XV CONGRESSO INSTM

SULLA SCIENZA E TECNOLOGIA DEI MATERIALI

7-10 giugno 2026
GENOVA

BOOK OF ABSTRACTS

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ISTITUTO ITALIANO DI TECNOLOGIA

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Cari amici e colleghi,

è con grande piacere che vi diamo il benvenuto al **XV Convegno INSTM sulla Scienza e Tecnologia dei Materiali**. Come da tradizione, il Convegno rappresenta un importante momento di incontro e confronto per tutti coloro che operano, a diverso titolo, nel campo della Scienza e Tecnologia dei Materiali, offrendo un contesto privilegiato per favorire il dialogo, stimolare nuove interazioni e promuovere opportunità di collaborazione all'interno della vasta comunità scientifica INSTM.

Nel corso del Convegno saranno presentate le attività di ricerca sviluppate dagli afferenti INSTM e verranno affrontate le nuove sfide scientifiche e tecnologiche che coinvolgono il Consorzio. L'evento costituirà un'occasione preziosa per **discutere aspetti fondamentali, innovativi e applicativi della scienza dei materiali**, incoraggiando un approccio interdisciplinare e una sempre maggiore integrazione tra competenze e ambiti di ricerca differenti.

Il **programma scientifico** alternerà momenti di approfondimento specialistico, tra cui la tavola rotonda "Materiali avanzati per la competitività industriale: strategie italiane ed europee" e la sessione dedicata all'Accordo CNR-INSTM, a sessioni interdisciplinari di carattere più generale. Particolare attenzione sarà inoltre riservata ai **giovani ricercatori**, ai quali verrà offerto uno spazio dedicato per valorizzare idee, competenze e prospettive innovative. Per la prima volta, infatti, il Convegno ospiterà una sessione specificamente dedicata ai giovani emergenti, con l'obiettivo di favorire la nascita di nuove collaborazioni e progetti di ricerca condivisi. Il programma scientifico prevede **8 keynote lectures, 100 contributi orali (60 Oral e 40 Short Oral), 83 poster, una plenary lecture** e sarà articolato nelle seguenti **cinque sessioni tematiche**:

- Materiali e tecnologie per il manifatturiero avanzato, il Made in Italy e l'aerospazio
- Materiali e tecnologie per l'energia, la transizione ecologica e la mobilità sostenibile
- Materiali e tecnologie per l'economia verde e l'economia circolare
- Materiali e tecnologie per il costruito e il patrimonio culturale
- Materiali e tecnologie per le scienze della vita e dell'alimentazione

Nel complesso, il programma offrirà contributi provenienti da **università, centri di ricerca e industrie**, delineando un panorama ampio e altamente qualificato delle attività di ricerca nel settore dei materiali. Questo ricco e stimolante programma è raccolto nel presente Libro Atti, disponibile in formato elettronico per tutti i partecipanti e gli sponsor.

Desideriamo esprimere **un sincero ringraziamento** ai membri del Comitato Organizzatore, del Comitato Scientifico e a tutto lo staff INSTM di Firenze per l'impegno e la professionalità dimostrati. **Un sentito ringraziamento va inoltre agli Sponsor e agli Enti patrocinanti**, per il loro fondamentale supporto e per la costante attenzione verso la Ricerca e l'Innovazione.

Ci auguriamo che questo Convegno possa rappresentare per tutti voi un'esperienza scientifica stimolante, proficua e piacevole, almeno quanto lo è stata per noi la sua organizzazione.

I Chair Genova, 7 giugno 2026

Prof. Domenico Caputo
Prof. Andrea Caneschi

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KEYNOTES

KN1

Metal halide nanocrystals: synthesis, growth mechanisms, reactivity, assembly

Manna L[1]

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Halide perovskite, and metal halides in general, can merge the highly efficient operational principles of conventional inorganic semiconductors with the low temperature solution processability of emerging organic and hybrid materials, offering a promising route towards cheaply generating electricity as well as light. Following a surge of interest in this class of materials, research on colloidal metal halide nanocrystals (NCs) has gathered momentum in the last decade. I will highlight several findings of our group on their synthesis, for example our recent study on the influence of various exogenous cations and of acid-based equilibria on the growth of halide perovskite NCs, which can lead to the formation of NCs with peculiar shapes (for example core-shell and hollow structures) and to NC heterostructures (for example perovskite-chalcogenide or perovskite-chalcohalide dimers) by promoting/suppressing the heterogenous nucleation of selected materials. The reactivity of these heterostructures towards exchange reactions and their potential use in catalysis will also be discussed. I will also present how we can computationally predict the feasibility of such heterostructures, based on interfacial matching, using software tools developed in collaboration with other groups. Superstructures of perovskite nanocrystals are also capturing the attention of the community, for example for what concerns their collective optical behavior. I will present our findings on the ordering of nanocrystals in superstructures, especially on how this is related to the specific surface ligands and how it influences exciton diffusion processes.

KN2

Perovskites, photocatalysis, and chirality: from materials design to function

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Compositional design is a central yet often underappreciated driver of materials functionality, extending far beyond simple elemental substitution. In this contribution, we frame materials development as a process of cultivation, where deliberate compositional choices during growth encode structure, defects, and interfaces that ultimately determine function. Rather than treating composition as a static parameter, we emphasize its dynamic role in directing structural dimensionality, lattice distortions, and electronic landscapes. Focusing on perovskite-based materials, we demonstrate how compositional tuning across inorganic frameworks and organic components enables precise control over dimensionality, symmetry, and interfacial chemistry. Such control governs charge localization, transport, and reactivity, allowing functionality to be programmed at the solid-state level. We further show that compositional asymmetry can be exploited to introduce chirality directly into the lattice, generating enantiodifferentiating and spin-selective environments without relying on molecular chiral additives. By integrating compositional design with growth chemistry and structure–property relationships, this work outlines a materials-by-design paradigm in which function is cultivated through rational control of composition across multiple length scales. This approach provides general design principles for adaptive and multifunctional materials, advancing materials chemistry beyond trial-and-error synthesis toward predictive compositional engineering.

KN3

ALD-Derived Ni–Co oxide thin films for alkaline water electrolysis: preliminary results from the H2GreenCoat project

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The transition toward sustainable energy systems has positioned green hydrogen as a key energy vector. However, the widespread deployment of water electrolysis technologies is still limited by efficiency, durability, and cost issues. In this context, the H2GreenCoat project (funded by the Italian Ministry of University and Research under the Fondo Italiano per le Scienze Applicate, Avviso n. 1075 of 18 July 2024, Project Code FISA-2024-00112 "H2GreenCoat - Hybrid Coating Technologies to Produce Green Hydrogen by Water Electrolysis", granted by Decree prot. n. 18365 of 20 November 2025 CUP: D73C25001300001; D33C25001000001). aims to develop advanced hybrid coating strategies based on the integration of Atomic Layer Deposition (ALD) and Physical Vapor Deposition (PVD), targeting improved performance and durability of electrolyzer components across different technologies. By combining conformal thin-film depositions with interface engineering, and minimizing the use of critical raw materials, these approaches enable precise control over catalyst composition and thickness, with particular attention to coatings on complex 3D substrates. As a first step of the project, Ni-, Co- and mixed Ni-Co- oxides ($NiCoO_x$) thin films were deposited by thermal ALD using metallocene precursors and ozone as oxidant. Coatings were realized on both planar and porous conductive substrates and physico-chemically characterized. Electrochemical tests were carried out in alkaline media to assess catalytic activity toward hydrogen and oxygen evolution reactions (respectively HER and OER). The ALD process enabled uniform and conformal growth of Ni- and Co-based oxide thin films on different substrates materials and geometries. Mixed oxide coatings showed homogeneous elemental distribution and the presence of mixed crystalline phases, while maintaining good adhesion and structural integrity. Preliminary electrochemical measurements indicate promising activity for both HER and OER, with performance trends depending on both catalyst architecture and substrate. These early results demonstrate the potential of ALD-derived Ni and Co oxides as cost-effective electrocatalysts for alkaline water electrolysis. Although still at an initial stage, the observed activity and stability are encouraging and support further optimization. Ongoing work is focused on tuning composition and architecture, as well as evaluating the most promising electrodes under more application-relevant conditions, including laboratory-scale anion exchange membrane water electrolysis cells. The integration with PVD processes within the H2GreenCoat framework is expected to further enhance performance and enable scalable manufacturing strategies.

KN4

Giving space to surfaces: their role in polymeric materials

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Surface science has developed into an exciting field, delving into the intriguing world of interfaces. In fact, it has been recognised that bulk materials can show significant compositional changes at their outermost layers. Moreover, with reference to polymeric materials, surfaces can be even more relevant than bulk as paints and coatings, adhesives, fibres are characterized by a surface to volume ratio highly exceeding unity. Thus, understanding surface composition and behaviours, besides encompassing the description and assessment of thermodynamic properties, is mandatory. First, it means predicting wettability, adhesion, friction, wear, biocompatibility, etc. Then, properties and phenomena occurring at the surfaces/interfaces, between different states of matter (e.g. a polymeric layer against air) and/or between different types of materials, (e.g. a polymeric matrix and its reinforcing fibres), determine both daily operations, like cleaning of a textile, and technological advancements, from developing of novel products and industrial processes to the designing of cutting-edge applications. To this aim, a set of technologies of surface engineering, also applied to consumer goods, are currently available to modify the surface/interface of polymers and enhance their performance or introduce new functionalities. The present talk gives an overview of the research on polymeric surfaces we have been implementing for a long time. After describing the main tools and strategies chosen for characterizing and modifying surfaces, examples of novel materials and their potential applications will be given, including superhydrophobic coatings, microfluidic devices, functional textiles and cellulose composites. Finally, the INFI-PA6-RECO project, recently launched, involving Politecnico di Torino, INSTM and Aquafil SpA will be introduced. Supported by FISA2024, it concerns polyamide 6 and its applications as textile fibres, nanofibers for filtration membranes and composites, with a sound commitment to sustainability and recyclability.

KN5

The GISEL-INSTM National Centre of Reference for electrochemical energy storage systems: community, achievements and initiatives

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The Italian Group for Electrochemical Energy Storage (GISEL), operating as a National Reference Center within the National Interuniversity Consortium for Materials Science and Technology (INSTM), represents Italy's primary coordination hub for advanced research in electrochemical storage systems. Established to unify fragmented academic research groups, GISEL aggregates key national expertise to compete effectively in European funding programs, such as Horizon Europe, and to foster Italy's technological independence in the battery sector. Between 2021 and 2026, the GISEL-INSTM network has solidified its role as a strategic pillar for electrochemical storage in Italy through high-profile initiatives and the coordination of complex research projects. On the events front, the organization of the IWES (Italian Workshop on Energy Storage) and the ACee-GISEL joint conferences stand out as the primary national forums for academic and industrial synergy. Great emphasis has been placed on excellence through the Elettra Awards, which recognize the most innovative contributions from young researchers in the field. Regarding project leadership, GISEL has steered significant national consortia such as ORANGEES (Organic materials for sustainable electrochemical energy storage) and G2G (Gas2Graphite), focusing on the development of organic materials and "green" recycling processes for batteries. At the European level, the network has actively participated in several Horizon Europe calls, contributing to the BATTERY 2030+ roadmap and safety-focused storage initiatives. These efforts have successfully integrated Italian expertise into European strategic agendas, promoting the use of non-critical raw materials and circular solutions, while ensuring a globally recognized scientific leadership in the energy transition.

KN6

L’Innovazione tecnologica di Michelin nella fabbricazione pneumatici in Italia: dall’estrusione complessa all’AI

Ambrogio M[1]

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La presentazione offre una panoramica completa del Gruppo Michelin, con un focus particolare sulla presenza e sul ruolo strategico dell’Italia, in particolare del sito di Cuneo, quale centro chiave di innovazione, sviluppo e produzione. Nel 2024 Michelin si conferma leader globale nel settore degli pneumatici e dei materiali ad alte prestazioni, con 129.800 dipendenti, 175 siti produttivi in 45 Paesi e investimenti annui in innovazione pari a 1,2 miliardi di euro. Le vendite globali raggiungono i 27,2 miliardi di euro, con una forte presenza nei mercati automotive, trasporto pesante, soluzioni “beyond road” e materiali compositi. In Italia, Michelin rappresenta il primo produttore di pneumatici ed il principale datore di lavoro del settore, con oltre 3.800 dipendenti, una capacità produttiva superiore ai 14 milioni di pneumatici/anno e un fatturato 2024 di circa 2 miliardi di euro. Il periodo 2021–2025 vede investimenti pari a 432 milioni di euro in Italia, a conferma della centralità del Paese per l’innovazione di prodotto e di processo. La presentazione approfondisce la struttura e la composizione dello pneumatico, evidenziandone l’elevata complessità (fino a 30 componenti e circa 200 materiali), e analizza i principali meccanismi fisici dell’aderenza (ingranamento e adesione), il comportamento viscoelastico della gomma e le strategie per ridurre la resistenza al rotolamento, conciliando sicurezza, prestazioni ed efficienza energetica. Un’ampia sezione è dedicata all’innovazione di processo, con il progetto KADEL presso il sito di Cuneo, che introduce nuove tecnologie di co-estrusione ad alta complessità e controllo volumetrico per migliorare qualità e riduzione degli scarti oltre a fornire prodotti contraddistinti da un sensibile gap prestazionale rispetto alle gamme precedenti. Infine, viene illustrato l’utilizzo avanzato dell’Intelligenza Artificiale e della Computer Vision in Michelin: dai sistemi IRIS per il controllo qualità automatico degli pneumatici, alla manutenzione predittiva, fino all’AI generativa per l’estrazione e l’analisi dei dati. L’AI viene presentata come strumento di supporto all’uomo, capace di aumentare l’efficienza, la qualità e il valore aggiunto dei processi industriali, senza sostituire il ruolo umano. Particolare attenzione viene anche rivolta a cosa si è appreso dall’utilizzo dell’intelligenza artificiale: cambiamento dei profili professionali richiesti, velocità di obsolescenza dei device nonché il ruolo centrale del machine learning.

KN7

Halloysite clay nanotubes: sustainable materials for conservation of Cultural Heritage

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Halloysite clay nanotubes are natural fillers with a hollow tubular morphology that can be exploited for the development of functional materials useful in a wide range of applications, including environmental remediation, drug delivery and conservation of Cultural Heritage. Halloysite nanotubes (HNTs) are natural aluminosilicates with unit formula $Al_2Si_2O_5(OH)_4 \cdot 2H_2O$. Depending on the geological source, the dimensions of the hollow tubular nanoclay may vary from 50 to 100 nm for the external diameter, from 15 to 50 nm for the inner diameter and from 0.2 to 3 μm for the length. Within Cultural Heritage applications, halloysite has been recently explored for coating protection of stone surfaces and historical wool yarns guaranteeing reinforcement and photo-protection. It was proved that aqueous dispersions of keratin and halloysite can be used for dipping coating of wool threads inducing improvements of the tensile resistance and UV-shielding capacity due to the synergistic actions of protein and clay nanotubes, which increase the light reflectivity. Moreover, halloysite is efficient to develop innovative technologies for surface cleaning of different types of materials, such as glass, paintings and marble. Biopolymeric gels with HNTs stabilized hydrocarbons droplets (such as isooctane and decane) are efficient for surface cleaning as demonstrated by wettability tests and colorimetric analyses. Recently, a novel sustainable cleaning system for corroded copper surfaces was developed by incorporating a W/O Pickering emulsion into a polyhydroxybutyrate-based organo-gel. Halloysite clay nanotubes are proper fillers for consolidation and deacidification of lignocellulosic artworks, including archaeological woods and papers. The loading of HNTs cavity with alkaline compounds, such as calcium hydroxide and magnesium oxide, led to obtain modified nanotubes that can protect the structure of lignocellulosic materials from acidic attack preventing their compactness and mechanical resistance. In addition, Pickering emulsions based on wax and halloysite nanotubes have been successfully employed for consolidation of waterlogged archeological woods. The filling of the wooden channels with microwax particles (stabilized by HNTs at their interface) significantly improved the robustness and compression resistance of archeological woods. Recently, adsorbent materials for CO_2 and VOCs compounds have been developed by incorporating HNTs within gel systems based on biopolymers, including alginate and chitosan. The capturing capacity of the composite biopolymer/HNTs gels can be promising for preservation of artworks collected in museum environments. The attained knowledge highlights that clay nanotubes are proper nanomaterials to develop ecocompatible protocols for conservation and restoration of Cultural Heritage within a wide range of applications.

KN8

Development and characterization of foamy albumin-based bioinks for 3D bioprinting of sinonasal tumor models

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The development of sustainable, bio-based materials for additive manufacturing is a key challenge in extrusion-based 3D printing technologies. Conventional hydrogel inks often suffer from limited intrinsic porosity, restricted mass transport and poor structural stability. Foamed hydrogels represent a promising strategy especially in bioprinting applications. Here, foamy bioinks based on natural polysaccharide and protein mixtures, i.e. sodium alginate (SA) and albumins, were developed and characterized, showing their possible application as 3D models of sinonasal cancers (SNCs). Foamy inks were obtained mixing SA with either bovine serum albumin (BSA) or ovalbumin (OVA) as natural foaming agents by high-speed mechanical stirring, promoting controlled air incorporation. The effects of SA concentration, albumin type and sodium dodecyl sulphate (SDS) on foam stability and printability using pneumatic extrusion 3D printing were studied. Calcium chloride served for crosslinking. Characterization included: mechanical (rheology), printability, gel fraction, swelling, physico-chemical, morphological (after freeze-drying) and biological analyses, the latter assessing viability of bioprinted primary intestinal-type adenocarcinoma (ITAC) cells from SNC. The selected formulations had 4% SA, 12% OVA (or BSA) (w/v) in water with (or without) 0.05% (w/v) SDS. Inks exhibited shear-thinning behavior, with viscoelastic properties dependent on albumin type and surfactant presence. OVA-based foams showed enhanced stability and print fidelity compared to BSA ones. FT-IR spectroscopy showed stable interactions among components. Adding SDS did neither increase foam lifetime nor gel fraction, while reducing hydrogel swelling. SEM analysis revealed highly porous matrices, preserved after freeze-drying and rehydration, with larger pore size (up to 100-200 μm) in samples without SDS, chosen for bioprinting. ITAC cell viability resulted > 90% after 72 h. SA/OVA foams were the best performing formulations. These findings highlighted fully natural foams as advanced material platforms for extrusion-based 3D bioprinting. EU Commission & Italian Minsitry of Health - PNRR-TR1-2023-12377661 ”Rare cancers of the head and neck: a comprehensive approach combining genomic, immunophenotypic and computational aspects to improve patient prognosis and establish innovative preclinical models (RENASCENCE)” CUP (D53C24000830006).

ORAL

O1

Synthesis and characterization of metal organic cluster and frameworks for energy and environmental applications

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Metal-organic frameworks (MOFs) and metal-oxo clusters (MOCs) are structures composed of multiple metal centres linked to each other via bridging oxygen atoms, that can evolve into porous crystalline structures with the aid of organic linkers. The properties of both metal ions and linkers determine the physical, structural, and morphological features of MOFs and MOCs, and these features make them suitable for a wide range of interesting applications ranging from energy to environmental protection, such as the fields of photocatalytic redox reactions, like water splitting or organic pollutant degradation, or the fields of optoelectronic and luminescence emission. The aim of this study was the synthesis of titanium-based metal-organic frameworks (Ti-MOF) built on poly-oxo titanium cluster (PTC) functionalized with a multidentate organic ligand. Samples were prepared through a building block approach, by means of a one-pot reaction, which involved the preliminary synthesis of the zero-dimensional cluster $[Ti_6O_4(OiPr)_{10}(O_3P\text{-}Phen)_2]^{2+}$ (OiPr = isopropyl group, O_3P-Phen = phenylphosphonic acid), functionalized with isonicotinic acid and labelled as (PTC-3). Subsequently, our aim was to operate modifications to the cluster to extend its dimensionality, by using silver nanoparticles or by the approach of ligand exchange reactions, using polycarboxylic ligands. Several variables involving the synthesis were investigated through a multivariate approach in order to identify the conditions which best promoted the crystals growth's process and all the synthesized compounds were characterized by means of powder X-Ray diffraction (PXRD), Fourier-transformed IR spectroscopy (FTIR), Brunauer-Emmett-Teller method (BET), and UV-Vis diffuse reflectance spectroscopy (DRS). The synthesis of both PTC-3 and PTC-3@AgNPs was successfully achieved through the solvothermal method, and AgNPs could be incorporated within the structure. In parallel, the synthesis was replicated by replacing isonicotinic acid with polycarboxylate ligands (2-amminoterephthalic acid, 2,5-pyridinedicarboxylic acid and 1,3,5-benzenetrycarboxylic acid) to increase the dimensionality of the structure and obtain an extended framework. The most promising T-MOF were tested towards the adsorption and the photocatalytic degradation of methylene blue (MB) in aqueous solutions and both samples showed promising results as adsorbents and as catalyst while in combination with hydrogen peroxide. According to the well-known properties of AgNPs, such as excellent electrical conductivity, chemical stability, catalytic, and antimicrobial properties, the application's fields of the composite material (PTC-3@AgNPs) could be broadened, by simply exploiting the presence of nitrogen atoms given by pyridinic ligands to coordinate silver nanoparticles, in accordance with the Pearson's soft and hard acid-base theory. The role of silver in the photocatalytic degradation still needs to be clarified.

