of their architectures, leading to 3D-, 2D- and 1D- final structures, allows the enhancement of specific features, suitable for specific applications in various fields, like organic solar cells¹. To this aim, the realization of halide perovskitic structures have been pursued. At the same time, the search of less toxic elements for the final devices has gone with the increase of their efficiency². As a more recent field of application, halide perovskites, both inorganic and hybrid organic-inorganic, have been tested as photocatalysts, activated by the visible light³. In this study, bismuth-halogen based powders have been produced using low temperature reactions, starting with bismuth and cesium chlorides and iodides. Different solvents and reactant-to-solvent ratios have been employed in order to find out the best synthesis conditions. The structure of the obtained powders has been characterized by means X-ray diffraction analysis and Diffuse Reflectance UV spectra have been collected for the evaluation of resulting Energy gap values. Aqueous solutions of organic dyes have been employed as probes towards the photocatalytic performances of these samples, under the irradiation of visible light, using solar lamps. Obtained results have highlighted that the development of the perovskitic structure strongly affect their photocatalytic behavior. In fact, best results are obtained when a well-defined stoichiometric phase is obtained, whereas the onset of a solid solution between two crystalline phases negatively affect the efficiency of the photocatalyst, together with the structural stability of the sample. The efficiency of regenerated catalysts, after various working cycles, has also been evaluated.

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Novel nanocomposites for thermal management: effect of interfacial interactions on thermal conductivity

S. Dirè,^{1,*} C. Romeo,¹ E. Callone,¹ R. Ceccato,¹ G. Fredi,¹ I. Roppolo,² A. Vitale,²
R. Bongiovanni,² M. D'Arienzo,³ F. Parrino,¹

¹ Department of Industrial Engineering, University of Trento; ² Department of Applied Science and Technology, Politecnico di Torino; ³ Department of Materials Science, University of Milano - Bicocca

*sandra.dire@unitn.it

With the development of smaller and more powerful electronic components, issues related to heat dissipation have increased significantly, prompting research into novel thermal management materials (TMMs). Controlling material properties such as thermal conductivity (TC), thermal and mechanical stability, electrical insulation, and flexibility is essential for effective heat dissipation in flexible electronic devices. Polymers ensure electrical insulation and flexibility, but their TC is low, and the incorporation of ceramic fillers is a common strategy to enhance it. However, it should be noted that the properties of the polymer matrix and the filler-matrix interface affect the TC of nanocomposites (NCs)¹.

In this study, we investigated the influence of both covalent and weak interactions on the TC of novel NCs made of photocurable ladder-like polysilsesquioxanes (LPSQs), bearing only methacrylate (LPMASQ) and methacrylate/phenyl groups (MAPSQ), and Al₂O₃ nanoparticles (NPs) functionalized with both methacrylate (MA) and amino (AA) groups². NCs were prepared by solvent-casting and UV curing, and characterized by FTIR, solid-state NMR, XRD, SEM, TGA, and photo-rheology experiments. The TC of samples was calculated from the experimental values of density, specific heat capacity, and thermal diffusivity. The introduction of MA NPs improved the TC of LPMASQ, due to the reduction of interfacial thermal resistance by copolymerization with the matrix, while the addition of AA was detrimental, as the reduced dispersibility of the NPs and the filler-matrix interactions negatively affected the organization of the LPMASQ chain and reduced the TC. On the contrary, the TC of MAPSQ samples increased significantly with the addition of both MA and AA: despite reduced polymerization, the phenyl groups promoted the formation of a densely packed ladder structure due to π - π stacking interactions; the development of effective weak interactions with the NPs further promoted heat transfer, improving thermal diffusivity. These results provided useful insights for the design of new TMMs, highlighting that the balance between covalent and weak interactions is a powerful tool for optimizing TC in NCs.

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An Ab initio analysis of V-doped WSe₂ as emerging materials for THz applications

E. Pavoni,^{1,*} E. Mohebbi,¹ M. Petroselli,¹ A. Civitavecchia,¹ S. Sabbatini,¹ D. Mencarelli,² L. Pierantoni,² E. Laudadio,¹ P. Stipa¹

¹ Department of Matter, Environmental Sciences, and Urban Planning, Marche Polytechnic University, 60131 Ancona, Italy.; ² Department of Information Engineering, Marche Polytechnic University, 60131 Ancona, Italy.