O2

Electrochemical and accelerated corrosion testing of automotive alloys in synthetic fuels

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The transition toward renewable energy sources and the implementation of strategies aimed at reducing greenhouse gas emissions have promoted the increasing use of synthetic fuels in the automotive sector. Bioethanol-based fuels and Hydrotreated Vegetable Oil (HVO) are among the most promising alternatives to conventional fossil fuels. However, their chemical composition and interaction with metallic materials may induce corrosion phenomena, potentially affecting the durability and safety of automotive components. The corrosion behaviour of alloys commonly used in automotive applications was investigated in different synthetic fuels, including bioethanol–gasoline blends, HVO and B7 diesel as a reference fuel. Electrochemical tests were performed in low-conductivity environments by optimizing the experimental setup. Electrochemical Impedance Spectroscopy (EIS) and potentiodynamic polarization measurements were carried out on copper, stainless steels, and aluminium alloys typically employed in automotive components. In addition, accelerated corrosion tests were conducted in autoclave under severe conditions to simulate long-term exposure. After accelerated corrosion testing, chemical analyses of the fuels were performed in order to investigate metal–fuel interactions. Electrochemical measurements allowed the evaluation of corrosion kinetics and surface stability of the investigated materials in the different fuels. Distinct electrochemical responses were observed depending on both the alloy type and the fuel composition. Accelerated tests revealed changes in surface morphology or severe interaction after exposure, highlighting different degradation behaviours. Chemical analyses of the fuels, suggesting fuel degradation processes associated with corrosion phenomena. The results provide a comparative assessment of the corrosive effects of synthetic fuels on automotive alloys, evidencing differences in corrosion mechanisms and material compatibility. Bioethanol-based fuels showed a higher tendency to induce corrosion compared to HVO and conventional diesel, especially when in contact with aluminium alloys. These findings contribute to a better understanding of corrosion risks related to emerging biofuels and support the selection of suitable materials for future automotive applications.

O3

A new method to characterize the porosity of materials: detailed description of nanoporous volume, definition of specific surfaces and prediction of gas adsorption

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Nanoporous materials (either crystalline or amorphous) are of great interest for several applications. To design new porous materials, predict their properties and interpret the experiments, an accurate description of their textural properties is of paramount importance. Widely used methods as the DFT fitting of adsorption isotherms and BET model for the specific surfaces are not always effective to correlate textural and adsorption properties. We propose a new approach, based on the Porosity Local Analysis (PoLA), to describe the porous volume distribution and the active surface, applicable to atomistic models as well as to real materials, and able to predict the gas uptake of various adsorbates. PoLA algorithm characterize the porous nature of each volume element inside the material using the distance from opposite walls: when applied to atomistic model, this is done by embedding the material atoms in a 3D grid and evaluating for each void block the minimum distance from opposite walls. The output is the Porous Volume Distribution (PVD), which describes in detail the porous nature of all the points inside the material. This description is physically more accurate than the ones based on pores of a specific shape. Being the PVD related to the adsorbate/adsorbent interaction potentials, it is also related to the adsorption isotherms and can be used to predict the uptake of various gases, as N2 or H2. We display this correlation using a dataset of (amorphous) porous carbons and (crystalline and defective) zeolites, based on atomistic models and Grand Canonical Monte Carlo (GCMC) simulations of nitrogen and hydrogen adsorptions. A machine Learning algorithm based on Neural Networks trained on the model dataset (PoLA textures and gas adsorptions) allows to analyse experimental isotherms, providing the Porous Volume Distribution for the real samples. The same algorithm is also able to predict the adsorption of H2 and other gases.

04

Laser-engineered interfaces for enhanced resistance to high differential pressure in solid oxide electrolysers

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Solid oxide electrolysers (SOECs) operating under high pressure differences require reliable joining solutions to ensure mechanical integrity and leak-tightness at elevated temperatures. Within the HyP3D EU project (GA 101101274), advanced integration strategies are being developed to enhance the robustness of critical interfaces. Among these, the interconnect/sealant/ceramic joint is a key element whose performance strongly depends on surface characteristics. This work investigates the role of laser-based surface engineering in improving joint reliability under high pressure difference. Infrared nanosecond laser surface texturing was applied to Crofer22APU steel and yttria-stabilised zirconia (YSZ) substrates. The treatment enabled controlled, reproducible microstructuring, thereby enhancing interfacial adhesion and mechanical interlocking. Joined specimens were subjected to apparent shear strength testing at room temperature (RT) and 850°C. Sealing performance under pressure difference at high temperature was also evaluated to verify leak-tightness. Laser processing produced homogeneous surface patterns on both Crofer22APU and YSZ substrates. The modified surfaces exhibited increased roughness and controlled texturing features, favouring improved mechanical anchoring. Mechanical testing showed a consistent improvement in shear strength for laser-treated samples compared to untreated references, with an average increase of approximately 30%. Fracture analysis revealed a shift from predominantly interfacial to more cohesive failure. Leak-tightness tests at 850°C confirmed stable sealing behaviour, with no critical leakage observed. The improvement in shear strength can be attributed to the tailored surface morphology induced by laser texturing, which promotes enhanced mechanical interlocking and a more favourable stress distribution at the interface. The reproducibility of the laser process ensures consistent surface features, contributing to reliable joint performance. The demonstrated leak-tightness under pressure gradients at 850°C further confirms that optimised surface engineering is a key factor in developing durable SOEC assemblies for high-pressure operation.

O5

Perovskite oxide catalysts for alkaline water electrolyzers

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Alkaline Water Electrolysis (AWE) is a mature technology for hydorgen and oxygen production, yet it suffers from low current density. A new membrane-based cell architecture has been recently developed, the Anion Exchange Membrane Water Electrolyzer (AEMWE), able to combine a more compact cell design to significantly higher current denisties. The Oxygen Evolution Reaction (OER) occurring at the AEMWE anode represents the rate determining step of the whole water splitting process thus high-performing, cost-effective and highly-surable catalysts are needed. Thanks to their structure tunability and intrinsic stability, perovskite oxides represent ideal candidates for reliable OER electrocatalysts. Two different perovskite oxides, $LaNiO_{3-\delta}$ (LN) and $La_{0.4}Ca_{0.4}Ti_{0.95}Ni_{0.05}O_{3-\delta}$, (LCTNi), were synthesized using citrate/nitrate solution combustion method. Structural, textural and morphological properties were assessed via X-ray Powder Diffraction (XRPD), N_2 fisisorption for specific surface area (BET) and pore size distribution (BJH) evaluation, electron microscopy (FE-SEM/TEM) and Raman analysis. Elemental analysis was carried out via X-ray Photoelectron Spectroscopy (XPS). Electrochemical evaluation was carried out using a three-electrode cell setup in 1 M KOH solution, using a Rotating Disk Electrode (RDE) as working electrode, an Hg/HgO reference electrode and a gold counter electrode. Cyclic voltammetries, chronoamperometries, galvanostatic tests and electrochemical impedance spectroscopy were used for catalysts characterization. Several LN synthetic routes were tested, and OER performance were directly linked to structural and chemical properties of the obtained oxides. LN exhibited in operando surface reconstruction, showing performance increase over 25 OER cycles. LCTNi was synthesized and characterized. The perovskite oxide was subjected to a high-temperature reduction process and Ni nanoparticles segregated onto the oxide surface in the so called exsolution phenomenon, forming highly distributed OER catalytically active sites. LCTNi activity was assessed over time in galvanostatic mode displaying remarkable stability. On one hand, a cost-effective route for obtaining highly active LN was established. On the other hand, despite containing only 5 mol% Ni, LCTNi after exsolution obtained comparable performance to those of LN, with enhanced stability. The obtained perovskite oxides performance were comparable to those of the state-of-the-art catalysts, paving the way for the establishment of a new generation of OER catalysts for alkaline water electrolysis.

O6

From red to blue: the key role of substituents on OLEDs based on highly luminescent 1,3-bis(4-phenylpyridin-2-yl)-4,6-difluorobenzene platinum(II) complexes

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Luminescent transition metal complexes find a wide range of applications in different fields, thanks to the presence of the heavy metal atom allowing for the efficient population of triplet excited states. Among this class of compounds, cyclometallated Pt(II) complexes bearing a rigid terdentate ligand based on 1,3-di(2-pyridyl)benzene received growing interest as a consequence of the possibility to tune their photophysical properties through the suitable functionalization of the N^C^N scaffold, this resulting in the production of electrochemical devices (such as OLEDs) with tunable emission. Starting from the simple [Pt(F_2bpyb)Cl] (F_2dpybH = 1,3-bis(pyridin-2-yl)-4,6-difluorobenzene), aryl rings with different substituents have been introduced on the pyridines to modify the steric hindrance on the ligand, going from a triphenylamine to tBu-substituted phenyl rings to mesityl groups. By doing this, the class composed of new complexes Pt1-Pt6 have been synthesized and deeply characterized from the luminescence point of view, also exploring the effect of aggregation by investigating solutions of different concentrations. Complexes Pt1-Pt6 have been characterized by registering excitation and emission spectra, and measuring their Quantum Yields (QY) and lifetimes in dearated diluted and concentrated solutions. It was possible to confirm the expected trend in the relationship between steric hindrance and aggregation tendency, with the amount of aggregated species being tunable, and consequently with the desired emission color being obtained on the basis of the substituents on the ligand. The QY values for all compounds in dilute solutions were very high, always exceeding 0.85 and in many cases approaching unity. The presented complexes Pt1-Pt6 were employed to prepare OLEDs having 6 and 100 wt% of complex in the emissive layer, to explore the real effect of aggregation on the color of the device; in this way it was possible to obtain both “emerald green” and “sky blue” emissions with 6 wt% layers of Pt4 and Pt6, respectively, and red emission in all cases of 100 wt% Pt complexes. The discussed new NCN-Pt(II) complexes represent a fascinating and useful tool to prepare OLEDs with various emission colors, spanning from blue to green to red depending on both the steric hindrance provided by the terdentate ligand and the amount of compound in the emissive layer of the device. Through these design strategies it could be possibile to obtain guidelines to expand and investigate new members of this appealing class of efficient cyclometallated complexes.

O7

Environmental assessment of MFI zeolite synthesis

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The goal of this study is to evaluate and compare the environmental impacts of different synthesis routes for zeolite MFI. The study seeks to identify and quantify the use of resources, energy demand, and associated emissions across alternative production methods, while also highlighting trade-offs in environmental performance. By doing so, it aims to provide recommendations that may guide the development of more sustainable synthesis pathways. In order to evaluate the environmental impacts throughout the confined life cycle of the MFI zeolite, the Life Cycle Assessment (LCA) methodology was applied. The study was conducted in accordance with the international standards ISO 14040 and ISO 14044, which establish the principles, framework, requirements, and guidelines for conducting an LCA study. Following these standards, the assessment was structured into four main phases: (i) goal and scope definition, including the identification of the functional unit and the system boundaries; (ii) life cycle inventory (LCI) analysis, involving the collection and quantification of relevant input and output data; (iii) life cycle impact assessment (LCIA), aimed at evaluating the potential environmental impacts associated with the inventory flows; and (iv) interpretation of the results to ensure consistency, completeness, and reliability of the findings. The results of the LCA are presented and discussed in terms of the main impact categories, highlighting the most significant environmental hotspots within the defined system boundaries. Particular attention is given to the contribution of each life cycle stage to the overall environmental profile of the MFI zeolite, enabling the identification of critical processes and potential improvement strategies. The LCA results indicate that raw reagent production and thermal treatment contribute significantly to the overall environmental profile within the defined system boundaries. In particular, the production of silica and alumina precursors and structure-directing agents showed relevant contributions to impact categories such as Global Warming Potential and cumulative energy demand.

O8

Sensing surface chemical interactions by dc magnetometry: a case-study on akaganeite arsenic-nanosorbents

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In the framework of adsorption studies, many techniques have been proposed to fully understand sorbent's removal performance, and to study the adsorbent-adsorbate interactions. Magnetometry is usually adopted to characterize the magnetic properties of the pristine sorbent with the aim of exploit them for magnetic separation. Recently, we compared the arsenic uptake from different iron oxides and oxyhydroxides with akaganeite acting as an effective sorbents for both AsIII and AsV species. In this work, in order to compare the properties of the pristine and "after use" states of the sorbents, among characterization techniques with different sensitivity, resolution and depth sensing ability, DC magnetometry was chosen as a technique able to study the adsorption uptake directly on the solid sorbents through possible changes in the magnetic response deriving from the adsorbate-adsorbent interactions. Akaganeite nanorods were synthesized by precipitation method and tested by batch experiments for the removal of AsV and AsIII at different concentrations and pH from aqueous solutions. The sorbents were characterised in their pristine and "after use" states by powder XRD, XAS, HRSTEM, EDXS, EELS, 57Fe Mössbauer spectroscopy, XPS, and DC-magnetometry by different protocols (ZFC-FC, isotherms) to identify changes due to the adsorption processes. XRD and XAS confirmed that the akaganeite structure remained unchanged upon adsorption, with no secondary phases or alterations in the Fe or As local environments, although STEM-EDXS mapping showed a homogeneous distribution of arsenic throughout the sorbent. Mössbauer spectroscopy revealed only slight variations in the electric field gradient around Fe ions. In contrast, DC-magnetometry revealed a distinct and selective magnetic response. Only AsV-loaded samples exhibited an additional peak in the ZFC curve, absent in pristine akaganeite and in AsIII-loaded samples, and ascribable to surface spin ordering process. The intensity of this peak correlated linearly with the amount of adsorbed AsV and was independent of the pH conditions. XPS analysis supported a ligand-exchange mechanism between surface –OH groups and arsenate species. Since no magnetic or XPS changes were detected for AsIII, the interactions with neutral arsenious acid were supposed to be weaker and not inducing spin ordering phenomena. These results demonstrate that DC-magnetometry uniquely captures surface spin perturbations arising from specific chemical interactions, enabling both qualitative and quantitative assessment of adsorption processes. This approach offers a powerful analytical tool for studying interfacial chemistry in magnetically responsive materials, with potential applications in water treatment, gas purification, and heterogeneous catalysis.

O9

Enhancing energy applications through ionic liquid confinement in electrospun fibers

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The growing demand for efficient thermal energy storage technologies has driven the development of advanced materials with tailored adsorption and heat properties. Ionic liquids (ILs) are promising candidates due to their high thermal stability, tuneable physicochemical properties, and favourable heat capacity. These features make them suitable for adsorption heat transformation and low-temperature heat recovery systems. However, their liquid nature poses handling and containment challenges. To address these limitations, ILs can be immobilized within electrospun polymeric nanofibers, which provide high surface area, interconnected porosity, and structural stability. Hybrid membranes were fabricated by electrospinning polymer solutions containing different IL loadings. The polymer was dissolved in a suitable solvent under controlled conditions until a homogeneous solution was obtained. The selected IL was then added and mixed thoroughly to ensure uniform dispersion. Electrospinning was carried out using a standard setup and main process parameters were optimized to achieve continuous fibres. Morphology was analyzed via scanning electron microscopy to evaluate fibre uniformity and diameter distribution. Water adsorption/desorption behaviour was assessed under controlled conditions to determine the effect of IL incorporation. Pure polymer fibers displayed smooth and homogeneous morphologies. The incorporation of IL led to a progressive increase in fiber diameter, which was attributed to modifications in the viscosity and electrical conductivity of the spinning solution. Higher concentrations of ionic liquid reduced jet stability but still preserved the overall structural integrity of the membranes, indicating the effective immobilization of the IL within the polymer matrix. Adsorption tests further revealed a clear trend of increasing water uptake with higher IL content. The observed increase in fiber diameter with IL addition highlights the interplay between solution properties and electrospinning parameters. The membrane integrity, despite partial clustering, suggested that the polymer network effectively stabilized the IL, enabling controlled confinement. By selecting appropriate polymer/IL combinations, it is possible to balance mechanical stability and sorption performance, establishing electrospun polymer/IL hybrids as a versatile platform for energy-related applications.

O10

Hydrogen-assisted mechanochemical recycling of end-of-life NdFeB magnets for sustainable energy and mobility applications

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NdFeB permanent magnets (PMs) are essential for electric mobility, wind energy and advanced electromechanical systems. Their production relies on critical rare earth elements (REEs), associated with supply risks and significant environmental impact. Recycling end-of-life (EoL) NdFeB magnets is therefore a strategic priority for the ecological transition. Hydrogen-based routes such as hydrogen decrepitation (HD) and hydrogenation–disproportionation–desorption–recombination (HDDR) are widely investigated, but they involve risk mitigation measures and complex processing. Developing safer, lower-impact recycling strategies is crucial to support circular economy models for PMs. We propose a hydrogen-assisted mechanochemical recycling route in which hydrogen is used only as a pre-conditioning step under a flow of H2 diluted in N2 (H2/N2 = 40/60 mL/min; 400–600 °C, 1 h) to embrittle demagnetized and coating-stripped EoL magnets. The brittle material was then refined by high-energy ball milling. Powder batches were prepared by varying hydrogenation temperature, milling speed and time. Structural and morphological evolution was monitored by XRD and SEM/EDX. Magnetic properties were measured using a Physical Property Measurement System (PPMS) equipped with a magnetometry option and a Vibrating Sample Magnetometer (VSM). Remanent induction mapping of pressed pellets was performed using a Hall-probe scanner to assess macroscopic magnetic uniformity. XRD shows that tetragonal phase remains the dominant phase after hydrogen treatment and milling. Optimal conditions yield coercivity up to ~0.44 T and MR/Mmax ~ 0.54. Longer milling (6 h) decreases coercivity, likely due to over-reduction and defect-induced disorder. Remanent field mapping confirms that pellets produced under optimal conditions exhibit higher average remanent induction and easier saturation, correlating with intrinsic coercivity rather than saturation magnetization alone. To quantify the environmental benefits, a prospective Life Cycle Assessment (LCA) was performed on the optimized process. The analysis indicates a potential 69% reduction in climate change impacts compared to primary magnet production, primarily driven by the avoidance of upstream rare-earth extraction steps This route avoids full hydrogen handling typical of HD/HDDR processes, reducing safety issues and potentially lowering energy consumption and CO_2 emissions compared to primary PMs production. By preserving the main magnetic phase with controlled microstructural refinement, the method provides a robust powder-from-scrap strategy compatible with bonded magnet fabrication and other advanced manufacturing routes. Overall, the approach supports closing the loop for critical REE-based PMs, contributing to sustainable energy technologies within a circular economy framework.

O11

Aerobic ethanol oxidation by magnetic inductive heating of palladium on nickel foam

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The heterogeneous aerobic oxidation of bio-derived ethanol to acetic acid represents an important chemical transformation and a valuable alternative to conventional industrial production routes. Supported palladium nanoparticles are well known to efficiently catalyze aerobic ethanol oxidation in aqueous media. In this work, we propose an alternative mode to carry out the aerobic ethanol oxidation with palladium by exploiting the magnetic induced heating of nickel. To increase the nickel surface area, crucial both for enhancing power absorption from the alternating magnetic field and for promoting palladium nanoparticle dispersion, nickel foam was employed as a low-cost, magnetically active support. Palladium was deposited on nickel foam using two different strategies: (i) spray-coating of surface-oxidized Ni foam with a colloidal Pd NPs acetone solution generated by metal vapour synthesis technique; and (ii) direct electrodeposition of palladium onto metallic nickel without a pre-formed nickel oxide layer. Catalytic tests were carried out under magnetically induced heating conditions. The catalytic activity was evaluated by varying both the palladium loading and the applied magnetic field power. Catalyst stability was assessed through recycling experiments and inductively coupled plasma (ICP) analysis of post-reaction aqueous solutions to detect possible palladium leaching. For comparison, the same catalytic systems were also tested under conventional electrical heating. Both palladium-supported nickel foam catalysts demonstrated efficient catalytic performance under magnetically induced heating, leading to the formation of acetic acid with high selectivity (>85%). In addition, both catalytic systems showed good stability, with no significant nanoparticle leaching detected in solution. Comparable reactions performed under conventional heating provided a benchmark for evaluating the benefits of magnetic induction. The results demonstrate that nickel foam is an effective magnetically responsive support for palladium-based catalysts in aerobic ethanol oxidation. The combination of magnetic induction heating and heterogeneous catalysis enables selective acetic acid formation while maintaining catalyst stability. The two palladium deposition strategies provide viable routes for catalyst preparation, with potential implications for optimizing catalytic performance and scalability. Magnetic induction heating thus represents a promising alternative to conventional thermal methods for sustainable catalytic oxidation processes.

O12

Preparation, characterization and testing of PVDF membranes for brine treatment by membrane distillation

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Membrane distillation (MD) has a great potential to become one of the best technologies for treating concentrated brines thanks to the relatively small influence of salt concentration on the distillation flux. Developing sustainable membranes that grant large distillation flux is still one of the key aspects needed to unlock the upscaling of MD at an industrial level. PVDF (polyvinylidene fluoride) is a common polymer used to prepare membranes thanks to its great thermal and chemical resistance. Moreover, PVDF can be easily dissolved in many organic solvents. However, non-sustainable solvents, such as N,N-dimethylformamide and pore forming agents are commonly used. In this work, porous hydrophobic PVDF membranes were prepared via non-solvent induced phase separation (NIPS), using triethylphosphate as a green solvent and ethanol solutions as non-solvent. The effect of the main preparation parameters on the membrane characteristics were investigated. The membranes prepared were characterized using gas-liquid displacement porometry to determine the pore size and their distribution, while the hydrophobicity was evaluated measuring the water contact angle. The membranes with suitable properties were tested using a lab-scale vacuum membrane distillation setup, to determine their productivity in terms of distillate flux and their salt rejection. Using a weak non-solvent it was possible to delay the PVDF precipitation, avoiding the formation of a dense skin layer and increasing the surface porosity and pore size. Moreover, this process increased the surface roughness enhancing the water contact angle up to 145°. The dope solution concentration had a great impact on the pore size of the membranes that decreased from almost 0.8 µm to 0.1 µm as the PVDF concentration was increased from 14wt% to 18wt%. In the meanwhile, the pore size distribution curve was also narrowed and the liquid entry pressure increased dramatically. This effect is related to the reduction of defects in the membrane structure. The membranes were then tested in a vacuum membrane distillation setup reaching a distillation flux up to 22.5 L/m^{2}h treating a 90 g/L NaCl brine at 60° C. The membranes showed a constant flux throughout the tests and complete salt rejection.

O13

High- and medium-entropy alloys for hydrogen storage

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In the last few years, high-entropy alloys (HEAs) and medium-entropy alloys (MEAs) have attracted considerable attention owing to their unique physical, chemical, and mechanical properties. They have potential applications in many fields, including structural materials, corrosion reduction, brazing, and solid-state hydrogen storage. Approximately 60 HEA compositions have been investigated for their hydrogen absorption properties, with the highest hydrogen capacities reported for HfNbTiVZr (2.50 H/M, 2.70 wt%) and (TiVNb)0.85Cr0.15 (1.79 wt%, 3.18 H/M). In this work, we investigated new medium- and high-entropy alloys based on Ti, Nb, and Zr, mixed with various non-hydrogen-absorbing elements. All samples were produced by arc melting. XRD measurements were performed on both the pristine and hydrogenated samples. The hydrogen sorption kinetics and thermodynamics were studied using a homemade Sieverts apparatus from room temperature to 450°C. Two of the investigated alloys exhibit a maximum hydrogen capacity above 2 wt% at room temperature and transform from a BCC structure in the pristine state to an FCC structure in the hydride. Most samples exhibit fast sorption kinetics, achieving a 95% maximum uptake in less than 10 s, even at room temperature. The samples currently studied complement the results reported in the literature on HEAs for hydrogen storage. Moreover, they consider elements that have been poorly investigated in the composition of pristine materials. The present data can be useful for constructing large databases to investigate the sorption properties of alloys using machine learning to identify optimal compositions.

O14

Bixbyite-structured high entropy oxides for advanced ceramic applications

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High-entropy rare-earth oxides have recently emerged as a new class of advanced ceramics in which multiple cations are incorporated in equimolar/near-equimolar ratios, stabilizing single-phase structures through configurational entropy. Fluorite and bixbyite are the main crystal structures exhibited by high-entropy rare-earth oxides. Several bixbyite HEOs have been synthesized, among which $(Ce_{0.2}Zr_{0.2}Yb_{0.2}Er_{0.2}Nd_{0.2})O_{3+\delta}$ and $(Ce_{0.2}Zr_{0.2}Yb_{0.2}Er_{0.2}Gd0_{.2})O_{3+\delta}$, as possible ionic conductor and photocatalyst, respectively. For all samples, synthesis method was the coprecipitation obtained by mixing an ammonium carbonate solution (precipitating agent) with a solution of rare-earth nitrates, or zirconium oxynitrate for zirconium. After filtering and drying the coprecipitates, the resulting powders were calcined at various temperatures ranging from 700 °C to 1200 °C, and possibly, upon uniaxial pressing, sintered at relatively high temperatures (1300 – 1500°C). Thorough characterizations were carried out on the powders and/or the pellets, by XRD, DTA-TG, SEM-EDS, EIS, photocatalytic degradation, etc. The formation of bixbyite single-phase occurred upon a calcination at 750 °C, although in a nanocrystalline form, as confirmed by XRD. SEM-EDS analysis showed very good homogeneity in the samples confirming the effectiveness of the simple synthesis cycle adopted. Almost full densification were achieved by sintering at 1400 °C for 3 h. Photocatalytics tests showed degradation of methylene blue almost complete in optimized conditions (alkaline medium and 180 min of irradiation). Very dense HE bixbyite showed an electrochemical behaviour characterized by mixed ionic-electronic conduction with an electrical conductivity equal to $1.6x10^{-2}$ S/cm at 600°C. The unique chemical desorder, typical of HEO, gives rise to unconventional combinations of properties. The excess of oxygen compared to the "normal" sesquioxide occupies interstitial positions within the bixbyite lattice, being free to diffuse in the lattice and originating electrode reactions involving atmospheric $O_2(g)$ while the presence of M^{4+} replacing M^{3+} introduces small polarons in the lattice responsible of electronic conductivity. The energy bands are also influenced by the complex chemical composition, making it possible for electronic excitations from the valence band to the conduction band through interaction with visible light so starting the processes leading to the photocatalysis.

O15

Structure-activity insights in mesostructured aluminosilicates for CO_2-to-dimethyl ether conversion

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Nowadays, research is increasingly focusing on green fuels produced from captured CO_2 (e-fuels). One of the most promising candidates is dimethyl ether (DME), a substitute for diesel fuel. DME can be synthesized from CO_2 via two consecutive reactions: the first, catalyzed by Cu-based reduction catalysts, involves the reduction of CO_2 to methanol; the second, promoted by solid acid catalysts, is the dehydration of methanol to DME. In this work, three mesostructured aluminosilicates with various pore structures (Al-MCM-41, Al-SBA-15, and Al-SBA-16) each one with three different Si/Al ratios (10, 15, and 20) are presented as methanol dehydration catalysts for the one pot-CO2-to-DME conversion. The catalysts have been tested and characterized with a particular focus on the correlation of their structural properties with their acid features and their catalytic performance. Al-MCM-41, Al-SBA-15, and Al-SBA-16 samples were obtained, respectively, with a conventional sol-gel, a hydrothermal sol-gel approach, and by an Evaporation-Induced Self-Assembly (EISA) method. For all the syntheses a silicon alkoxide (TEOS) was used as the silicon precursor, while aluminum isopropoxide, nitrate, and chloride were used, respectively, as Al precursors. The samples were studied with a wide range of techniques to determine their structural (XRD, ^{27}Al- and ^{29}Si-SS-NMR), textural (N_2-physisorption), morphological (TEM-EDX), and acid properties (pyridine-adsorption FTIR), compositional (ICP-OES) and evaluated to determine their catalytic performance. Catalytic results show that increasing Al content enhances DME selectivity, particularly in samples exhibiting lower surface area and thus higher surface density of acid sites, in agreement with pyridine-FTIR acid site characterization, which shows a moderate increase in acid site number with decreasing Si/Al ratios. This trend highlights the relevance of acid site density rather than total acidity in steering product distribution. Aluminum coordination speciation was probed by ^{27}Al solid-state NMR, alongside with ^{29}Si-SS-NMR, and correlated with acid features derived from pyridine-adsorption FTIR. ^{27}Al MAS NMR reveals the coexistence of framework tetrahedral Al and extra-framework penta-coordinated and octahedral species. Higher Al loadings promote partial segregation of Al into amorphous Al_2O_3 domains, with the extent of segregation depending strongly on both synthesis route and mesostructure. ^{29}Si MAS NMR shows a slight downfield shift of Q^4 signals together with variations in Q^3/Q^2 relative intensities, consistent with partial Si substitution by framework Al. Overall, the results demonstrate that mesostructure topology and aluminum coordination environment jointly determine acid site distribution and surface density, which ultimately govern DME selectivity in CO_2 hydrogenation.

O16

Bridging detection and degradation: a multilayered architecture for the identification and solar-driven photodegradation of emerging water contaminants

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The increasing impact of anthropogenic activities on natural ecosystems, coupled with the urgent need for sustainable resource management, makes water protection a critical global challenge. In this context, detection and removal of emerging pollutants -including pharmaceuticals, personal care products, endocrine-disrupting compounds, pesticides, and perfluorinated substances- has become a major priority due to their persistence and associated risks to both ecosystems and human health. In this work, we demonstrate that rational materials design enables the development of polymeric and inorganic films and coatings with tailored nanostructures, capable of selectively adsorbing, detecting, and degrading these contaminants through the exploitation of solar radiation. Solution-processed polymer and hybrid polymer–oxide films were fabricated using spin- and dip-coating. Selective sorption of specific pollutants is achieved by tuning solubility parameters and interfacial interactions through rational polymer selection and the de novo synthesis of semiconductor oxides. The controlled combination and nanostructuring of these materials into planar photonic architectures via sequential film deposition enable coatings with a dual function, integrating optical sensing with solar-driven photocatalytic degradation. Through appropriate design and integration into photonic structures, the combination of polymers and porous inorganic oxides enables specific interactions with different classes of pollutants, allowing label-free optical and colorimetric recognition of diverse analyte families, including polar, non-polar, and perfluorinated molecules, with sensitivities down to the microgram-per-liter range. This response arises from differences in pollutant intercalation kinetics, governed by their interactions with the films, which induce controlled variations in the photonic lattice and, consequently, in its optical response. Furthermore, coupling these systems with suitable semiconductor oxides extends their functionality, enabling both selective targeting and photocatalytic degradation of specific contaminants under solar irradiation. In this configuration, the photonic lattice enhances the process by concentrating light within the structure, thereby accelerating photodegradation kinetics. The integration of tailored material properties with photonic and photocatalytic functionalities provides a versatile platform for the simultaneous capture, identification, and degradation of emerging pollutants. This approach represents a promising strategy for water remediation technologies, enabling energy-efficient and atom-economical processes for sustainable environmental protection.

O17

Mechanochemically engineered biochar for next-generation hydrophobic coatings

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This Biochar represents a sustainable alternative to fossil-derived carbon materials, as it is produced through the pyrolysis of biomass under inert conditions. Its surface chemistry, characterized by oxygenated functional groups that can be tuned by pyrolysis parameters or post-treatment, makes biochar well suited for further functionalization. Recently, mechanochemical methods have been shown to enable solvent-free ionic functionalization of biochar with reduced reaction times and energy demand. Building on this approach, we demonstrate for the first time that solid-state grinding activation can promote covalent functionalization of biochar with octadecylamine, yielding a highly stable hydrophobic material. The modified biochar was applied to coat hemp fibers, forming an oleophilic layer enables efficient oil uptake from emulsified solutions. The biochar (BC) used in this study, obtained from Caesar & Loretz GmbH (Hilden, Germany) and derived from the pyrolysis of Fagus sylvatica, was first oxidized with hydrogen peroxide and then functionalized with octadecylamine in a 1:1 ratio via planetary ball milling under solvent-free conditions. Milling was performed at 300 rpm for 2 hours. The resulting hydrophobic powder was dispersed in water, and hemp fibers were subsequently coated by immersion in the modified biochar dispersion Biochar oxidized (oBC) was firt characterized and then functionalized with octadecylamine in a 1:1 ratio via planetary ball milling under solvent-free conditions. The product was fully characterized by FTIR, EA, WAXD and XPS to confirm the covalent functionalization. The resulting hydrophobic powder was dispersed on hemp fibers by dip coating and oil uptake ability from emulsified solutions was successfully verified. This study presents an innovative, sustainable approach for functionalizing biochar via mechanochemical amidation with octadecylamine. The solvent-free procedure offers a cost-effective and scalable alternative to conventional solution-based methods, aligning with environmental sustainability goals. Incorporation of long alkyl chains increases the hydrophobicity of biochar by exposing hydrophobic groups and enhancing surface roughness, yielding a material suitable for water-repellent coatings on hemp fibers. Following dip-coating, the modified hemp exhibited a water contact angle of 126° with a single biochar deposition layer. In addition, the biochar-coated hemp fibers demonstrated remarkable oil absorption capacities - up to 1400% - for various oils, including frying, motor, pump, and sunflower oils, from emulsified solutions.

O18

NiO nanoarchitectures by a plasma-assisted route as electrocatalysts for oxygen evolution

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Oxygen evolution reaction (OER) is a key cornerstone of water splitting to molecular hydrogen, a promising and renewable energy vector. In this regard, an open challenge is the development of cheap, eco-friendly and highly active OER electrocatalysts to replace the ones based on noble metals, which suffer from instability at high potentials, high cost, and low natural abundance. In this work, we report for the first time on the fabrication of NiO architectures as OER catalysts by plasma enhanced-chemical vapor deposition (PE-CVD). The systems were grown on conducting glasses from a fluorinated Ni(II) precursor and subjected to an *ex-situ* annealing in air. Variations of the growth temperature from 100 to 400°C enabled a morphology modulation from hierarchical quasi-1D nanopillars to cauliflower-like structures, featuring homogeneously distributed fluorine inside NiO. The systems obtained at 100°C yielded the best activity in the target material family (≈390 mV overpotential at 10 $mA \times cm^{-2}$ and Tafel slope as low as 39 $mV \times dec^{-1}$), surpassing the state-of-the-art values for various OER Ni(II) oxide-based catalysts reported so far and favorably comparing even with different Ir- and Ru-based benchmarks. An experimental and theoretical investigation enabled us to account for this achievement in terms of material nano-organization, structural defect content, and chemical composition, with particular regard to the presence of different fluorine types in the target systems. From a microscopic viewpoint, the present investigation allowed us to disclose the nature of the plausible active sites in OER process, and to rationalize the better performances of NiO-based materials fabricated at the lowest growth temperature. Overall, the present results enable the rational design of active electrocatalysts based on low-cost and earth-abundant materials for sustainable energy conversion.

O19

Environmental sustainability evaluation of a microwave-based technology to recover phosphorous from incinerated waste streams

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Closing the loop of the anthropogenic phosphorus (P) cycle is crucial to sustain the continuous growth of the world population. The increasing demand for P-based fertilizers is leading to inefficient phosphorus use, especially in the agricultural sector, causing environmental issues such as eutrophication of natural water bodies and contributing to the depletion of phosphate rock reserves. For these reasons, the efficient recovery of P from incinerated waste streams (P-rich secondary sources) is of strategic importance in order to reduce dependence on primary raw materials. In this context, the present work focuses on the sustainability assessment of a new P recovery technology based on microwave-assisted treatment. This innovative approach aims to enhance phosphorus extraction efficiency from secondary sources (e.g., sewage sludge ash) through rapid and selective heating, potentially reducing processing time and energy consumption compared to conventional thermal or wet-chemical methods. A simplified environmental sustainability evaluation method is adopted to assess the performance of the microwave-based technology. The methodology is based on the calculation of two key parameters: embodied energy and CO_2 footprint, which account for the total energy demand and greenhouse gas emissions associated with the production of the recovered P-based material. These indicators are used to quantify the upstream environmental impacts of the process, focusing specifically on the raw material substitution stage. The environmental performance of the microwave-assisted recovery route is then compared with the current state-of-the-art extraction process from primary phosphate rock. In this way, the potential of the microwave technology to serve as a sustainable alternative is evaluated. The assessment concentrates on the upstream phase of the life cycle, avoiding the need for a full Life Cycle Assessment (LCA), which can be time-consuming and costly, particularly for industrial applications in early-stage technology evaluation. The results highlight the potential of microwave-based processing as a promising strategy for phosphorus recovery, emphasizing its role in promoting resource efficiency and supporting the transition toward more sustainable raw material management. Overall, the study underlines the importance of developing innovative and energy-efficient technologies to foster the rational and sustainable use of global phosphorus resources.

O20

Integrated Cr(VI) and dye removal from complex wastewaters via multifunctional Sn/(II)/hydroxyapatite/carbon composites

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Hexavalent chromium and dyes such as methylene blue (MB) are problematic contaminants in wastewaters due to their toxicity, persistence, and resistance to conventional treatment technologies. In this context, the development of multifunctional materials capable of addressing mixed organic–inorganic pollution within a single treatment step is gaining increasing interest. Recent studies demonstrated that hydroxyapatite/carbon (HAP/AC) composites can be designed to merge the adsorption properties of both components, enabling the simultaneous removal of MB and metal ions. In parallel, tin(II)-functionalized hydroxyapatite has been proposed as a reductive adsorbent to convert Cr(VI) into the less toxic Cr(III) form and subsequently immobilize it through adsorption. Building on these two complementary approaches, this work investigates a multifunctional composite integrating Sn(II), HAP, and activated carbon, where Sn(II) acts as a reducing agent, HAP captures Cr(III), and AC adsorbs both residual Cr(VI) and MB, aiming at the simultaneous remediation of wastewaters containing inorganic-organic contaminants. Sn/HAP/AC composites (Sn10 wt%, HAP45 wt%, AC45 wt%) were prepared via a two-step procedure. First, aqueous solutions of calcium and phosphate precursors were added dropwise to a slurry of carbon in water. Subsequently, Sn(II) was deposited on the resulting HAP/AC material. The composites were characterized using N_2 physisorption, XRD, and XPS.
Removal performance for Cr(VI) and MB from simulated aqueous solutions was evaluated in batch tests. Residual pollutant concentrations were determined by UV–vis spectroscopy: MB was monitored at 664 nm, while Cr(VI) was quantified via the 1,5-diphenylcarbazide method. The Sn(II)/HAP/AC composite demonstrated efficient Cr(VI) removal under mild conditions, achieving a chromium uptake of 12 mg/g in 4 h batch tests at the natural pH. XPS analysis revealed that the ternary composite has higher surface Cr content than the binary Sn/HAP and Sn/AC materials, with Cr predominantly as Cr(III). MB adsorption tests showed uptake exceeding 50 mg/g, highlighting the key contribution of the activated carbon fraction. Leaching tests confirmed the stable confinement of pollutants, with less than 0.1% released. The results confirm the effectiveness of a multifunctional strategy based on the synergistic integration of reduction and adsorption mechanisms. Sn(II) promotes Cr(VI) conversion to Cr(III), which is then preferentially immobilized on HAP, while AC contributes to the adsorption of both residual Cr(VI) and MB. This hybrid system is therefore suitable for the treatment of wastewaters containing both inorganic-organic contaminants. The proposed composite represents a promising low-cost and ecofriendly material, potentially enabling integrated remediation processes compared to conventional single-function adsorbents.

O21

Synthesis and rapid quantification of phase-pure vaterite for industrial waste valorisation and CO2 emission mitigation

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Calcium carbonate particles are widely applied due to their morphology, porosity, high surface area, and non-toxicity. Among synthesis methods, CO_2 mineralization is one of the most eco-friendly, as it mitigates emissions by fixing CO_2 from industrial flue gases into valuable products. The reuse of $Ca(OH)_2$-rich industrial waste, such as air pollution control residues, further lowers the environmental impact of the process. Calcium carbonate occurs in three crystalline forms; among them, vaterite is metastable but exhibits excellent binding properties, making it a promising clinker substitute in cements and mortars. Its formation is favoured by additives able to stabilize its crystal faces. Two additives were investigated: sodium tripolyphosphate (STPP) and polyacrylic acid (PAA). Their ability to steer precipitation towards vaterite at different temperatures was evaluated through batch carbonation reactions, within the framework of the PR FESR Program – CCS4CER Project (CUP: E87G22000550007). Attenuated Total Reflectance Infrared Spectroscopy (ATR-IR) was employed to quantify calcium carbonate polymorphs, enabling reliable quantification based on band intensity. An ATR-IR calibration curve was constructed using binary mixtures of phase-pure calcite and vaterite. The ratio between the vaterite peak area and the sum of calcite and vaterite peak areas was calculated and employed as a predictor for vaterite molar fraction. Carbonation reactions were carried out in an autoclave by loading 10 g of ceramic waste (72wt% $Ca(OH)_2$) with either STPP or PAA added at 5mol%, suspended in water to obtain a 10 wt% slurry. After nitrogen flushing (15 min), the reactor was heated (25–100 °C) and pressurized with 7 bar of CO_2 for 5 minutes. The calibration curve showed a linear correlation coefficient close to one, with good agreement between real and predicted vaterite content, including validation samples. Optimization of reaction conditions and additive selection enabled a maximum vaterite yield of 61% at 50 °C using STPP. When PAA was used, the maximum vaterite yield obtained was 32% at 25 °C. The accurate prediction of the ATR-IR method on the validation samples confirmed its reliability; it was then used to expedite the study on the real samples. The addition of additives during carbonation is crucial for obtaining significant amounts of vaterite. The obtained materials show promising features as secondary raw materials for the cement industry, with vaterite potentially replacing part of the costly and environmentally impactful clinker, increasing the sustainability of the cement while promoting the valorisation of materials commonly regarded as waste.