*e.pavoni@staff.univpm.it

Tungsten diselenide (WSe₂) is a material whose remarkable properties have drawn significant scientific interest¹. This work presents a computational study using first-principles methods to investigate the optical and electronic properties of WSe₂. The analysis employed density functional theory (DFT) using the Perdew-Burke-Ernzerhof (PBE) exchange-correlation functional within the Generalized Gradient Approximation (GGA) framework, along with PseudoDojo pseudopotentials. Both bulk and monolayer configurations were examined to assess how the number of layers influences the behavior of the material. To deepen the investigation, four vanadium-doped WSe₂ systems were studied from both optical and electronic points of view, with dopant concentrations of: (i) 1.4%, (ii) 2.8%, (iii) 5.6%, and (iv) 11.2%. The inclusion of vanadium led to a reduction in the bandgap and a redistribution of the projected density of states. Moreover, the Valence Band Maximum (VBM) shifted across the Fermi level, in agreement with the p-type character typically associated with vanadium doping. Furthermore, vanadium incorporation produced measurable changes in the absorption spectra, affecting both the position and intensity of the optical transitions².

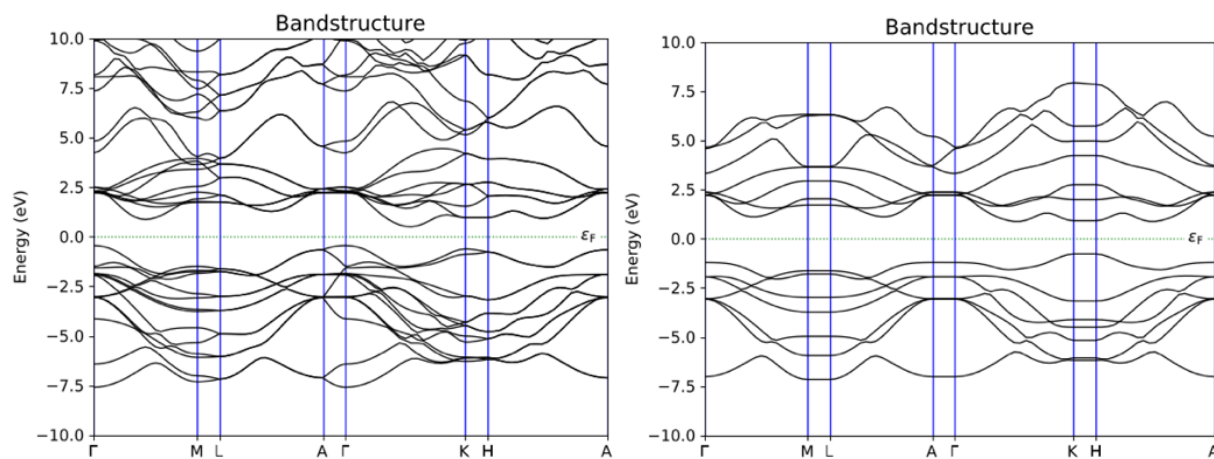


Figure 1. Electronic band structure of bulk (left) and a single layer (right) of WSe₂.

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Temperature-dependent microspectroscopy of Egyptian Blue crystals and exfoliated nanosheets

E. Lunedei^{1,*}, M. Goudjil^{1,2}, M. Nicola³

¹ Institute for the Study of Nanostructured Materials (ISMN-CNR), Via P. Gobetti 101, 40129 Bologna, Italy; ² Department of Industrial Engineering (DIEF), University of Florence, Via S. Marta 3, 50139 Florence, Italy; ³ Department of Chemistry, University of Turin, Via Giuria 7, 10125, Turin, Italy
*Eugenio.Lunedei@cnr.it