O22

Structural separation of multilayer packaging for mechanical recycling

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Multilayer packaging (MLP) is widely used because it delivers barrier performance, strength, and product protection that single-material systems cannot match. Worldwide, flexible MLP contributes a substantial portion of production, amounting to 100 million tons each year. Its complex structure, involving various materials, makes traditional recycling very challenging. As a result, MLP recycling rates remain very low, and most of this waste is currently sent to landfills or incinerated. Therefore, developing technologies capable of separating MLP into clean, reusable material streams is critically important. This study investigates a mild aqueous formulation approach for the structural separation of multilayer systems, including PE/Al, PET/Al/PE, and PP/Al/PP. Formulations composed of organic acid (30-50 vol%), surfactant (0-10 vol%), and water were designed to weaken interfacial adhesion while maintaining the chemical and physical properties of the primary polymer layers. The design of experiments was employed to evaluate the influence of temperature (50-90 °C), acid concentration, and surfactant loading on delamination kinetics. Separation performance was assessed by measuring delamination time, material recovery efficiency, and preservation of polymer properties using FTIR, DSC, and TGA analyses. Two recycling pathways for aluminum were observed: delamination, which preserves intact foil layers, and leaching, which recovers ultrathin, vapor-deposited metallized aluminum to recover polymer substrates. Both methods achieved recovery efficiencies exceeding 95 wt%. Results reveal that adding a surfactant alongside the acid shortens the separation time. The results demonstrate that mild aqueous formulations can effectively reduce interfacial adhesion in multilayer systems without compromising bulk polymer integrity. The strong temperature dependence indicates kinetically controlled separation, while the surfactant contribution suggests enhanced interfacial wetting and improved penetration of the acidic medium into adhesive domains. This dual effect enables rapid and controlled structural separation under moderate processing conditions. Compared to aggressive chemical or thermal treatments, the proposed approach operates under milder conditions, preserves material quality, and achieves high recovery yields. These characteristics make the method promising for scalable integration into mechanical recycling workflows.

O23

Comparative life cycle assessment of conventional and biodegradable high-barrier multilayer packaging films

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Food packaging requires high-barrier materials with low environmental impact. While conventional PET/PE/EVOH multilayers provide excellent protection, they depend on fossil resources and present end-of-life issues. Bio-based alternatives such as PLA, PBAT, and PVOH may offer environmental advantages, which were evaluated through a Life Cycle Assessment (LCA) comparing a conventional film with an innovative biodegradable structure for dry food applications. A cradle-to-grave LCA was performed considering 1 m^2 of flexible film with equivalent barrier performance as functional unit. The conventional film (66.1 g/m^2) consisted of PET/PE/EVOH layers, while the biodegradable alternative (46.4 g/m^2) was based on PLA/PBAT with m-PVOH and PLA coating. Data were modelled in SimaPro (Ecoinvent database, cut-off system model, v3.x). Impacts were assessed through IPCC 2021 GWP100, ReCiPe 2016 Endpoint (H), and Cumulative Energy Demand. End-of-life scenarios considered landfill (100%), incineration (100%), mixed landfill/incineration (20%/80%) for conventional packaging; composting (100%), incineration (100%), mixed composting/incineration (60%/40%) for biodegradable packaging. The conventional film showed a GWP of 0.21 kg CO_2 eq/m^2, compared to 0.23 kg CO_2 eq/m^2 for the bio-based alternative. However, the cumulative energy requirement was significantly lower for the biodegradable film (5.52 MJ/m^2) than for the conventional one (7.83 MJ/m^2; -29.5%). The ReCiPe 2016 Endpoint indicator, expressed in points (Pt) and representing normalized and weighted overall environmental damage, was 0.00814 Pt/m^2 for the conventional system and 0.0112 Pt/m^2 for the bio-based option (+37.6%). Overall, the bio-based solution reduced energy demands but exhibited higher climate and aggregated environmental impacts. The findings highlight a divergence between energy efficiency and overall environmental performance. Although the bio-based alternative lowered primary energy demand by nearly 30%, it showed higher GWP and endpoint scores, mainly due to raw material production and processing stages. Therefore, reduced fossil energy use did not automatically translate into lower total environmental impact. Material and process optimization are essential to achieve truly competitive and sustainable bio-based packaging systems.

O24

HDPE packaging recycling: combined effects of aging, cross-contamination, and reprocessing

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Effective mechanical recycling of polyolefins is hindered by thermo-mechanical degradation during reprocessing, aging during service life, and cross-contamination due to imperfect sorting, which lead to heterogeneous recyclates with limited performance and applications. This work investigates the combined effects of aging and cross-contamination on high-density polyethylene (HDPE) containing small amounts of polypropylene (PP) and polyethylene terephthalate (PET), highlighting that contaminants significantly reduce HDPE ductility after thermo-oxidative aging, while their impact is less pronounced under photo-oxidative conditions. Three different systems were prepared: pristine HDPE, HDPE with 10 wt% PP, and HDPE with 10 wt% PP and 2 wt% PET. Compounding was performed using a twin-screw extruder. Samples were subjected to photo-oxidative or thermo-oxidative treatments, both for 300 h. After aging, all systems were reprocessed and characterized through spectroscopic, rheological, morphological, and mechanical analyses. Spectroscopic analyses showed that PP contamination reduces the carbonyl index of HDPE compared to pristine material, both before and after photo-oxidative aging. This result suggests a sort of stabilizing effect, due to the faster radical formation of PP, which acts as a sacrificial oxidizable phase and delays HDPE oxidation. However, under thermo-oxidative conditions, this effect is less evident. When both PP and PET are present, higher carbonyl index values are obtained. Nonetheless, this is partly due to the intrinsic carbonyl absorption of PET, suggesting that cross-contamination still limits HDPE degradation. Rheological and morphological analyses revealed that PP and PET form immiscible blends with HDPE, with microstructure strongly influenced by aging-induced changes in matrix viscosity. Photo-oxidized and reprocessed HDPE/PP/PET systems showed marked morphological refinement, whereas thermo-oxidized samples exhibited only minor changes in dispersed phase size and distribution. Mechanical tests indicated that elastic modulus and tensile strength are largely unaffected by contamination and aging, while ductility is highly sensitive. The presence of PP has a limited effect before aging, whereas PET significantly reduces elongation at break. Photo-oxidative aging combined with reprocessing leads to severe embrittlement, especially in contaminated systems, due to heterogeneous microstructures arising from chain scission, branching, and crosslinking. Thermo-oxidative aging has limited impact on pristine HDPE but significantly reduces ductility in cross-contaminated materials.

O25

Sealing post-treatments of plasma electrolytic oxidation (PEO) coatings on AZ31 magnesium alloy: effects on corrosion resistance

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Plasma electrolytic oxidation (PEO) is a surface treatment based on the application of high voltages between the processed component (behaving as the anode) and a counter electrode, both immersed in an electrolytic solution. As a result, a quite thick but porous oxide coating is produced on the surface of the piece. To close the porosity and increase the protective effect of the PEO coatings, sealing post-treatments could be carried out. During sealing, insoluble compounds precipitate on the surface of the oxide which is also partially converted into hydroxide. As a result, the pores of the PEO layer are closed. PEO is performed on AZ31 disks using an alkaline solution containing metasilicate. The applied signal consists of a square AC-pulsed duty cycle. Sealing is performed by immersion of the PEO-samples in a heated zinc nitrate bath for a time varying from 15 to 60 minutes. Different pH values of the sealing bath are tested. A set of samples undergoes a second step during which the sealed specimens are immersed in a solution containing sodium metavanadate. The metavanadate ions deposit on the $Zn(OH)_2$ structures, providing an effect of corrosion inhibition. SEM is performed for morphological characterization, while the corrosion assessment is executed through electrochemical impedance spectroscopy and potentiodynamic polarization tests, carried out in solutions at different concentrations of chlorides. SEM analyses highlight the change in the morphology of the oxides following the formation of the $Zn(OH)_2$ structures, which appear as lamellae spread over the surface of the coating. When the vanadate deposition is carried out the lamellas result reach also in vanadium. The experimental results show an increase in polarization resistance, Rp, and a reduction in corrosion current density, icorr, for the sealed samples. Comparing the morphology of the samples obtained at different immersion time and pH level significant differences are found. First, shorter treatments allow $Zn(OH)_2$ precipitation preventing the dissolution of the lamellas which instead is observed for processes longer than 30 min. Moreover, it is found that the higher the solution pH the more developed are the lamellas structures, that for pH larger than 11 appear with a petal-like shape. The increased Rp and reduced i_{corr} confirm the capability of sealing to enhance the protective effect against corrosion offered by PEO coatings. This is a consequence of the barrier effect opposed to the diffusion of aggressive species through the coating.

O26

4D printing of photocurable shape memory resins activated via indirect heating

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4D printing represents an evolution of additive manufacturing in which materials are engineered to actively respond to external stimuli, enabling printed components to change shape or functionality over time. In this paradigm, the material itself becomes an active element rather than a passive structural component. Among stimuli-responsive systems, shape memory polymers are particularly attractive due to their ability to fix a temporary shape and recover a permanent geometry upon activation. This work investigates photocurable resin systems suitable for Digital Light Projection (DLP) processing, aiming to develop high-resolution 4D-printed structures with programmable and electrically controllable actuation. Commercial polyurethane- and methacrylate-based photopolymer resins were blended in different weight ratios to optimize printability, thermomechanical behavior, and shape memory performance. Rheological analysis was performed to assess viscosity and suitability for DLP processing. Chemical structure and curing were evaluated using Fourier Transform Infrared Spectroscopy (FTIR-ATR). Thermomechanical properties and switching temperatures were investigated by Dynamic Mechanical Analysis (DMA), while thermal stability was analyzed through thermogravimetric analysis (TGA). Mechanical performance was assessed by tensile testing and Shore D hardness measurements. Shape memory behavior was evaluated through thermally induced deformation–recovery cycles. Electrically triggered activation was explored by incorporating carbon nanotubes into the polymer matrix and by embedding nickel–chromium resistive wires within printed specimens to generate internal heating via the Joule effect. The developed resin formulations demonstrated suitable viscosity for DLP printing and enabled the fabrication of high-resolution structures with good dimensional stability. DMA results confirmed well-defined transition temperatures compatible with programmable shape memory activation. Thermally induced tests showed stable fixation of temporary shapes and effective recovery of the original geometry. Electrically conductive formulations and embedded resistive elements successfully generated internal heat under applied current, allowing localized and controllable shape recovery without external heating sources. The results confirm that DLP-printed photopolymer blends can be engineered to combine structural integrity with programmable actuation. The integration of electrically induced activation expands the functional potential of 4D-printed systems, enabling more precise and application-oriented control strategies. These findings highlight the relevance of stimuli-responsive photopolymers for adaptive structures, smart components, and deployable devices, supporting further development toward multifunctional and autonomous material systems.

O27

Surface-anchored iron (III) on silica nanoparticles as high-performance vulcanization activator

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In the rubber industry, vulcanization is the primary process for crosslinking polymer chains via sulfide bridges to enhance mechanical performance, typically relying on Zinc Oxide (ZnO) as an activator. However, low affinity of ZnO for rubber entails high dosages to ensure proper dispersion, resulting in significant environmental concerns, which makes the development of a sustainable replacement a priority. This study proposes silica nanoparticles functionalized with anchored Fe(III) sites (Fe@SiO_2) as a high-performance alternative. Fe@SiO_2 activator was synthesized in two stages:

1. Functionalization: Silica (SiO_2) surfaces were treated with silane in a toluene medium.
2. Anchoring: The functionalized SiO_2 was dispersed in ethanol with $Fe_2(SO_4)_3$ to anchor Fe(III) ions onto the surface.

The resulting material was characterized using TGA, FT-IR, ICP-OES, EPR, XPS, and TEM. To evaluate performance, rubber nanocomposites were prepared in a Brabender mixer, and vulcanization kinetics were monitored using a Rubber Process Analyzer (RPA).
Activators were synthesized with Fe(III) concentrations ranging from 0.25% to 2.5%. EPR analysis revealed two distinct signals at $g \approx 4.3$ and $g \approx 2.0$ with the latter increasing in intensity as iron loading rose. TEM-EDX mapping confirmed the presence of iron on the silica surface. Notably, all Fe@SiO_2-based compounds exhibited faster vulcanization kinetics than traditional ZnO compounds. Furthermore, the maximum torque (MH) increased proportionally with the iron content. The EPR signals at $g \approx 4.3$ and $g \approx 2.0$ correspond to isolated Fe(III) centers and coupled Fe(III) ions respectively, this latter originating from electronic interaction due to proximity or the formation of oxygen-bridged iron clusters. While cluster formation increases with iron concentration, vulcanization performance appears to depend on the total iron content rather than the specific iron species. The superior kinetics of Fe@SiO_2 likely arise from the high accessibility of Fe(III) sites to the curing agents. Ultimately, Fe@SiO_2 achieved comparable performances to ZnO in terms of MH values with lower metal concentration. This demonstrates that Fe@SiO_2 is not only a functional equivalent but a more sustainable and efficient alternative for industrial rubber curing.

O28

High-energy-density, shape-stable phase change nanocomposites with enhanced thermal response enabled by aligned carbon nanotubes

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Thermal energy storage (TES) and management systems require materials that combine high energy density with shape stability. This work focuses on the development of shape-stabilized organic phase change material (PCM) nanocomposites reinforced with horizontally aligned carbon nanotube (HACNT) architectures. In this way, the exceptional CNT properties for efficient heat and load transport are exploited, simultaneously addressing the two main issues of organic PCMs, i.e., leakage above the melting point and low thermal conductivity. Vertically aligned CNT arrays (~1 vol%) were synthesized via chemical vapor deposition and mechanically knocked down. Two superimposed HACNT layers were melt-impregnated under vacuum with various PCMs including alkanes (octadecane, docosane, hexacosane) and fatty acids (decanoic, dodecanoic, tetradecanoic acids) with phase change temperatures in the range 28-57 °C. Vacuum-assisted infiltration ensured complete PCM integration, while excess PCM removal via tissue paper absorption produced shape-stabilized nanocomposites that exhibited no leakage above the PCM's melting temperature. The resulting composites achieve substantial heat storage capabilities with melting enthalpies of 150-250 J/g and final CNT volume fractions of 2-6 vol%, depending on the PCM's chemistry and molecular weight. Scanning electron microscopy of cryofractured surfaces confirms complete infiltration without evident porosity while preserving CNT alignment. Dynamic mechanical analysis reveals mechanical integrity throughout phase transitions and superior shape stabilization: storage moduli ~1.5 GPa below melting temperatures (scaling with CNT concentration) and maintained structural integrity (MPa-range moduli) above melting points. Although the melting enthalpy decreases with an increase in the CNT concentration, the thermal conductivity along the CNT direction shows the opposite trend, reaching ~1.7 $W \cdot (m \cdot K)^{-1}$. This leads to an increase in thermal effusivity up to ~11.3 $J \cdot cm^{-3/2}(m \cdot s \cdot K)^{-1/2}$. Moreover, these HACNT-PCM nanocomposites exhibit solar- and electro-to-thermal energy conversion capabilities. Therefore, the developed nanocomposites are promising candidates for next-generation thermal management applications requiring rapid, reversible thermal response with high energy density and mechanical robustness.

O29

Melt-pool boundary corrosion in innovative additive manufactured al-based alloys

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Additively manufactured (AM) aluminium alloys are promising for lightweight applications due to their excellent strength and low density. $AlSi_{10}Mg$ has been widely used, but new Al-Si-Cu and Al-Cu alloys for Laser Powder Bed Fusion (LPBF) improve the strength-to-weight ratio. Rapid solidification rates open new opportunities to develop innovative alloys due to the different supersaturation mechanisms. The uneven distribution of alloying elements which are prone to segregate at the melt pool boundary leads to the formation of unique microstructures but can severely affect the corrosion performance. Three different AM aluminium alloys were considered with different Cu content to assess the effect of this element on the corrosion behaviour. $AlSi_9Cu_3$ and AM2139 alloy have 3 and 5% Cu respectively. $AlSi_9Cu_3$ has also 9% silicon, whilst Al2139AM has no Si. $AlSi_{10}Mg$ alloy was considered as reference widespread used AM aluminium alloy. Microstructural analysis was performed by scanning electron microscopy with energy-dispersive X-ray spectroscopy. Susceptibility to intergranular corrosion was assessed according to EN ISO 11846 (Method B) standards. Volta potential measurements were performed by Scanning Kelvin Probe Force Microscope. Local and average line scans size varying from 50 x 45 μm^2 to 20 x 20 μm^2 were collected. Microstructural analysis evidenced melt pool macrostructure with precipitates particularly coarsened along the melt pool boundary. For $AlSi_{10}Mg$ and $AlSi_9Cu_3$, the heat affected zone exhibits a more discontinuous network of silicon. The addition of Cu in Al-Si alloys – i.e. in $AlSi_9Cu_3$ - leads to the build-up of Al2Cu at the melt pool boundary/heat affected zone interface. Volta potential measurements confirmed the unique distribution of such Cu-rich phases at melt pool boundary/heat affected zone. Corrosion behaviour is strictly related to the macrostructure assuming an inter-melt pool morphology. Galvanic coupling between α-Al matrix and Cu- and Si-rich phases drives the corrosion phenomena. The addition of Cu increases the susceptibility to melt pool boundary selective penetrating attack. Selective corrosion is strongly related to the cathodic effect of secondary phases, while the macro-galvanic coupling between the melt pool boundaries, heat affected zone and the center of the melt pool defines the preferential path of corrosion attacks. The higher the Cu content, the higher the macro-galvanic effect was noticed.

O30

Enhanced properties of 3D-printed graphene oxide nanocomposites through itaconic acid polyester grafting

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Vat photopolymerization (VP) enables high-resolution additive manufacturing but suffers from intrinsically brittle and mechanically weak commercial resins, limiting structural and load-bearing applications. This study investigates PBIA-grafted graphene oxide (GO@PBIA) as a sustainable surface-engineered nanofiller to enhance dispersion, interfacial bonding, and overall performance in 3D-printed nanocomposites. GO was carboxylated, esterified, and subsequently grafted with photocurable poly(butylene itaconate-co-adipate) (PBIA) via polytransesterification. The modified filler was blended with commercial rigid and flexible VP resins at different loadings and processed by LCD-based 3D printing. The resulting materials were systematically characterized through tensile and flexural testing, rheological analysis, SEM/TEM imaging, TGA, spectroscopy, and electrical conductivity measurements to assess structure–property relationships. GO@PBIA exhibited markedly improved colloidal stability, homogeneous dispersion within the resin, and enhanced printability without sedimentation. At 0.05 wt%, it increased elastic modulus and tensile strength up to 57% and 100%, respectively, while significantly improving flexural modulus, strength, and overall toughness. Fractographic analysis confirmed improved interfacial adhesion and effective stress transfer. Thermal stability was preserved, and electrical conductivity of GO was maintained without detrimental effects from surface modification. Covalent grafting promoted strong filler–matrix interactions and efficient stress transfer, reducing aggregation and preventing sedimentation during printing. The improved dispersion minimized stress concentration sites and enhanced load distribution across the crosslinked network. Compared to pristine GO, GO@PBIA provided superior reinforcement at low loadings, demonstrating that controlled surface functionalization is crucial to balance stiffness, strength, and toughness while preserving processability and multifunctional properties in VP-based nanocomposites.