Egyptian Blue (EB, $\text{CaCuSi}_4\text{O}_{10}$ or *cuprorivaite*, Fig.1a), a two-dimensional Cu^{2+} -bearing silicate with a 5000-years long history as a blue pigment¹, is an efficient near-infrared (NIR) emitting material. Progresses in understanding how its optical properties correlate with electronic structure have been mainly limited by lack of sufficiently pure crystalline samples, with minimal amorphous content. Starting from nanosilica, we synthesized EB powder with over 70% crystallinity using an optimized patented method². Making use of temperature-dependent absorption and emission microspectroscopy techniques (77 K – 420 K) both on crystalline powder and exfoliated nanosheets, we analysed the continuous modulation of the weakly allowed, parity-forbidden d-d transitions characteristic for Cu^{2+} complex in D_{4h} symmetry ($2B_{1g} \rightarrow 2B_{2g}$, $2B_{1g} \rightarrow 2E_g$, $2B_{1g} \rightarrow 2A_{1g}$), within a square planar ligand field (Fig.1b). The observed decreasing of photoluminescence intensity upon heating, with a marked red-shift and band broadening, was interpreted in terms of crystal thermal expansion and enhanced electron-phonon coupling (Fig.1c). Even in exfoliated nanosheets absorption and emission spectra exhibit bands, rather than sharp lines, as a consequence of a very strong vibronic coupling, together with a large Stokes shift. Low-temperature emission band was deconvoluted into two components (~ 1.43 eV and ~ 1.38 eV) whose relative intensity varies with temperature, providing a direct measure of a sublevel splitting of the excited-state. This insight into the luminescence properties is fundamental to optimize the design of efficient NIR-emitting devices based on Cu silicates.

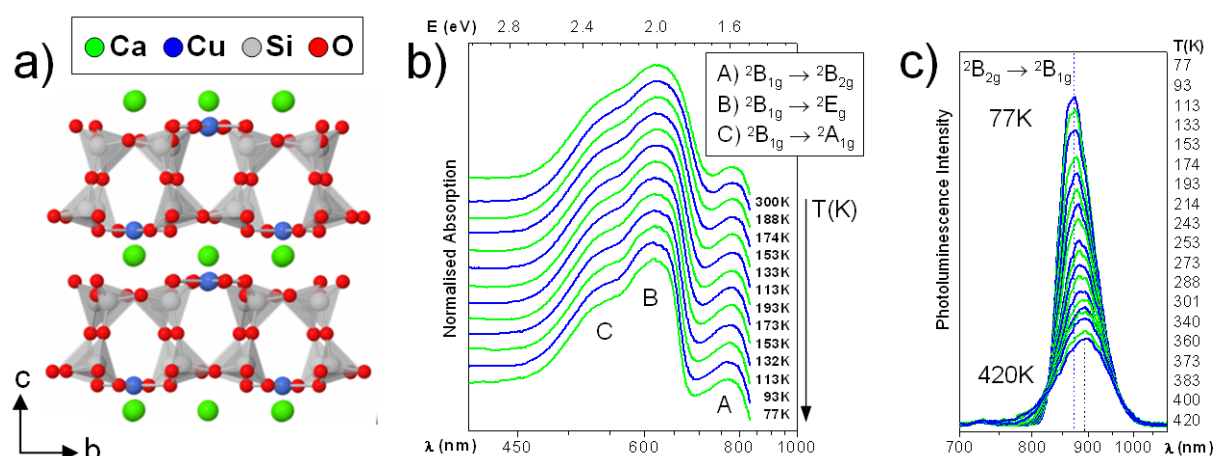


Figure 1 a) $\text{CaCuSi}_4\text{O}_{10}$ crystal structure; b) normalised optical absorption ($T = 300\text{K} - 77\text{K}$) and band assignment; c) crystal emission: relative intensity, position and FWHM change with T .

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Sol-gel synthesis of nonlinear optical materials

A. Aronne,^{1,*} L. Sirleto,² Z. Iqbal,² I. Mazzuoccolo,¹ I. Climaco,¹, A. Vergara,³, A. Bifulco,¹ C. Imparato,¹

¹ Department of Chemical, Materials and Production Engineering, University of Naples Federico II, P.le Tecchio, 80, I-80125 Naples, Italy ; ² National Research Council, Institute of Applied Sciences and Intelligent Systems, Via Pietro Castellino 111, I- 80131 Naples, Italy; ³ Department of Chemical Science, University of Naples Federico II, Via Cinthia, I-80126 Naples, Italy

*anaronne@unina.it

Nonlinear optical (NLO) materials play a key role in photonics because of are widely used for generating quantum light.¹ Glassy and/or crystalline nanostructured materials with significant NLO properties obtained by sol-gel represent a remarkable alternative to traditional NLO materials due to the intrinsic versatility of the synthetic technique. Here, sol-gel nanomaterials belonging to Nb₂O₅-SiO₂, ZrO₂-SiO₂ and TiO₂-SiO₂ binary oxide systems, with variable contents of high polarizable element, were synthesized by cost-effective sol-gel routes inspired to the circularity criteria of Green Chemistry and energy-efficient protocols.

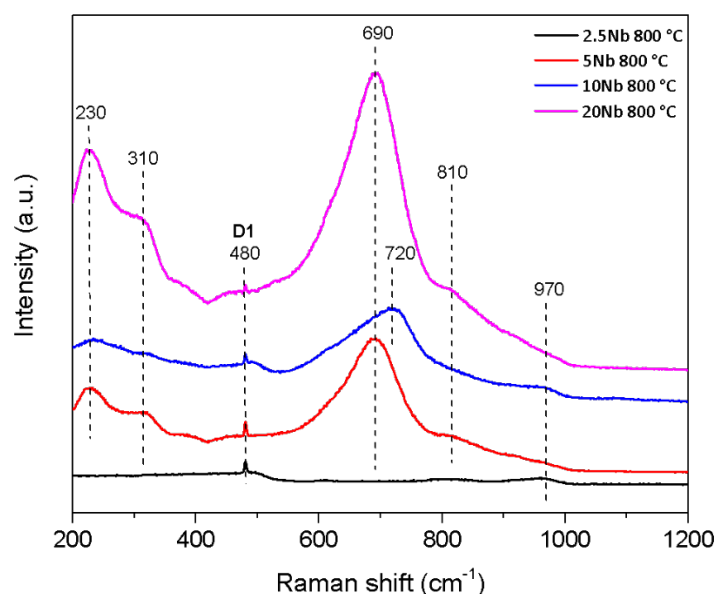


Figure 1. Raman spectra of Nb₂O₅-SiO₂ samples annealed for 1 h at 800 °C

Third order nonlinear susceptibility $\chi(3)$ of some nanostructured samples were measured by Z-scan technique obtaining very promising values for nonlinear and quantum optics applications.

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Improvement of the morphological features and functional properties of non-covalently functionalized carbon nanotubes and graphite nanosheets

M. Raimondo,^{1,*} L. Guadagno,¹

¹ Department of Industrial Engineering, University of Salerno, Via Giovanni Paolo II, 84084 Fisciano, Italy

*mraimondo@unisa.it

In this work, we demonstrate that both carbon nanotubes (CNT) and graphite nanosheets (G) have been successfully modified by π -stacking interactions with a py-rène derivative (PY) to give, respectively, the functionalized nanofillers CNT-PY and G-PY, which were dispersed within an aeronautical epoxy matrix. The modification protects the electronic properties of the carbon nanotubes and graphite nanosheets, while also improving their dispersion due to lower viscosity. This leads to better rheological properties and overall performance of the nanocomposites compared to those with unmodified CNT and G. The enhancements include better electrical properties, self-healing capability, and thermal stability. The efficient dispersion of carbon-based nanofillers results in superior composites for advanced applications. Tunneling Atomic Force Microscopy (TUNA) is used to examine the morphological features of the carbon nanofillers, their dispersion in the matrix, and how the modification affects electrical pathways and conductivity at micro- and nanometer levels.¹ Figure 1 shows the schematic drawing of TUNA apparatus.