O31

Stress relaxation behavior of PMMA: insights into viscoelastic mechanisms from fractional modeling

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Stress relaxation measurements are widely used to investigate the viscoelastic behavior of polymeric materials. In amorphous polymers such as poly(methyl methacrylate) (PMMA), relaxation reflects segmental dynamics and proximity to the glass transition temperature (T_g). Below T_g, PMMA exhibits non-exponential relaxation, indicating a broad distribution of relaxation times associated with dynamic heterogeneity and cooperative molecular motions. Fractional viscoelastic models provide an efficient and physically meaningful framework to describe such distributed relaxation mechanisms. Stress relaxation experiments were performed on PMMA using a universal testing machine (MTS) under linear viscoelastic conditions over a temperature range below and approaching T_g. Time–temperature superposition (TTS), applying horizontal and vertical shift factors, was used to construct relaxation master curves in the time domain. In parallel, Dynamic Mechanical Thermal Analysis (DMTA) was carried out to investigate the viscoelastic response as a function of temperature and frequency. Frequency–temperature superposition enabled the construction of master curves of storage modulus (E') and loss modulus (E'') over an extended frequency range. The dynamic moduli obtained experimentally were compared with those calculated through Fourier transform of the relaxation master curve. Experimental data were interpreted using a Fractional Maxwell Gel (FMG) model. PMMA shows pronounced non-exponential stress relaxation across the investigated temperature range. The relaxation curves exhibit good superposition, allowing the construction of a master curve spanning several decades in time. DMTA measurements similarly provide extended master curves for E' and E'' in the frequency domain. The fractional relaxation exponent remains nearly temperature-independent, while horizontal shift factors display strong temperature dependence consistent with thermally activated molecular mobility. Good agreement is observed between experimentally measured dynamic moduli and those derived from the Fourier-transformed relaxation master curve. The combined time-domain (stress relaxation) and frequency-domain (DMTA) analysis provides a comprehensive description of PMMA viscoelasticity. The consistency between experimental and transformed data supports the robustness of the fractional viscoelastic approach, which effectively captures wide time and frequency behavior with a limited number of physically interpretable parameters.

O32

PLA films containing wood tannins as multifunctional additives for active food packaging applications

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Tannins obtained from wood-industry residues represent an underexploited bio-based resource with intrinsic antioxidant, antimicrobial and UV-blocking properties. Their multifunctionality makes them attractive candidates for active packaging applications. However, their strong polarity and heterogeneous polyphenolic structure limit their compatibility with hydrophobic polymer matrices such as polylactic acid (PLA), hindering their incorporation via scalable melt-processing technologies. In this work, chestnut (Castanea sativa) and mimosa (Acacia mearnsii) tannins, characterised by hydrolysable and condensed polyphenolic structures, respectively, were incorporated as a combined additive system into PLA. Poly(ethylene glycol) (PEG) was employed as a plasticising and processing aid to enable tannin incorporation through melt extrusion. Prior to extrusion, tannins (50 wt.% chestnut and 50 wt.% mimosa) were dispersed in molten polyethylene glycol (PEG) at 80 °C to obtain a homogeneous additive mixture. The PEG/tannin blend was then physically premixed with PLA pellets and dried before melt extrusion. Films (≈ 250 µm thick) containing 1, 2, and 5 wt.% tannins were produced. Morphology was analysed by SEM, chemical interactions by ATR-FTIR, and thermal and mechanical behaviour by DSC, TGA, and tensile testing. Multifunctional properties relevant to active food packaging were assessed via UV-Visible spectroscopy (UV-blocking), DPPH assay (antioxidant activity), and antimicrobial activity against model microorganisms (*Listeria monocytogenes, Salmonella Typhimurium, Bacillus subtilis*). Tannins were successfully incorporated into PLA through melt extrusion, yielding continuous films. PEG induced a marked reduction in Tg and promoted a ductile behaviour, while tannin addition did not significantly modify thermal transitions or provide mechanical reinforcement, though high ductility was retained across all compositions. Importantly, tannin incorporation led to a pronounced concentration-dependent enhancement of UV-blocking, with a decrease in UV transmittance. DPPH assays demonstrated strong antioxidant activity, which increased with tannin loading and reached complete radical scavenging (100% RSA) after 48 h, indicating potential for oxidative protection in food systems. The preservation of UV-blocking and antioxidant activity after melt processing at 180-200 °C demonstrates the thermal stability and functional retention of both hydrolysable and condensed tannins under industrially relevant processing conditions. PEG primarily acts as a plasticiser and enables the integration of hydrophilic tannins into PLA, preserving processability while introducing multifunctionality. The results show that enhanced active performance can be achieved without compromising the ductile behaviour of the plasticised PLA matrix, supporting the feasibility of producing multifunctional films for active food packaging applications through conventional extrusion technologies.

O33

Upcycling proteins from marine resources

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Marine byproducts, often discarded as waste, represent an abundant and underutilized source of structurally rich proteins, particularly collagen. In this talk, I will show how the upcycling of collagen extracted from marine sources, such as fish skin and swim bladders, can produce high-performance materials for biomedical, industrial, and textile applications. Dried sturgeon swim bladders was used as a source for collagen extraction. Gelatin from cold water fish skin, microbial transglutaminase, transglutaminase assay kit and Phosphate Buffer Saline (PBS) solution (pH 7.4) were purchased from Sigma Aldrich and used as received. Commercial transglutaminase, was used to crosslink the extracted collagen. The swim bladder was cut into small pieces, and put in deionized water under continuous magnetic stirring at 60°C for 1 hour to dissolve. The obtained solution was then centrifuged at 1500 rpm for 5 minutes to remove impurities. The supernatant, which is made of water-soluble collagen, was collected and used for material fabrication. 97% of the initial weight of the swim bladder was being dissolved with this method. The supernatant was characterized and used for hydrogel fabrication. The collagen and gelatin solutions were mixed with the solutions of the enzyme, at different proportions and incubated to allow crosslinking from enxyme. In a second project, the collagen was crosslinked with carboxymethylcellulose (CMC) via EDC coupling of the carboxyl groups of CMC and the amino groups of collagen. Through enzymatic and chemical crosslinking strategies, marine-derived collagen was transformed into versatile hydrogel systems with tunable mechanical properties and swelling behavior, enabling their use as bioactive wound dressings. These hydrogels demonstrated antioxidant delivery capability, cytocompatibility, and in vivo efficacy in mitigating inflammation in burn injuries. In a parallel development, collagen was combined with carboxymethylcellulose to produce fully biodegradable, superabsorbent hydrogels with high water retention and swelling capacity, suitable for applications in wound exudate management and sustainable hygiene products. Extending beyond biomedical uses, marine collagen was also employed to enhance the performance of fish leather, an emerging sustainable material that can replace leather from exotic animals with a more sustainable alternative. Collectively, these studies demonstrate the immense potential of marine-derived proteins as circular, sustainable building blocks for advanced material design. By valorizing waste streams from the seafood industry, we establish a protein-based materials platform that supports both environmental goals and high-value innovation.

O34

Overcoming hazardous solvent lock-in in electrospinning through green solvent systems and process-structure-property correlations

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Electrospinning is a key technology for producing advanced nanofibrous membranes, but its large-scale adoption is strongly limited by the reliance on hazardous and potentially carcinogenic solvents such as chloroform (CHF), dichloromethane (DCM). This dependence generates a "hazardous solvent lock-in", hindering environmental sustainability, operator safety, and industrial transfer. This work aims to overcome such lock-in through a methodological framework for the identification and optimization of green solvent systems for widely used biodegradable polymers, namely poly(lactic acid) (PLA) and poly-caprolactone (PCL). PLA and PCL were dissolved in selected green solvent systems at different concentrations. Solutions were first evaluated from a thermodynamic perspective to verify their compatibility with electrospinning. Rheological behavior and electrical conductivity were then characterized. Electrospinning was carried out using standard processing parameters (needle-collector distance 15 cm, applied voltage 15 kV, flow rate 3 mL/h, rotating collector, temperature 25 °C) to assess the real transferability of the proposed systems without process intensification. The resulting membranes were characterized in terms of morphological, mechanical, and thermal (DSC–TGA) properties. Their functional performance and stability were also evaluated, particularly in view of potential oil spill clean-up applications. The investigated green solvents exhibited a wide electrospinning processability window, enabling the production of stable nanofibrous membranes with morphologies ranging from uniform fibers to beads-on-string and bead-like structures. Solvent composition and polymer concentration significantly affected fiber morphology, diameter distribution, and structural homogeneity. Membranes produced from green solvents showed mechanical and thermal performances comparable to those obtained using traditional hazardous or potentially carcinogenic solvents. Functional oil spill clean-up tests revealed good absorption capacity, confirming the effectiveness of the developed membranes. The results demonstrate that the dependence on hazardous solvents in electrospinning is not a technical necessity. A rational approach based on thermodynamic, rheological, and electrostatic considerations enables the design of alternative solvent-polymer systems compatible with standard electrospinning parameters. This strategy allows hazardous solvent lock-in to be overcome without substantial process modifications, facilitating safer and sustainable electrospinning routes. Overall, this study supports safer, more sustainable, and scalable electrospinning processes for various applications.

O35

Comparative analysis of blowing agents in waste-derived glass foams: advantages of recycled carbon microfibers

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Urban glass waste powder, a major by-product of residential glass recovery processes, and scrap carbon fiber, an industrial waste material generated during secondary production of non-woven carbon fiber fabrics, both present significant recycling challenges and are often disposed of in landfills. This research aims to develop a sustainable and eco-friendly optimized approach to produce light-weight foam glass (FG) by using these wastes. A critical challenge in foam glass production lies in optimizing its structural and functional properties. Foam glass, characterized by its porous microstructure and low density, is widely utilized in industrial applications due to its excellent thermal insulation, mechanical properties, and environmental benefits. Post-consumer glass bottles were collected from public waste bins in Rome, Italy. Powered recycled carbon fiber (PRCF) was used. The effects of sintering temperature, and foaming agent content were investigated using optical microscopy, scanning electron microscopy, laser thermal constant analysis, and a universal testing machine, respectively. The impact of (PRCF), a different technique for recovering waste carbon fiber, as the foaming agent of FG is examined in this study. In relation to powdered waste glass, PRCF has been used at mass concentrations of 0.5%, 1%, and 1.5% at 900 °C, 950 °C, and 1000 °C to fabricate foam glass. The effects of sintering temperature, and foaming agent content were investigated as the key parameters influencing foam structure, pore distribution, compressive strength, thermal conductivity, bulk density, and total porosity. Thus, the combination of 1 wt.% PRCF and 950 °C sintering was found to be optimal, offering a favorable balance of high porosity, low density (~1.076 g/cm^3), and structural stability. The findings are consistent with the expected outcomes of FG processing, wherein increased porosity leads to a substantial reduction in bulk density. Such materials are highly desirable for construction applications requiring lightweight insulation, as they reduce load-structural load while maintaining essential thermal resistance properties. Thus, the combination of PRCF content and sintering temperature must be carefully optimized to tailor the bulk density and porosity of foam glass for targeted engineering applications.

036

Valorization and mechanical recycling of hazelnut shell-reinforced polybutylene succinate composites

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Most packaging producers still rely on non-degradable petroleum-based polymers such as polypropylene and polyethylene. Circular economy models ask for renewable and degradable alternatives. Among them, biopolymers like polybutylene succinate (PBS) are gaining interest. Fillers are commonly used to mitigate biopolymers cost, as well as to improve mechanical performance. In this view, agrifood byproducts work as abundant and cheap fillers. PBS granules grafted with maleic anhydride (MA) were filled with up to 30 wt.% Hazelnut Shell (HS) (180 µm) using a co-rotating twin screw extruder and injected to obtain samples for further characterisation. PBS-30HS was mechanically recycled up to 10 times. Testing included tensile and three-point bending tests, differential scanning calorimetry, thermogravimetric analysis (TGA), and scanning electron microscopy (SEM). Life Cycle Assessment (LCA) was performed to investigate potential benefits across impact categories for increasing filler content. Mechanical testing shows, for increasing filler content, a progressive increase in tensile/flexural strength (>130%) and moduli (>40%). Consecutive recycling cycles of composite formulation reduce the mechanical performance compared to unrecycled PBS-30HS. SEM micrographs highlight poor adhesion at the matrix/filler interface. dTG peak progressively reduces for higher filler content and after different recycling cycles (from 403.2 °C PBS, to 393.0 °C PBS-30HS_10rec). Crystallinity decreases from 59.3% to 48.6% for 30 wt.% HS, then raising to almost 60% after 10 recycling cycles. LCA shows that increasing the filler content leads to a progressive reduction in impact categories values, typically ranging from −10% to −30%. Renewable energy mixture can further reduce the overall environmental footprint. Untreated HS improves the strength and stiffness of the composites, despite the non-optimal matrix/filler adhesion, which may require superior MA content or filler pretreatments which, in turn, will reduce the gap in environmental footprint benefits. HS reinforces the composites thanks to its lignocellulosic nature and superficial roughness that contributes for mechanical interlocking. However, this reduces the thermal stability of the composites compared to the neat matrix. It is excluded any effect as nucleating agent of the filler. Overall, the results indicate that these materials can be considered valid candidates for rigid packaging application. The research was funded by the European Union – NextGenerationEU, Mission 4, Component 1, within the BOOMERANG project (Bio-cOmpOsite Material dEsign foR pAckagiNG, CUP B53D23006530006) and within the MUSA – Multilayered Urban Sustainability Action – project, funded by the European Union – NextGenerationEU, under the NRRP Mission 4 Component 2 Investment Line 1.5.

037

Integrated valorization of artemisia arborescens: biomass and essential oil in pbsa-based biocomposites

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Essential oil distillation generates significant amounts of residual biomass, creating environmental and economic challenges. In a circular economy approach, the integrated valorization of both essential oil and exhausted biomass represents a sustainable strategy to enhance resource efficiency. This study examines the use of distillation by-products and essential oil from the Sicilian native species *Artemisia arborescens* (Vaill.) L. for the development of biodegradable PBSA-based biocomposites with potential packaging applications. Powdered exhausted biomass of A. arborescens was incorporated (10 and 20 wt%) into poly(butylene succinate-co-adipate) (PBSA) via melt compounding. The systems were characterized through rheological, mechanical, thermo-mechanical, thermal, wettability, and morphological analyses, and their biodegradation under composting conditions was evaluated. Additionally, 20 phr of essential oil (relative to PBSA), obtained from the same distillation process, was added to neat PBSA and to the composite containing 20 wt% biomass. The physical properties and antimicrobial activity of the resulting materials were investigated. The incorporation of spent biomass increased stiffness and melt viscosity while reducing ductility compared to neat PBSA. The presence of the biomass also accelerated biodegradation under composting conditions: compared to pure PBSA, biocomposites showed a faster weight loss, increased crystallinity, higher wettability, and enhanced microbial colonization, indicating accelerated biodegradation. The addition of essential oil acted as a plasticizer, decreasing stiffness and increasing material extensibility and the degree of crystallinity. However, the presence of the biomass limited oil release over time, resulting in only weak antimicrobial activity. The results demonstrate that distillation residues of A. arborescens can be effectively valorized as functional fillers in PBSA-based biocomposites, enhancing stiffness and promoting biodegradation. Although essential oil incorporation improves flexibility, its limited release reduces antimicrobial effectiveness. Overall, the study highlights a sustainable and integrated approach for transforming agro-industrial by-products into value-added biodegradable materials.

O38

Advanced materials in shipbuilding: recent developments and future challenges

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The Italian shipbuilding industry is facing converging pressures due to domestic and extra-EU competition. Increasingly demanding safety, environmental and operational requirements, coupled to the need to reduce lifecycle-costs, call for a strong innovation effort to be pursued into the narrow industrial sustainability framework. Materials innovation is a primary lever to address these challenges simultaneously, yet adoption in shipbuilding remains complex because of certification pathways, solutions scalability and harsh operating environments. However, recent developments in material science, design and manufacturing processes paved the way to introduce innovative solutions in the multiform ship-ecosystem. The inherent complexity of ship platforms demands tailored material solutions that vary with innovation drivers and application areas, such as structures, outfitting and interiors, paints and coatings, propulsive, energy and onboard systems as well as ballistic protection, electromagnetic and acoustic signature management solutions specific for naval applications. In this context, main innovative material categories such as metamaterials, nanomaterials, Polymeric and Ceramic Matrix Composites (PMCs, CMCs) and others are being investigated across the aforementioned areas to deliver novel solutions aligned with operational requirements while accounting for regulatory, manufacturing, and economic constraints. In recent years, Fincantieri has strengthened its innovation ecosystem through structured foresight activities and systematic scouting partners. This has catalyzed multiple R&D initiatives in Advanced Materials (AdM) across diverse shipboard applications, accelerating Technology Readiness Level (TRL) progression and bringing several solutions closer to industrial deployment. Significant advances have been achieved in lightweighting, an essential driver to reduce fuel consumption and environmental impact, alongside improvements in operational performance and long-term durability in harsh marine environments. Despite current constraints, the adoption of Advanced Materials (AdM) in shipbuilding is feasible through careful selection of use cases, robust design methodologies and mature manufacturing processes. However, these choices often narrow the available design space, thereby limiting the achievable performance gains. Looking ahead, the challenge is not only to develop innovative, higher-performing and multifunctional materials, but also to raise the maturity, scalability and qualification readiness of enabling manufacturing technologies inside the industrial sustainability context, to fully unlock the potential of AdM.

O39

Use of fenolic resins on board naval units

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The materials used on board Naval Vessels must comply with the fire behavior and resistance standards prescribed by the Naval Registry Regulations. For fire suppression on ships, passive (fire compartmentalization of spaces) and active (fire extinguishing systems) protection systems are provided. There are various types of fire walls. In particular, the B15 class wall is normally made with steel/rock wool/steel sandwich panels that must be certified according to the IMO FTP Code, regarding the material's flammability and resistance to flame and heat transmission. To reduce the amount of rock wool on board, Fincantieri and Acell have developed a fireproof panel for furniture, using phenolic-based products that have obtained the non-combustibility certification according to IMO FTP Code Annex 1 part 1: ACELL SF GLUE (density 1850 kg/m^3), ACELL FOAM NC 260 (density 260 ± 10% kg/m^3), and ACELL AMC GLUE-MAT_MARINE. Furthermore, to obtain certification for use on board, the panel was subjected to the fire resistance tests (IMO FTP Code Annex 1 part 3) and mechanical tests required by the Naval Registry and Fincantieri. Following successful testing and a physical mock-up of a cabin, an innovative product for class B15 fire compartmentalization is now available. The new panel eliminates the use of rock wool in sandwich panels and achieves a 20% weight reduction (from 21 kg/m^2 for the traditional solution to 17 kg/m^2 for the new solution). The phenolic resin used is an ablative material: upon contact with heat, it carbonizes and burns away, retaining heat and thus reducing heat transmission. The possibility of using phenolic-based materials to protect metal structures from fire is currently being investigated.

O40

Advanced materials for effective antennas and sensors integration on modern naval vessels

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The increasing operational demands of modern naval platforms require advanced solutions for the physical and functional integration of onboard subsystems. This challenge is particularly critical in above-deck areas, where the density of radio-frequency (RF) sensors has significantly increased to support enhanced communication, surveillance, and electronic warfare capabilities. At the same time, the continuous effort to reduce the weight and volume of masts and superstructures - driven by performance optimization and radar cross-section (RCS) mitigation requirements - has further intensified integration constraints. The resulting compact architectures force antennas and RF devices to operate in close proximity to each other, exacerbating electromagnetic interference, coupling effects, and overall system complexity. In this context, Fincantieri Naval Shipbuilding Division has initiated a research program focused on the application of innovative materials, specifically metamaterials, in naval environments, in collaboration with the RaSS National Laboratory, CNIT, and Free Space Srl. The activity aims to investigate engineered materials capable of tailoring electromagnetic behavior to improve antenna integration, mitigate interference phenomena, and enable more compact and efficient topside architectures. The integration of structural metasurfaces and metamaterials represents a particularly promising approach to enhance antenna performance within highly constrained external environments. For naval applications, such engineered materials must be combined with protective layers capable of withstanding harsh marine conditions, thereby ensuring long-term durability, environmental resistance, and stable electromagnetic performance. A prototype of the metamaterial solution based on the use of properly designed FSSs (Frequency Selective Surfaces), was realized and tested on a scaled naval mast mock-up to measure its effect on the decoupling between X band antennas. The results have shown an average decrease of more than 10 dB on the antennas decoupling in several configurations (i.e. different arrangements of metamaterial and antennas).This work presents metamaterial-based solutions designed to operate as Artificial Magnetic Conductors (AMC) and Electromagnetic Band Gap (EBG) structures in selected topside areas, with the objective of improving antenna decoupling and mitigating mutual coupling effects in dense RF scenarios.