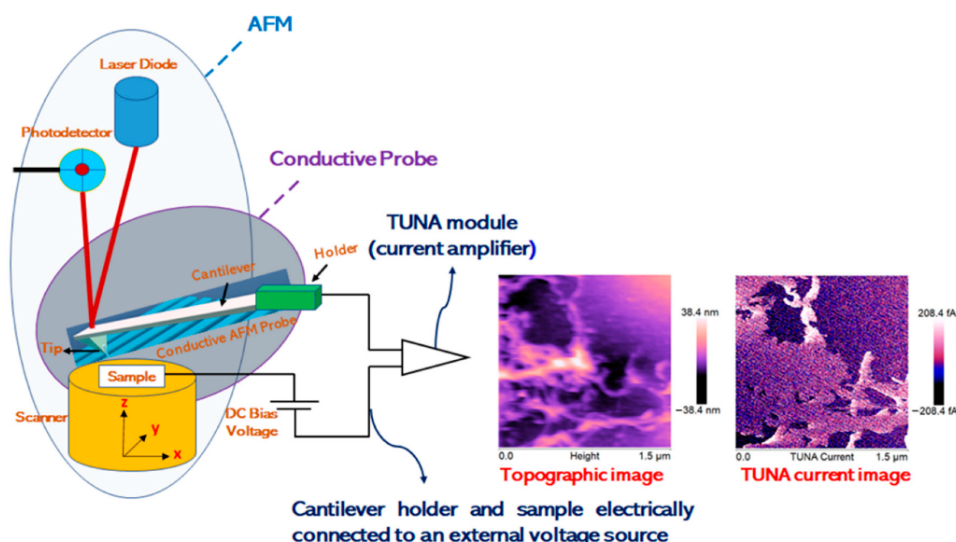


Figure 1. Schematic drawing of TUNA apparatus.

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Recycling Spent Li-Ion Battery Materials into Pd-Based Catalysts for Biomass Upgrading

Giulia Maria Itri^{1,2}, Francesco Mauriello¹, Andrea Donato¹, Tapio Salmi³, Emilia Paone¹

¹ Università degli Studi Mediterranea di Reggio Calabria, Italy; ² Università degli studi di Perugia, Italy; ³ Åbo Akademi University, Finland
giulia.itri@unirc.it

The continuously growing amount of electronic waste represents a major environmental and resource-related challenge, mainly due to the presence of critical and valuable metals in spent lithium-ion batteries (LIBs).¹ However, these complex waste streams can also be considered a valuable resource for the development of heterogeneous catalysts or catalyst supports, enabling the direct valorization of metal-containing materials for catalytic applications. In this work, a Pd/LiCoO₂ catalytic system was investigated for the hydrogenation of furfural, an important platform molecule derived from lignocellulosic biomass (Fig.1). LiCoO₂ was selectively recovered from spent LIB cathodes through a simple mechanical separation process and directly employed as catalyst support, avoiding conventional hydrometallurgical or pyrometallurgical treatments typically required for metal recovery. Palladium was subsequently introduced by impregnation to generate the active catalytic phase and to exploit potential synergistic effects between Pd and the cobalt-containing support. Cobalt species are known to promote strong metal-support interactions and enhance catalytic performance in hydrogenation reactions.² The catalytic material was characterized by several physicochemical techniques, highlighting the role of the LiCoO₂ matrix in promoting strong interactions with palladium species, which significantly influence catalytic performance. The Pd/LiCoO₂ catalyst exhibited high activity and selectivity in furfural hydrogenation, producing mainly furfuryl alcohol (FAL) and tetrahydrofurfuryl alcohol (THFA) under mild conditions (150 °C).³ Overall, this work demonstrates a viable waste-to-catalyst strategy that effectively integrates e-waste valorization with biomass upgrading, providing a sustainable pathway toward the development of high-performance catalytic materials within a circular economy framework.

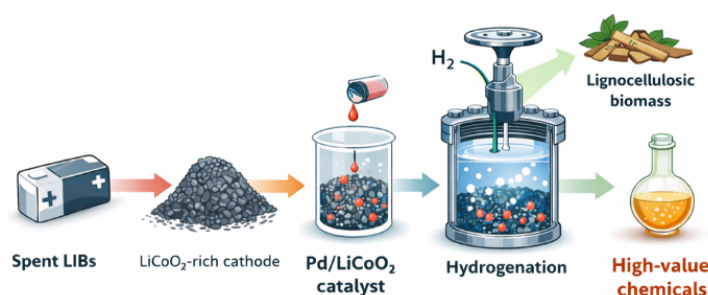


Figure 1. Schematic illustration of Pd/LiCoO₂ catalyst preparation from spent LIBs and its application in furfural hydrogenation.

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