O41

Reconfigurable radar-absorbing metasurfaces for dynamic signature control

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Naval platforms operate in highly demanding environments characterized by severe atmospheric exposure and increasingly complex threat scenarios. In addition to long-term durability, modern military vessels must integrate advanced technologies that reduce size and weight while preserving high-performance electromagnetic functionality. In this context, radar signature management has become a strategic requirement, particularly against evolving surveillance and targeting systems. This work presents the design, fabrication, and experimental validation of active radar-absorbing metasurfaces developed for dynamic radar cross-section (RCS) control in naval applications. Unlike conventional radar-absorbing materials, the proposed solution enables reconfigurable electromagnetic behavior, providing enhanced adaptability to different operational scenarios. Stable and controllable signature reduction ensures that both passive stealth strategies and active electronic countermeasures maintain their effectiveness. The metasurface architecture consists of a multilayer structure engineered to achieve the desired electromagnetic response. High-conductivity and resistive layers are combined with printed circuit board (PCB) substrates incorporating Smart Selective Surfaces. The structure is loaded with active electronic components, including switching diodes and varactors, enabling tunability of the surface impedance. Precise geometric shaping and tight assembly tolerances are adopted to ensure accurate reproduction of the targeted frequency response. By controlling the biasing state of the embedded components, the metasurface can dynamically adapt its electromagnetic properties according to the operational environment and threat conditions. Several active prototypes were manufactured and experimentally characterized. A dedicated measurement campaign was conducted to evaluate tunability and reconfigurability performance. The results demonstrate that switching the state of the active elements produces an instantaneous transition between reflective and absorbing regimes, confirming the effectiveness of the proposed design methodology.These findings indicate that active metasurfaces represent a promising solution for next-generation smart protection of naval platforms. When strategically applied to structural radar hot-spots, such materials enable dynamic RCS modulation, offering advanced capabilities for adaptive signature control and enhanced survivability against hostile radar systems.

O42

Sustainable PBS/glochids biocomposites from agri-food waste: from material development to data-driven optimization

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The transition toward sustainable materials requires replacing conventional plastics with bio-based and biodegradable alternatives. Polybutylene succinate (PBS) is a promising biodegradable polyester with mechanical properties comparable to polyolefins, but its relatively high cost and limited stiffness restrict broader industrial applications. One strategy to overcome these limitations involves incorporating natural fillers derived from agricultural waste. In this context, the glochids of Opuntia ficus-indica fruits represent an abundant agri-food by-product that can be valorized as reinforcement in biodegradable composites, contributing to circular economy strategies. Biocomposites based on PBS reinforced with glochids were prepared by melt compounding in a twin-screw extruder with different filler contents. The resulting materials were characterized through thermal (TGA, DSC), spectroscopic (ATR-FTIR), morphological (SEM, OM), and mechanical tests. Compost burial tests were carried out to evaluate biodegradation behavior. In parallel, a Design of Experiments (DoE) approach was implemented to optimize the filler content and identify the best balance between stiffness and ductility. The experimental dataset was then used to train artificial neural networks (ANN) capable of predicting mechanical performance and evaluating the effects of mechanical recycling cycles. The incorporation of glochids improved the stiffness of PBS-based materials, with Young's modulus increasing by up to ~70% at the highest filler loading. Thermal analyses showed that glochids acted as heterogeneous nucleating agents, increasing the crystallinity of the polymer matrix. Despite a slight decrease in ductility, the mechanical properties remained suitable for applications such as packaging, consumer goods, and automotive interiors. Compost burial tests demonstrated that the natural filler accelerated degradation of the composites within 90 days. Statistical optimization identified an optimal filler content around 13–14 wt%, achieving a significant increase in modulus while maintaining acceptable elongation at break. Machine-learning models trained on experimental data showed strong predictive capability ($R^2 \approx 0.88$) for estimating the mechanical behavior of recycled materials. The results demonstrate that glochids represent a valuable renewable reinforcement for PBS-based biocomposites, enabling both performance enhancement and waste valorization. The integration of statistical experimental design and machine learning further provides a powerful framework for accelerating materials development and predicting performance under recycling conditions. This combined experimental and data-driven approach supports the development of eco-efficient polymeric materials suitable for sustainable industrial applications.

O43

Additive manufacturing of advanced alumina-based ceramic materials (ECOBAM project)

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The ECOBAM project explored the use of "direct" (single-step) additive manufacturing to overcome the geometric constraints of traditional solidification techniques. Specifically, the research focused on alumina-based ceramic materials, investigating their processability and microstructural evolution during high-energy beam interaction. Powder feedstock was prepared via spray drying to achieve a spherical morphology and high flowability. Several “direct” AM technologies were evaluated: laser powder bed fusion (L-PBF) with fiber and CO_2 lasers, and electron beam melting (EBM). Characterization was carried out using SEM, XRD, profilometry, granulometry, micro-CT and microhardness. Finally, the environmental profile of the L-PBF technologies was preliminarily evaluated and benchmarked against conventional methods, specifically pressing and sintering. Spray drying enabled the production of homogeneous particle size fractions (<50 µm and 50–200 µm). EBM tests were prematurely terminated due to powder bed instability under vacuum (the “smoke effect”). Experimental results showed that CO2 laser-assisted PBF is the most suitable technology for alumina-based ceramics, yielding samples with a relative density of approximately 94–96% and a homogeneous microstructure. Furthermore, it was demonstrated that the quality of alumina parts is highly sensitive to the control of volumetric energy density. Indeed, insufficient energy density induces porosity, delamination and microstructural heterogeneity via lack-of-fusion mechanisms. Tests on graphene-doped eutectic mixtures revealed that high scanning speeds and beam defocusing are essential to mitigate material vaporization and pore formation. The LCA indicated that the L-PBF process operating in an argon atmosphere (fiber laser) generally results in higher environmental impacts than conventional methods. The adoption of a CO2 laser, in turn, generates a greater environmental footprint than the fiber laser due to extended processing times; however, it offers the advantage of eliminating the need for inert gases. Overall, the project established an optimal process window for the 3D printing of dense ceramics, highlighting the direct correlation between laser parameters, powder absorption, and microstructural quality, while identifying key environmental hotspots to be addressed for sustainable manufacturing. This study was carried out within the « Dense Eutectic Ceramic Oxide by Additive Manufacturing; Sustainable by Design Materials and Techonogies (ECOBAM) » project – funded by European Union – Next Generation EU within the PRIN 2022 PNRR program (D.D.1409 del 14/09/2022 Ministero dell’Università e della Ricerca). This manuscript reflects only the authors’ views and opinions and the Ministry cannot be considered responsible for them.

O44

Next-generation ODS copper alloys via additive manufacturing for advanced thrust chamber manufacturing

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Advancing propulsion systems requires improving lifespan and cost-effectiveness of reusable launch components. Rocket thrust chambers are subjected to extreme thermo-mechanical loads that accelerate material degradation. Copper-based alloys are attractive candidates for these applications due to their thermal conductivity combined with favourable mechanical strength. Conventional strengthening approaches rely primarily on precipitation strengthening (PS) through alloying additions such as Cr, Zr, or Nb. Although PS improves strength via intermetallic precipitate formation, these systems suffer from limited thermal stability due to precipitate coarsening and dissolution at elevated temperatures. Oxide dispersion strengthened (ODS) copper alloys offer a promising alternative by incorporating stable oxide nanoparticles that enhance high-temperature strength, creep resistance, and microstructural stability while preserving the thermal conductivity of copper. This work investigates the development of ODS copper alloys derived from GlidCop Al-15 using laser powder bed fusion (L-PBF) combined with an in situ oxide formation strategy. Intentionally oxidized Cu-Al powders were processed to promote redox-driven oxide formation during laser melting. The reduction of the copper oxide surface layer released oxygen, which subsequently reacted with dissolved aluminium promoting nucleation of finely dispersed Al_2O_3 particles within the molten pool.The scalability of this approach was evaluated by systematically varying L-PBF process parameters and applying post-process heat treatments on the resultant samples at different temperatures and holding times. Microstructural characterization was performed using advanced microscopy and X-ray diffraction to analyse oxide dispersion nature, size, and clustering behaviour. Microhardness testing were conducted to quantify the strengthening effects associated with each processing condition. L-PBF processing successfully promoted the formation of nanoscale oxide dispersions throughout the copper matrix. Process parameters influenced melt pool dynamics, extent of reaction, and overall microstructural refinement. Post-process heat treatments revealed temperature and time dependent microstructural rearrangment due to clustering phenomena. SEM confirmed the presence of finely distributed oxide nanoparticles, while X-ray diffraction validate phase nature and stability across all the thermal exposured conditions. Microhardness helped to understand the factors contributing to the overall strengthening response characteristic of each condition. The results confirm that redox-assisted in situ oxide formation during L-PBF represents a viable route for producing ODS copper alloys without conventional mechanical alloying. The stability of Al_2O_3 nanoparticles effectively restricts dislocation mobility, grain boundary migration, and recrystallization, contributing to improved thermal stability compared with precipitation-strengthened systems. Furthermore, the integration of additive manufacturing enables precise control over microstructural development while allowing fabrication of complex geometries required for advanced propulsion components. This work was supported by the Metal-AMUSE project, funded by the Italian Space Agency (ASI) in collaboration with the National Interuniversity Consortium for Materials Science and Technology (INSTM), under the framework of the five years Master Agreement No. 2023-17-Q.0.

O45

Preparation and characterisation of composite materials based on polycarbonate-polybutylene terephthalate blends reinforced with recycled carbon fibres for advanced applications

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This work presents the development and characterization of sustainable composite materials based on a polymer blend of polycarbonate and polybutylene terephthalate (PC–PBT), reinforced with recycled short carbon fibers (rCF). The study focuses on the influence of fiber content, processing conditions, and post-processing heat treatments on the thermo-mechanical and physico-chemical properties of the composites. Particular attention is given to establishing correlations between microstructural features and macroscopic behavior.Four formulations were prepared by varying the rCF weight fraction (0%, 10%, 20%, and 30%) within the PC–PBT matrix. Compounding was carried out using a twin-screw extruder to ensure homogeneous dispersion of the reinforcement. The extruded materials were subsequently injection molded into standardized Type 5A specimens according to ISO 527. Selected samples were subjected to a post-processing heat treatment aimed at enhancing thermodynamic stability and promoting crystallinity. Calorimetric analysis indicates that recycled carbon fibers act as effective heterogeneous nucleating agents. In heat-treated samples, a progressive increase in the fusion enthalpy was observed with increasing fiber content, rising from 34 J/g for the neat matrix to 39 J/g for the composite containing 30 wt% rCF. Mechanical characterization revealed a significant modification in material behavior with fiber addition, highlighting a transition from ductile to brittle response. The Young's modulus exhibited a linear increase with fiber content, ranging from 2.7 GPa for the unfilled matrix to 10.2 GPa (+277%) for the composite with 30 wt% rCF. Heat-treated specimens showed further improvements in both stiffness and tensile strength. The results confirm the effectiveness of recycled carbon fibers as high-performance reinforcement for polymer blends, providing a viable solution aligned with circular economy principles. Heat treatment was found to play a dual role, not only relieving internal stresses but also promoting microstructural optimization. Overall, the findings demonstrate the potential to convert industrial waste into advanced composite materials suitable for demanding structural applications in sectors such as automotive and aerospace, combining enhanced mechanical performance, thermal stability, and reduced environmental impact.

O46

Biochar as a low-carbon substitute for cement in high-performance mortars

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Cement production is responsible for a significant share of global CO_2 emissions, making the development of low-impact cementitious materials increasingly urgent. Biochar, a carbon-rich solid residue obtained from the pyrolysis of biomass waste, represents a promising solution due to its high chemical stability and its potential to permanently sequester carbon within cement-based matrices. In this work, the partial replacement of cement with biochar derived from different feedstocks was investigated, evaluating its influence on the microstructural and mechanical properties of mortars. Four biochars obtained from pine pellets (PP), walnut shells (WS), wood chips (WC), and recycled wood (RW) were used. The powders, milled and sieved (50-200 µm), were characterized by SEM, laser particle size analysis, thermogravimetric analysis (proximate analysis), and XRD. Mortars were prepared by partially replacing cement with biochar (2.5-15 wt%), keeping constant water-to-binder (0.50) and aggregate-to-binder (3) ratios. A Taguchi design of experiments was adopted to optimize biochar type, replacement level, maximum particle size, and superplasticizer content. Mechanical properties were evaluated by compressive strength tests at 7 and 28 days, while porosity was analyzed by mercury intrusion porosimetry. Microstructural analyses revealed significant morphological differences among the biochars, with PP showing a particle size distribution more compatible with cement and a high fixed carbon content (~95%). Optimization results indicated that 106 µm sieved biochar, 2% superplasticizer, and low replacement levels provided the best performance. Mortars containing PP biochar exhibited compressive strength up to 45 MPa at 10% cement replacement, outperforming the reference mortar (~36 MPa). In contrast, RW and WS biochars led to increased porosity in the 0.1–10 µm range and reduced mechanical performance at higher replacement levels. Mercury intrusion porosimetry confirmed that PP biochar refines the pore structure, whereas RW and WS introduce larger pores. The results demonstrate that a proper selection of biochar enables a significant reduction in clinker content without compromising - and in some cases even improving - mechanical performance. The nucleation effect and the water absorption/release capacity of PP biochar contribute to matrix densification and to a reduction in the effective water-to-binder ratio. Cement replacement up to 10% allows a reduction in mortar carbon content of up to 60%, highlighting biochar as a strategic additive for low-carbon or potentially carbon-negative mortars.

O47

Recycled windshield glass as aggregate and binder in flowable sand concrete

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Automotive windshield glass is a persistent landfill waste due to the polyvinyl butyral (PVB) interlayer, while flowable sand concretes consume large amounts of natural sand. This work evaluates End-of-Life windshields in flowable sand concrete by replacing natural sand with windshield glass aggregate (WGA) and partially replacing cement with windshield glass powder (WGP). Windshield sheets were manually pre-treated to remove rubber seals and PVB. The glass was crushed and sieved to obtain WGA (dmax = 4 mm) and WGP (dmax = 63 µm). Mixes were designed at constant water/binder ratio (w/b = 0.44). Step 1 replaced sand with WGA from 0% to 100% (vol.) at 20% increments. Step 2 replaced cement with WGP at 5%, 10%, 15%, and 20% (mass). Step 3 combined 20% WGA with the same WGP dosages. Superplasticizer (0.65–1.00% of binder) was adjusted based on the EFNARC spread test. Compressive and flexural strengths were measured on 40×40×160 mm prisms at 7, 28, and 90 days; density, static elastic modulus, and ultrasonic pulse velocity were measured at selected ages. Microstructure and phase evolution were assessed by SEM/EDS, XRD, and TGA/DTA/DSC. All WGA mixes showed compressive and flexural strengths higher than the control. The best 28-day performance occurred at 20% WGA, while the maximum 90-day strength was obtained at 40% WGA. For WGP-only mixes, increasing WGP (5→20%) increased both strengths at 7, 28, and 90 days, with pronounced late-age gains. In the combined series (20% WGA + 5–20% WGP), both compressive and flexural strengths at 28 and 90 days exceeded the corresponding 20% WGA and WGP-only mixes, indicating a synergistic late-age effect. SEM/EDS–XRD–thermal outputs were benchmarked against literature indicators of glass-powder reactivity, including paste/ITZ refinement, silica-enriched hydrates, and progressive portlandite consumption. Recycled windshield glass can replace virgin sand and reduce clinker demand while maintaining or improving mechanical performance. The combined WGA–WGP approach highlights mix-design pathways for high recycled-content flowable sand concretes, with microstructural interpretation supporting the observed late-age strength development.

O48

Inside the venetian walls: composition and hydration processes of sixteenth-century lime mortars from Bergamo fortress

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Characterization of historic mortars is becoming increasingly important for factors related to the preservation, restoration and maintenance of historic buildings. Various techniques are often used in combination, to gain an understanding of the microstructure and chemical and physical characteristics of materials. This study aimed at characterizing the mineralogical composition of the historical lime mortars used in the Venetian Fortress of Bergamo, in order to clarify both the provenance of the raw materials and the construction techniques employed in the construction. Mortar samples were collected from nine horizontal cores extracted at the base of the Venetian walls. 43 spot samples and 3 bulk samples were analysed. The materials were characterized through a multi-analytical protocol combining X-ray powder diffraction, ICP-OES, EDS elemental analysis, optical microscopy, and TG-DSC thermal analysis. Principal component analysis (PCA) was used to evaluate phase-abundance patterns across the specimens. The mortars exhibited good cohesion and a predominantly light grey to white color, with aggregates uniformly distributed within the matrix. Petrographic analysis identified quartz, quartzite, limestone and schist fragments, while XRD revealed a binder composed of calcite, brucite, hydrocalumite, hydrotalcite-type phases, aragonite, plombierite and a significant amorphous fraction. Chemical analyses confirmed Mg-rich binders, and TG-DSC data showed CO_2 / bound H_2O ratios and thermal signatures consistent with hydraulic behavior. The same set of crystalline and amorphous phases recurs consistently across all cores, with no significant clustering by depth or sampling position, indicating homogeneous mineralogical composition in the investigated sections. The combined mineralogical, chemical and thermal evidences indicate that the mortars were produced using a lime rich in magnesium and reactive silicate components, leading to the formation of LDH phases and hydrated products typical of hydraulic systems. The notable amorphous content and the presence of brucite and hydrotalcite-like compounds suggest active interactions between lime and silicate aggregates. The absence of magnesite or hydromagnesite points to specific raw material sources, wich will be investigated further in future activity.

O49

Sustainable synthesis and in situ application of a new nanolime for the compatible consolidation of historic plasters. A case study in the old port of Genoa

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The conservation of historic plasters requires consolidation treatments that ensure chemical, physical and mechanical compatibility, long-term durability, and low environmental impact. In recent years, nanolime-based products have shown promising performance in the consolidation of calcareous substrates; however, issues related to sustainability of synthesis, and effectiveness on large surfaces remain open challenges. In this context, a new aqueous nanolime, named NANOLAQ, produced by the Spin Off of the University of L'Aquila through a sustainable and patented synthesis route, has been developed and employed for green and compatible consolidation treatments of historic mortars and plasters. NANOLAQ was synthesized through a low-impact, environmentally friendly process and dispersed in water, avoiding organic solvents. The material was fully characterized in terms of particle size distribution, morphology, phase composition, and carbonation behavior. The consolidating performance was evaluated in situ application carried out by airbrush on a deteriorated historic plaster located on the external façade of a building in Via Vico Palla, in the Old Port area of Genoa. The treatment effectiveness was assessed through non-destructive and micro-destructive techniques, including surface cohesion tests, and microdrilling measurements (DRMS technology). The synthesized nanolime exhibited nanoscale particle size, and effective carbonation under ambient conditions. The in-situ application showed a marked enhancement in surface cohesion, good penetration depth, and excellent aesthetic compatibility, with no visible chromatic alteration or surface film formation. The obtained results highlight the high potential of NANOLAQ as a sustainable and effective consolidant for historic plasters. The combination of green synthesis, aqueous formulation, and high consolidating efficiency makes this product particularly suitable for large-scale and environmentally compatible conservation interventions. The successful case study in the Old Port of Genoa demonstrates the applicability of NANOLAQ in real conservation scenarios, contributing to the development of innovative and sustainable materials for cultural heritage preservation.

O50

Design of multifunctional chitosan patches loaded with alginate microspheres for drug and cell delivery

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Chitosan electrodeposition is a well-established technique for fabricating polymeric scaffolds for tissue engineering and drug delivery. It offers key advantages such as process simplicity, fine control over coating thickness and morphology, and mild operating conditions that may preserve the activity of embedded biological components. However, electrodeposition of living cells remains challenging due to low survival rates under conventional conditions. To date, no successful examples of eukaryotic cell electrodeposition have been reported. This study aims to develop a versatile platform based on Electrophoretic Deposition (EPD) of chitosan (CS) combined with alginate microspheres (MS) for the controlled release of drugs and viable cells. To enhance cell survival during EPD, an acid-free chitosan solution was prepared. Chitosan (2% w/v) was first dissolved in 0.07% v/v acetic acid, then neutralized to pH > 7. The resulting hydrogel was washed until conductivity dropped below 30 µS/cm. The gel was subsequently dissolved using CO_2 and diluted to a final concentration of 1% w/v [2]. Alginate MS were fabricated by extrusion dripping through coaxial laminar flow into $CaCl_2$ solutions (100–900 mM) to modulate crosslinking degree and obtain diameters below 1 mm. Microspheres were prepared using low-viscosity (LV) or medium-viscosity (MV) alginate. Both L929 fibroblasts and curcumin (model drug) were encapsulated into MS, which were then dispersed in the acid-free chitosan solution. EPD was conducted at 30–50 V for 3 minutes (drug-loaded films) or 1–3 minutes (cell-loaded patches). Cell viability and proliferation were evaluated using Live/Dead staining and Alamar Blue assays. Curcumin-loaded MS showed controlled release in PBS and acetate buffer. After deposition, curcumin diffused from MS into the chitosan matrix, as indicated by a visible color change, while the patches maintained structural integrity. L929 cells encapsulated in both LV and MV MS survived the EPD process and proliferated within the patches for up to 10 days. Alamar Blue assays confirmed metabolic activity, and Live/Dead staining showed viable cells after 10 days. The acid-free chitosan preparation method, combined with MS encapsulation, enabled the formation of a non-cytotoxic solution suitable for EPD. Encapsulation effectively protected cells during deposition. However, longer electrodeposition times resulted in reduced cell viability. These findings demonstrate the feasibility of EPD for producing multifunctional chitosan–alginate patches capable of drug and cell loading with tunable release properties. Release behavior can be modulated by adjusting alginate viscosity and crosslinking degree. This platform shows promise for applications in drug delivery and tissue regeneration.

O51

Designing reversible shape memory cycles within a biocompatible thermal window for biomedical applications

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Two-way shape memory polymers hold promise for dynamic scaffolds actuated by thermal stimuli for mechanobiology studies. These semicrystalline networks use structural changes over melting/crystallization to induce macroscopic shape changes. However, wide actuating thermal regions are unsuitable for cytocompatibility. While lowering the melting to 37 °C is possible, the resulting crystallization below room temperature hinders cell-friendly actuation. This study optimizes two-way shape memory cycles in crosslinked polycaprolactone (PCL) by tuning actuation temperatures in the melting region and crystallization conditions for actuation in a narrow, biocompatible thermal window. Semicrystalline PCL networks were obtained via a sol-gel approach. DSC analysis was used to evaluate thermal properties. Shape memory characterization was performed with the dynamic mechanical analyzer for studying the effect of the actuation temperature, Tact, and isothermal holding temperature, Tlow, on the shape memory response. The test protocol involved stretching the material in the melt, cooling it under the applied stress at -20 °C, removing the external load, then applying heating/cooling cycles between Tact (30-39 °C) and Tlow (10-30 °C). The reversible two-way deformation was significantly affected by the Tlow value in the cooling step, while keeping Tact fixed at 37 °C. Decreasing the Tlow value (from 30 to 10 °C) led to an increase in the extent of the attained reversible deformation (from 2 to 10%) and in a decrease of the half-time of the reversible deformation process (from 16 to 10 min). Leveraging isothermal crystallization was demonstrated to be a viable strategy to actuate the reversible shape memory cycle in a narrow thermal window (10-37 °C). These findings link thermo-mechanical parameters to PCL crystallization, enabling the design of biocompatible two-way shape memory cycles for biomedical applications, like cell-compatible actuators. This work was funded by the European Union ERC CoDe4Bio Grant ID 101039467. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Council. Neither the European Union nor the granting authority can be held responsible for them.

O52

Indocyanine green-loaded layered double hydroxide nanostructures for optical imaging in clinical surgery: preparation in sterile conditions

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Layered Double Hydroxides (LDHs) are an exciting class of materials known for their ability to load ionic or molecular groups, thereby forming supramolecular structures. Some LDHs have also been investigated for possible biomedicine applications due to their excellent biocompatibility, as demonstrated by toxicity studies. Moreover, LDHs have been considered as optical probes, scaffolds for loading fluorescent dyes, or carriers for drug delivery to the biological tissue of interest. In this communication, hydrotalcite-like nanostructured LDHs (nanoLDHs), constituted by Mg^{2+}, Al^{3+}, and Gd^{3+} metal ions, will be presented. The nanoLDHs have been synthesized via coprecipitation, followed by a microwave-assisted solvothermal treatment at mild temperatures. Then, the nanoLDHs were loaded with Indocyanine Green, a near-infrared fluorescent dye, via a facile adsorption procedure, thereby developing a multifunctional (fluorescent and paramagnetic) hybrid nanocomposite. To develop luminescent inks for delineating precise portions of biological tissues during surgery, nanoLDHs have been embedded in Pluronic F-127 to prepare a thermoresponsive nanocomposite that gels at physiological body temperature (37°C). The gelling procedure allows the immobilization of the luminescent nanocomposite in biological tissues, facilitating easy identification of the region to be considered during clinical surgery. The finished nanocomposite-containing gel is prepared in a sterile environment and stored at 4 °C until use. The detailed preparation procedure will be presented and analyzed. The project is funded by the European Union – Next Generation EU – NRRP M6C2 – Investment 2.1 Enhancement and Strengthening of Biomedical Research in the NHS.

O53

Development of a chemical-physical model to simulate coffee extraction

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Every day, approximately three billion cups of espresso are consumed worldwide, and this number is still increasing. This growing demand underlines the central role of coffee in global dietary habits and highlights the urgency of addressing its long term sustainability. It is generally believed that by 2050 half of the land now used for the growth of coffee will not be suitable for this purpose. Among the various factors contributing to the environmental footprint of coffee, ground coffee itself represents a major component. A promising solution to mitigate these impacts is to reduce the amount of coffee powder used per brew, which constitutes the primary objective of this project. The focus of the work has been on model development to obtain information on the effects of extraction parameters. Rigorous chemical-physical equations have been developed to obtain reliable and general data. Input parameters are used to track the natural changes in the matrix. The model results in a system of Partial Differential Equations (PDE). It can be solved both for individual beans and for extraction chamber. To characterize the bean structure tomography analysis has been performed. The model can track the evolution of concentration over space and time, i.e. in every point of the exctraction chamber and following the evolution of the extraction respectively. This is done for both the solid matrix and the liquid. Furthermore, it is able to simulate the pressure drops across the coffee bed. So, it is possible to evaluate variables of interest such as the concentration at the outlet, the mass of compounds still present in the extraction chamber and the total amount of compounds found in the liquid beverage. Pressure drops show greater sensitivity to changes in particle size than to changes in the mass fed. Both have a linear trend, but in the first case the slope is greater and allows for a wider range of variation. Furthermore, pressure drops behave quadratically as the speed or flow rate of the fluid varies. The concentration of the compounds always increases from top to bottom of the extraction chamber because the liquid becomes enriched in the compound as it passes through the bed. At the outlet, the concentration increases in the first few seconds due to the breakthrough of the liquid front and then decreases because the content in the solid matrix decreases.

O54

NEMESI – Development of new membranes as smart devices to limit infections

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The recent COVID pandemic has highlighted the risks posed by microbial infections, and the urgent need to strengthen and re-establish effective control and prevention measures. Although many infections can be successfully treated with antimicrobial drugs, antimicrobial-resistant strains are rapidly increasing, and new pathogens and variants continue to emerge for which no vaccines are available yet. Consequently, searching for new molecules, formulations, and materials with potential antimicrobial properties has become a critically important area of research. In this context, NEMESI project (CUP F53D23001700006) proposes the development of new generation of mixed matrix membranes (MMMs) with antimicrobial activity according to a "repelling-killing approach". MMMs produced within the project are based on antimicrobial agents - metal-doped macro-mesoporous silica and metal organic framework (MOF) particles with an innovative design - dispersed in hydrophobic polymeric matrices to better match high and wide spectrum antimicrobial activity, long-term persistence, high stability, and low toxicity. NEMESI methodology combines in-silico and experimental methods, biological testing and life cycle analysis to the development of the antimicrobial membranes. Implementation and efficacy demonstration of the novel membranes in real applications – antimicrobial face masks and coating of sanitary clothing– against selected bacteria and viruses has been proposed for pre-emptive and proactive control of microbial transmissions. Incorporation of the active metals in the silica structure or in the MOFs avoids the metal release with uncontrolled rate, eluding human and environmental risks. Further dispersion of the inorganic antimicrobial agents in the polymeric matrices confers improved workability, allowing processing with various techniques to obtain membranes with potent antimicrobial activity and liquid-repelling capability. The MMMs developed within NEMESI project combine the easy processability of polymers with the unique functional properties of inorganic particles. As a result of the project, a functional technology based on antimicrobial membranes has been established. The findings demonstrate that, through a rational design and appropriate implementation, MMMs can serve as highly effective antimicrobial devices suitable for application across a wide range of fields.

O55

Mechanical and electrical transport properties in 3D network of silk pyorprotein-coated ZnO tetrapods

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The ZnO tetrapodal crystals are built out of four 1D rod-shaped arms, that are interconnected together via a central crystalline core. The tetrapodal shape of microstructures exhibits a high aspect ratio in the three directions resulting in micrometer-sized voids between the individual arms. This study introduces a novel method for synthesizing a highly porous (~80% porous) three-dimensional (3D) graphitic pyroprotein (GPy) around ZnO tetrapod (ZnO-TP) network through the pyrolysis of silk fibroin (SF). SF was prepared in a ternary solvent by solubilizing degummed silk fibers and calcium chloride (CaCl2) in water and ethanol. ZnO tetrapods were synthesized using a flame transport approach developed at Kiel University. In this method, a mixture of zinc powder (Sigma Aldrich, dust < 10 µm, purity: ≥ 98%) and polyvinyl butyral (PVB) (Kuraray) in a ratio of 1:2 (total mass between 10 and 20 g) was placed in a ceramic crucible and heated to 900 °C for 30 min under ambient atmosphere. The resulting loose powder of ZnO tetrapods was consolidated to a pellet (with a mass density of 0.3 g cm^{-3}) and sintered at 1150 °C for 5 h, to form an interconnected ZnO template. We find that a simple wet infiltration of SF in 3D ZnO ceramic template followed by heating in vacuum, transform the β-sheet fraction of SF into sp2-hybridized carbon coating of the ZnO network. The coating of the template was investigated by infiltrating fibroin obtained using two different solvents, water and a water–ethanol mixture, observing that the addition of ethanol results in a higher wettability. Techniques such as Raman, XRD, and SEM with EDS mapping demonstrate the successful creation of GPy/ZnO-TP composites characterized by a higher electrical conductivity and mechanical properties than those observed for ZnO-TP network. A high reinforcement effect in compression characteristics is achieved by the coating of GPy around the ZnO networks. Electrochemical impedance spectroscopy of GPy/ZnO-TP composites revealed that the electrical conductivity is dominated by the formation of pyrolysìzed silk. Considering specific physical and microstructural characteristics such as substantial porosity, pore volume, interconnected pores, and an extensive internal surface area, GPy/ZnO-TPs prove to be exceptional hybrid ceramic template within the context of functional materials.

O56

3D bioprinted model of functional neural tissue

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The study of neural development and the CNS's complexity is a key challenge in neuroscience. Bioprinting offers a promising solution for creating precisely shaped scaffolds that replicate the complexity of neural tissue. While 3D bioprinted neural tissues with soft gels provide layered structures and neuronal maturation, functional connectivity between neural cells has not yet been demonstrated. This work aims to develop functional, compartmentalized 3D bioprinted neural networks using chitosan-based thermogels, supporting neuronal growth from h-iPSCs co-cultured with astrocytes. A natural bioink was developed by modifying a chitosan-based thermogel, previously developed and tested with nervous cells. Chitosan was selected for its similarities to the native ECM, low cost, and versatility. The rheological and mechanical properties were characterized, and the printing protocol optimized, ensuring efficient bioink deposition, resulting in multi-compartmental models with excellent print resolution and shape fidelity. The bioink facilitated the incorporation of different neural cells to create functional compartmentalized neuron-glia networks, which were characterized morphologically and functionally using immunocytochemistry and high-density microelectrode arrays. The rheological tests showed a gelation time suitable for maintaining good cell viability, and mechanical tests demonstrated that the bioink's stiffness is close to the ranges observed in the brain tissue, thus more closely reproducing the physiological conditions of the nervous tissue. The bioprinted constructs provide a high shape fidelity with respect to complex geometries. The developed chitosan-based thermogel bioink demonstrated stability over time and bioactivity toward neural cells. Morphological and electrophysiological analyses revealed good cell distribution, network formation, and functional activity under culture conditions. These results highlight the bioink's potential. The developed bioink possesses the characteristics to be considered a bioink for fabricating complex constructs with precise control over the spatial distribution of nervous cells, allowing the creation of in vivo like in vitro models for neural tissue studies, disease modelling, drug testing, and neurotoxicity evaluation.

O57

Development of bio-based polymer coatings containing phenolic acid by la-app polymerisation for food packaging application

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The increasing demand for sustainable food packaging has driven the development of bio-based polymeric materials that reduce environmental impact while enhancing food preservation. In this context, active packaging systems incorporating natural antioxidants represent a promising approach to delay oxidative degradation and extend food shelf life without the use of synthetic additives. This study reports the development of bio-based active polymer coatings incorporating phenolic acids by liquid-assisted atmospheric-pressure polymerisation (LA-APP). Isobornyl acrylate (IBOA), a renewable terpene-derived acrylate, was employed as monomer, while rosmarinic acid (RA) and gallic acid (GA) were selected as natural antioxidant agents. Thin coatings were deposited under mild plasma conditions using a dielectric barrier discharge. The effects of the IBOA-to-ethanol ratio and antioxidant concentration in the precursor solution were investigated evaluating film thickness, surface wettability, and chemical composition by means of profilometry, contact angle measurements, UV–vis spectroscopy, FTIR and high-pressure liquid chromatography (HPLC). Antioxidant activity was evaluated using the DPPH radical scavenging assay. The plasma-deposited coatings exhibited uniform and continuous coverage on the substrates, with thicknesses that could be tuned by adjusting the precursor formulation and deposition parameters. Surface wettability measurements revealed moderately hydrophobic behaviour, consistent with the polymerisation of the hydrophobic IBOA monomer. UV–vis spectroscopy and HPLC analysis confirmed the successful incorporation of both rosmarinic acid and gallic acid into the polymer matrix, indicating that the LA-APP process preserved the phenolic structures. An optimal IBOA-to-ethanol ratio was identified, which promoted efficient aerosolisation of the precursor solution and enhanced the loading of antioxidants within the coatings. Increasing antioxidant concentration led to improved radical scavenging activity, as assessed by the DPPH assay. GA-containing coatings consistently displayed higher antioxidant activity than RA-based coatings, reaching scavenging efficiencies above 90%, whereas RA-based films showed a more gradual concentration-dependent response. These results demonstrate that LA-APP is a versatile and effective technique for fabricating bio-based active coatings, combining the structural stability and adhesion of plasma polymers with the functional properties of natural antioxidants. The developed coatings show strong potential for sustainable active food packaging applications, offering tunable antioxidant performance, solvent-free processing, and compatibility with temperature-sensitive substrates.

O58

Statistical evaluation of the degradation mechanism of bio-based materials for sustainable food-packaging

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The development of enhanced barrier coatings for paper-based packaging often improves material performance but can slow microbial degradation. Therefore, integrating biodegradation assessment into material design is essential to ensure environmental sustainability. This study aims to evaluate the soil degradation rates of different environmentally friendly paper-based coatings and to identify the factors influencing their biodegradability using a statistical approach. Four types of biobased coatings composed of polycaprolactone (PCL), cutin, glycerol, starch, and agar were applied to paper substrates. Coated samples were buried in two types of soil with different pH values—universal soil (pH 6.5) and acidic soil (pH 4.5)—for 14 and 28 days. Material performance was evaluated before and after soil exposure by measuring weight variation, chemical structure, surface morphology using: environmental scanning electron microscopy (ESEM), FT-IR and tensile mechanical properties evaluation. Statistical analyses trought Design of Experiments tecniques and ANOVA were performed to assess the significance of soil type and coating composition on degradation behavior. Mechanical properties were most significantly affected by the interaction between soil type and coating composition (p-value < 0.005). In universal soil, complete degradation of coated papers occurred within 20 days. ESEM analyses confirmed overall coating degradation in universal soil, while in acidic soil, degradation was selective: starch coatings were entirely removed, whereas PCL and cutin/glycerol coatings showed minimal morphological changes. Weight loss and chemical structure analyses aligned with these observations, indicating that soil pH strongly influences microbial activity and, consequently, the rate of degradation. The findings suggest that biodegradation of paper-based coatings is highly dependent on soil environment and coating composition. Universal soil, with near-neutral pH, promotes microbial activity and accelerates degradation of all coating types. In contrast, acidic conditions selectively hinder the breakdown of hydrophobic or cross-linked coatings, such as PCL and cutin/glycerol, while easily degradable components like starch are still removed. These results highlight the importance of considering environmental conditions when designing biodegradable packaging materials. Integrating statistical and morphological analyses provides a robust framework for evaluating coating performance and sustainability, supporting the development of materials that balance durability with rapid, environmentally responsible degradation.

O59

Design and development of a 3D in vitro lung model to study the biological effects of microplastics

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Environmental pollution threatens human health, with microplastics entering the body via ingestion, skin contact, and inhalation, accumulating in organs. Their effects and role in pulmonary disease remain unclear. To investigate them, we propose a 3D in vitro lung model using GelMA to study microplastic-lung interactions. This study's first step is developing a model that mimics the physiological gas-blood alveolar barrier. GelMA was synthesized and its methacrylation confirmed by 1H-NMR analysis. To avoid cellular damage associated with UV crosslinking, visible-light crosslinking using riboflavin and sodium persulfate was employed. Stability tests were conducted on 1 and 0.5 mm thick hydrogels over 14 days in culture medium. Alveolar-like spherical morphologies were replicated using PDMS molds fabricated via stereolithography. Mechanical properties were evaluated through compression tests up to 30% strain and subsequent unloading to assess elastic modulus and residual deformation. Oxygen permeability was measured using a custom-designed system with an oxygen-sensitive sensor in an isolated chamber. In vitro biological assessments were performed by seeding A549 cells on smooth GelMA hydrogels of both thicknesses. Cell metabolism, distribution, viability, and functionality were evaluated over 14 days using AlamarBlue, DAPI, Live/Dead, and Nile Red staining. GelMA exhibited a degree of functionalization of 51–56% and formed stable hydrogels. PDMS molding produced intact, smooth constructs with thicknesses down to 300 µm and reproducible hemispherical features of 100 µm radius. Compression tests revealed an elastic modulus of 8 kPa and residual deformation of approximately 7%. Preliminary oxygen permeability tests indicated high permeability, comparable to or exceeding that of the native alveolar barrier. Biological assays demonstrated A549 cell clustering, increasing metabolic activity and viability over 14 days, and lipid droplet formation from day 7, confirming hydrogel suitability. GelMA proved to be a promising biomaterial for developing a 3D lung model, enabling replication of alveolar morphology and supporting epithelial cell growth. Future work will focus on blending GelMA with Elastin-Like Recombinamers to better mimic lung extracellular matrix composition and mechanics. Co-culture systems of pulmonary epithelial and endothelial cells will be developed to reconstruct the air–blood barrier. These models will be exposed to various microplastics under static and dynamic conditions to evaluate their impact on lung cell viability and function, providing insights into inhalation-related health risks. This work was funded by the National Plan for NRRP Complementary Investments in the call for the funding of research initiatives for technologies and innovative trajectories in the health and care sectors (Directorial Decree n. 931 of 06-06-2022) - project n. PNC0000003 - AdvaNced Technologies for Human-centrEd Medicine (ANTHEM).

O60

Ag nanoparticle–decorated reduced graphene oxide on cellulose: engineered nanocomposites for advanced healthcare applications

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Graphene-based nanocomposites decorated with inorganic nanoparticles (NPs) offer diverse properties and compatibility with flexible wearable technologies. Here, we report a unified graphene platform on cellulose substrates, showing how controlled nanoscale engineering enables multifunctionality spanning antimicrobial activity, personal thermal management, and environmental monitoring. A hybrid RGO-based nanocomposite, functionalized with histidine (His) and decorated with Ag nanostructures, was synthesized via in situ colloidal methods. By tuning synthetic parameters, Ag NPs or nanowires (NWs) were obtained, enabling morphology-dependent properties. The dispersions were then deposited onto cellulose substrates (cotton fabrics and paper) using scalable processes, preserving flexibility and structural integrity. Morphological tuning of Ag nanostructures on His-RGO enabled control over antimicrobial, thermal, and SERS performance. His-RGO/Ag NPs coatings on cotton showed >99% antibacterial activity against E. coli and good cytocompatibility, supporting use in medical textiles. The Ag/RGO network also enhanced heat transfer in cellulose fibres, increasing thermal conductivity to ~0.1 W m^{-1} K^{-1} (vs ~0.04 W m^{-1} K^{-1} for pristine cotton) while preserving flexibility. His-RGO/Ag NWs modified papers exhibited strong SERS activity, enabling propranolol detection down to 10^{-6} M, demonstrating potential for portable environmental monitoring. Controlled colloidal synthesis emerges as a key strategy for functional diversification. By tailoring nanoscale morphology while maintaining a common graphene-based platform and cellulose support, application-specific performance can be achieved without altering the fundamental material design. This approach highlights the potential of sustainable nanochemistry to generate multifunctional, flexible, and scalable systems addressing health and environmental challenges.
Acknowledgements: The work was partially supported by the bilateral agreement CNR/MHESR (Italy, Tunisia), ZEROIMPACT project, 2025-2026.

TALK SPONSOR

AC SCIENTIFIC

Advanced instrumentation for materials synthesis and operando diagnostics

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This presentation showcases cutting-edge technologies for materials science and chemical engineering. We feature Hiden Analytical's mass spectrometers, highlighting DEMS for real-time electrocatalyst off-gas analysis and SIMS for nanoscale depth profiling of thin films. Next, we introduce Korvus Technology's highly modular HEX Series PVD platform for versatile thin-film deposition. Finally, Reacnostics presents their Compact Profile Reactor, enabling operando spatial measurements of temperature and concentration fields to optimize catalytic processes

JEOL

JEOL: instrumentation and methodologies in the context of materials science and technology

Ferraina Paolo

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JEOL provides an overview of its instrumentation portfolio dedicated to materials science and technology. The presentation will include a brief focus on the main hardware/software functionalities and on the specifications of FIB-SEM and TEM techniques, with references to sample preparation instrumentation and analytical integration. The contribution of advanced chemical analysis will be highlighted, for example in the study of light elements and in the determination of chemical bonding states. Operational aspects in terms of productivity and data quality will also be discussed. The talk will provide a general overview of JEOL solutions oriented toward the main applications in the field of materials characterization.

ANTON-PAAR

Tecniche analitiche integrate per la caratterizzazione avanzata delle polveri e dei materiali granulari

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Nel manifatturiero avanzato e nelle applicazioni aerospaziali, le polveri e i materiali granulari rappresentano elementi chiave per processi ad alta precisione, come formulazione di materiali funzionali, produzione additiva, rivestimenti e sistemi compositi. In questi contesti, la riproducibilità dei processi e l'affidabilità delle prestazioni dipendono dal controllo rigoroso delle proprietà fisiche, strutturali e superficiali delle polveri lungo l'intera filiera produttiva. Il contributo presenta approcci di caratterizzazione analitica integrata, basati sulla combinazione di tecniche complementari, finalizzati alla comprensione e al controllo del comportamento delle polveri in condizioni operative realistiche. Attraverso esempi applicativi tratti dal manifatturiero di alta qualità e da materiali per applicazioni tecnologicamente avanzate, viene illustrato come l'analisi granulometrica, la determinazione di area superficiale e porosità, la reologia delle polveri e delle sospensioni concentrate, insieme alle tecniche strutturali e superficiali, possano essere correlate in modo sistematico.
L'integrazione dei dati analitici consente di collegare le caratteristiche delle polveri ai parametri di processo, come scorrimento, compattazione, stabilità meccanica, comportamento sotto stress termico e ambientale. Questo approccio permette di ridurre la variabilità di processo, supportare strategie di controllo qualità avanzato e accelerare il trasferimento dalla ricerca alla produzione industriale, contribuendo allo sviluppo di materiali ad alte prestazioni per il manifatturiero avanzato e l'aerospazio. L'intervento riflette l'impegno di Anton Paar nel supportare l'innovazione tecnologica e la qualità dei processi industriali, promuovendo metodologie di caratterizzazione affidabili come strumento strategico per il manifatturiero avanzato e per le applicazioni a elevato contenuto tecnologico.

RISING STARS

RS1

Hot-press processing and preliminary characterization of bio-based thermoplastic composites incorporating regolith simulants for in-situ resource utilization (ISRU) in space applications

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Enabling the design and construction of long-term lunar settlements, a strategic priority of the international space agencies, requires the effective utilization of resources locally available on the Moon to develop materials suitable for space applications. Lunar regolith has high potential as a raw material due to its advantageous characteristics such as abundance, resistance to extreme temperature cycles, and radiation-shielding behaviour enabling the sustainable approach of In-Situ Resource Utilization (ISRU). In this context, the development of bio-based polymer composite materials emerges as a promising strategy to implement regolith-based technologies. When reinforced with regolith simulants, they enable multifunctional, potentially recyclable materials for sustainable lunar infrastructure. The engineering-grade Lunar Highlands Simulant (LHS-1E, Space Resource Technology) was implemented as a reinforcing filler to develop bio-based thermoplastic composites with a polyamide matrix (PA11 Rilsan grade, Arkema) at two different weight fractions (10 wt.% and 20 wt.%). Composite slabs were produced via hot pressing using a 9T Labs Fusion Module press. Polymer-regolith pellets were previously prepared with a Brabender internal mixer. Mechanical testing (three-point flexural test), thermal analyses (DSC and TGA), thermomechanical characterization (DMA at quasi-cryogenic temperatures), and SEM microstructural observations were conducted to investigate the influence of the filler on the composite properties. The incorporation of regolith progressively increases the flexural modulus, reaching an enhacement of approximately 30% for the composite containing 20 wt.% filler. A reduction in flexural strength is initially observed but the implementation of a second compaction step during hot pressing restores the mechanical performance of the composites. DMA reveals that regolith-based composites maintain higher thermomechanical stability, in terms of storage modulus, down to temperatures approaching -150 °C, indicating enhanced performance under lunar-like conditions. The ~3 °C increase in glass transition temperature of the PA11–regolith composites indicates a nucleating effect of the filler (confirmed by a rise in crystallization temperature from DSC) and reduction in polymer chains mobility. SEM analysis shows good regolith–matrix adhesion, supporting that hot-pressing process optimization is crucial to achieve high-performance composites. This preliminary study demonstrates the feasibility of reinforcing bio-based PA11 with regolith simulants for lunar infrastructure. Further optimization of processing parameters is needed to improve performance. Testing under simulated lunar conditions will support the development of resource-efficient components for long-term settlements.

RS2

Innovative agriculture: bijels as delivery systems for fertilizers and pesticides

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Fertilizers and pesticides management has become essential over the past few years. The role of fertilizers in increasing crop yields, together with the protection against pests provided by pesticides, is of utmost importance to support the population growth and the increasing pest demand. Moreover, the abuse of these substances has caused significant damages to underground waters and water body, such as eutrophication. Bicontinuous interfacially jammed emulsion gels (bijels) are used as controlled release systems and co-release systems for an effective use of both fertilizers and pesticides. Initially, the bijel systems have been completely characterized, and their abilities of releasing the loaded molecules have been tested both in water and solid media. Then, the co-delivery scenario has been studied and analytical method for the quantification of both fertilizers and pesticides has been developed, allowing the quantification of such molecules even in the ppb range. Derivatization and UV-Vis have been selected for the fertilizer analysis, while GC-ECD has been exploited for the pesticide. After all the initial trials have been performed, analyses on real soil and plants have been carried out. Different seeds have been selected for germination studies and treated in real soil. Bijels showed controlled release for fertilizers and pesticides up to three weeks in soil. Real plant experiments confirmed positive effects of the system used on specific target seeds (Zea Mays and Brassica sp.), without damaging the plant vitality. Bijels can be positevely used as novel delivery systems in agricultural application. Their controlled release will avoid the loss of fertilizers and pesticides inside the soil, thus avoiding further purification techniques. Furthermore, the complete biodegradability of the system is of pivotal importance in avoiding pollution problems.

RS3

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

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Oxidative stress, characterized by an imbalance between reactive oxygen species (ROS) production and cellular detoxification, is a primary driver of numerous pathologies, including neurodegenerative diseases and cancer. The nitroxyl radical 2,2,6,6-tetramethylpiperidin-1-oxyl (TEMPO) is a powerful antioxidant capable of scavenging reactive radicals and mimicking superoxide dismutase activity. However, its therapeutic utility is hindered by rapid systemic clearance and challenging encapsulation into standard hydrophobic carriers due to its water solubility. Hence the need of innovative delivery systems designed to protect and deliver TEMPO derivatives to target sites while overcoming these pharmacokinetic drawbacks. Nanogels (NGs) were synthesized using the emulsification-evaporation method, utilizing polyethylene glycol (PEG 8000 Da) functionalized with carbonyldiimidazole (CDI) and linear polyethyleneimine (l-PEI 2500 Da). To incorporate the antioxidant activity, a specific linker with TEMPO was developed and either covalently grafted into the polymer backbone or coated onto the NG surface. Chemical-physical characterization was conducted using both FT-IR and NMR for evaluating the synthetical outcome, DLS to determine hydrodynamic diameter and ζ-potential, and AFM for morphology and size validation. Antioxidant efficacy was quantified via the Oxygen Radical Absorbance Capacity (ORAC) assay, while cellular safety was investigated through in vitro cytotoxicity tests. This study explores the development of stable TEMPO-PEG-PEI nanogels, with diameters ranging between 120 nm and 250 nm depending on the specific formulation. The ORAC tests demonstrated that TEMPO preserves its antioxidant capacity when loaded onto nanocarriers. Notably, grafted NGs exhibited superior antioxidant power (66.4 μmolTrolox/gNG) compared to coated versions (28.4 μmolTrolox/gNG). This research demonstrates that PEG-PEI NGs, already proved to be effectively internalized in the cental nervous system (CNS), are also effective carriers for TEMPO, embedding its radical-scavenging properties. These findings support the potential of TEMPO-NGs as promising versatile platforms for targeted antioxidant therapy in stress-driven pathologies, particularly within the CNS.

RS4

Modelling the effects of relative humidity on O_2 and CO_2 gas transport in polyetherimide membranes

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In the context of accurately modeling membrane-based separation processes, transport of low molecular weigth compounds through high-performance polymers plays a crucial role in tailoring barrier properties for various energy as well as environmental technologies such as gas separation, carbon capture and protective barriers. Polyetherimide (PEI) is widely used in demanding applications due to its thermal stability and mechanical strength. However, the investigation on the intectation between these small molecules and such polymers remains a scientific and thechnological challenge. In this contribution, O_2 and CO_2 transport trough PEI dense barrier films was studied by combining experimental measurements (sorption and permeation) and thermodynamic modeling. Measurements were conducted over a range of pressures and relative humidities to study the influence of water vapor on gas–polymer interactions. To this end, sorption thermodynamics in a glassy polymers (Ultem®) has been interpreted within the framework of the Non-Equilibrium Thermodynamics Glassy Polymer-Perturbed Chain-Statistical Associating Fluid Theory (NETGP-PC-SAFT). Sorption thermodynamics and kinetics were modeled by using NETGP-PC-SAFT to interpret and describe gas–polymer and gas–water–polymer interactions. The full set of parameters is used in a predictive manner to calculate the permeability coefficients of O2 and CO2 in PEI at different temperatures and relative humidity conditions. The model results are validated against a complete set of experimental data specifically gathered for the present investigation. The described approach accounts for associative contributions by enabling a quantitative reproduction of the complex interactional scenario. This investigation provided a validation of the NETGP-PC-SAFT model when self and cross-interactions occur in a polymer-penetrant system, by comparing model predictions with experimental data. Following the validation of the NETGP-PC-SAFT model in terms of sorption thermodynamics, the model was implemented within the Standard Diffusion (SD) model to self-consistently describe O_2 and CO_2 mass transport in the glassy PEI at humid and dry conditions.

RS5

Polysaccharide–based aerogels for environmental remediation

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Polysaccharide-based aerogels are a promising class of sustainable, high-performance materials for environmental remediation, particularly for removing contaminants through adsorption. This study systematically investigates material-related parameters that govern the availability and accessibility of active adsorption sites, and thus the interaction between aerogels and various classes of aqueous contaminants. Special attention is given to how the chemical composition, surface functionality, and porous architecture of polysaccharide networks influence adsorption mechanisms and efficiency. Additionally, the influence of processing parameters in aerogel fabrication via freeze casting is thoroughly examined. Freeze casting allows controlled tuning of porosity and internal architecture through the formation and growth of ice crystals, which serve as structure-directing templates. The resulting pore morphology and distribution affect not only mass transport and adsorption performance, but also play a critical role in determining other key material properties, such as mechanical strength, structural stability, and handling robustness under practical operating conditions. Overall, this work provides a fundamental understanding of material–process–structure–property relationships and a framework for the rational optimization of polysaccharide-based aerogels. By exploiting these correlations, the study shows how processing strategies can be leveraged to tailor aerogel properties and enhance final material performance. These insights support the development of efficient, sustainable, and tunable aerogel systems for advanced water treatment and environmental remediation applications.

RS6

Persistent luminescence at the nanoscale

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Persistent luminescence (PeL) is a peculiar optical phenomenon in which a material continues to emit light after the excitation source has been removed, i.e., it glows in the dark following proper excitation. Interest in PeL materials significantly increased in the 1990s after the discovery of $SrAl_2O_4:Eu^{2+},Dy^{3+}$. To date, hundreds of different compositions are known to exhibit PeL, ranging from oxides to sulfides and fluorides. Some of these materials display intense and long-lasting emission, persisting for days or even weeks. Notably, several PeL materials have already found practical applications in everyday objects (e.g., toys, watches) and emergency signage. However, their widespread use is still limited by suboptimal emission performance. Moreover, from a fundamental perspective, the mechanisms governing PeL - especially in nanomaterials - remain poorly understood. Here, we present our results on the study of PeL nanomaterials. This study focuses on halide perovskite nanomaterials and zinc–gallium–germanate compounds. The materials were prepared via a hot-injection method and a hydrothermal process, respectively. The as-synthesized compounds were first structurally characterized by X-ray diffraction and synchrotron analysis and subsequently investigated through detailed spectroscopic measurements. Our results demonstrate that nanostructuring induces changes in trap density, leading to either a decrease or an increase in PeL intensity. In contrast, oxide materials appear to be less affected by size reduction. We hypothesize that the differences in PeL observed between bulk and nanocrystalline samples arise from variations in trap energy levels within the bandgap. These changes may be induced by modifications in the oxidation state of the constituent elements (particularly the dopant) or by local structural distortions. Our findings contribute to a deeper understanding of how compositional and size tuning influence the PeL mechanism, suggesting possible strategies to enhance performance and thus improve practical applicability.

RS7

Electrodialysis for selective desalting of olive mill wastewater: from membrane screening to scale-up and advanced configurations

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Electrodialysis (ED) is an electro-membrane separation process based on the selective migration of ions through ion-exchange membranes under the influence of an electric field. Compared to pressure-driven membrane processes, ED enables selective desalination of low-salinity streams under mild conditions, with reduced fouling and lower chemical consumption. For these reasons, it is widely applied in the agri-food sector, including dairy processing, juice deacidification, and brackish water treatment. However, its application to olive mill wastewater (OMW) remains limited, particularly in integrated processes aimed at preserving valuable phenolic compounds. In this work, ED was investigated as a downstream refining step for OMW streams previously treated by acidification and membrane filtration. OMW was used as feed solution (diluate), while a NaCl solution was used as the concentrate. Initial experiments were carried out using a PCCell ED64 stack operating in batch mode under constant voltage, by testing different combinations of cation- and anion-exchange membranes to evaluate conductivity reduction and phenolic retention. Subsequently, semi-batch experiments were conducted to better simulate continuous operation. A bleed-and-feed strategy was applied to both diluate and concentrate streams, allowing control of salinity build-up and repeated treatment cycles. The influence of operating parameters, including flow rate and membrane fouling, was assessed through repeated runs and reference experiments using NaCl solutions. Further process development included preliminary scale-up tests using a larger pilot-scale setup. In addition to conventional ED operation, a modified configuration inspired by electrodialysis with bipolar membranes (EDBM) was explored. The system was operated in a three-stream configuration, generating one diluate and two separate concentrate streams. Membrane screening highlighted the key role of membrane properties in balancing ion removal and phenolic retention, with selected configurations achieving significant conductivity reduction while minimizing losses of low-molecular-weight phenolics. Semi-batch operation enabled high demineralization efficiency (>90%) and stable performance over multiple cycles, while providing insight into the influence of flow rate and fouling on process reproducibility. Preliminary scale-up experiments confirmed the feasibility of operating ED at higher volumes. Notably, the three-stream configuration allowed a partial fractionation of ionic species between two concentrate streams, potentially mitigating excessive salinity build-up and improving process control. Overall, ED proved to be a promising and flexible technology for the selective desalting of OMW-derived streams. The transition toward advanced configurations inspired by EDBM opens new perspectives for process intensification and selective fractionation, supporting the development of integrated and sustainable biorefinery approaches. This research is funded by Agritech Project (PNRR), National Center for Technology in Agriculture.

SESSIONE INSTM-CNR

OA1

CO_2 conversion to light hydrocarbons on membrane-embedded catalysts

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Implementing carbon capture and utilization strategies is a priority within the framework of decarbonization policies. Membrane-based technologies offer an interesting playground in this context, as foreseen by the DAM4CO2 EIC-Pathfinder project. In DAM4CO2, mixed matrix membranes (MMMs) are under development to both separate CO_2 and subsequently convert it to hydrocarbons. The catalytic performances of membrane-embedded catalysts based on non-critical elements will be discussed. A selection of Fe-based photothermocatalysts was embedded within thermally resistant polymers of intrinsic mesoporosity and operated at 250 °C under ambient pressure and simulated sunlight, targeting C_{4+} hydrocarbons via Fischer-Tropsch synthesis (FTs). The effect of different pre-activation treatments (namely reduction and/or carburization) in determining catalytic performances was considered as well. Beside testing, a thorough characterization of MMMs and their pristine components (including in situ approaches) was performed. The catalytic MMMs were tested under photothermo catalytic conditions by co-feeding CO_2 and H_2 in variable ratios, and their performances were compared with these of corresponding catalysts in powder form. A main finding is that catalyst incorporation in the polymeric matrix resulted in a significant decrease in catalytic activity compared to its pristine powder form for any considered material. Still, a CO_2 conversion up to ca. 10% was measured on best system, with C_4 products detected. In situ characterization under reaction conditions demonstrated as carburization of the catalysts (i.e. the formation of the catalytic active phase for FTs) occurs much faster on the powder form rather than in MMMs, suggesting the polymeric matrix is not simply a bare physical support. Despite encouraging preliminary results, catalytic performances of MMMs are still way lower than for parent powder catalysts. This can be either related to diffusion problem and/or specific interaction occurring at the catalyst/polymer interface, that likely hampers catalyst carburization. The immediate priority is thus enhancing catalytic activity of the embed catalysts, an issue we are facing by exploring different catalyst pre-activation and embedding strategies.

OA2

Bio-based polyurethane foams with integrated phase change materials for sustainable mobility

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The transition toward circular and low-carbon mobility requires lightweight materials combining renewable sourcing, thermal insulation, and functional energy management. Flexible polyurethane foams (PUFs) are widely used in automotive interiors but are predominantly fossil-based and lack thermal storage capability. This study presents multifunctional bio-based PUFs incorporating microencapsulated phase change materials (PCMs), aiming to integrate latent heat storage while valorising waste cooking oil (WCO) as a renewable feedstock. Flexible PUFs were synthesized using a polyol derived from WCO and a partially bio-based isocyanate. Microencapsulated paraffin-based PCMs (up to 15 phr) were dispersed within the foam matrix during formulation. Morphological analysis was performed via microscopy, while density and mechanical properties were evaluated through compression force deflection (CFD) and cyclic fatigue testing. Thermal behaviour was assessed using differential scanning calorimetry (DSC), thermal conductivity measurements, and fire performance testing. The incorporation of PCMs provided an energy storage capacity up to 26.2 J/g at 15 phr, with a stable phase-change temperature of 36 ± 0.1 °C. Microcapsules were uniformly distributed, leading to a moderate density increase (128–157 kg/m^3) and a reduction in cell size. Mechanical strength and rigidity increased, with CFD values reaching 234.8 kPa, while elasticity decreased. Fatigue testing confirmed structural stability under cyclic loading, with increased dynamic stress and stiffness associated with PCM integration. Thermal conductivity showed only a slight increase (46.55–48.58 mW/m·K), and fire performance remained substantially unchanged due to the balancing effect of the silica-based shell.The developed PCM–PUFs demonstrate a synergistic combination of renewable content, structural integrity, and latent heat storage near room temperature. Despite moderate reductions in elasticity, mechanical and thermal performances remain compatible with mobility interior applications. The integration of PCMs enables passive thermal management without significantly compromising insulation or safety behaviour. These findings highlight the potential of WCO-derived multifunctional foams as circular materials supporting energy efficiency, waste valorisation, and reduced fossil dependency in advanced mobility systems. This research was funded by the European Union - Next Generation EU (National Sustainable Mobility Centre. CN00000023. Spoke 11 - Innovative Materials & Lightweighting - Projects “ECO-FRIEND” and “CO-SMART”.

OA3

Towards low-energy CO_2 capture: design and performance of innovative liquid sorbents

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Aqueous monoethanolamine (MEA) solutions represent the industrial benchmark for CO_2 capture due to their fast kinetics and high efficiency. However, their large-scale application is limited by the high energy required for sorbent regeneration. This penalty is mainly related to the formation of stable carbamate species, leading to elevated regeneration temperatures (typically 120-140 °C). In this context, the design of advanced liquid sorbents offers a promising route to reduce the overall energy consumption of CO_2 capture. A series of aqueous amine blends were developed by combining tertiary amines with primary, secondary, and sterically hindered amines of different reactivity and basicity, to tailor reaction pathways and improve regeneration behavior. Their performance was evaluated in a continuous absorption–desorption setup and benchmarked against MEA. In parallel, solid acid catalysts (SACs), including waste-derived materials such as fly ash and sepiolite-based systems, were investigated to enhance CO_2 desorption kinetics. Desorption was carried out at lower temperatures (88-100 °C) compared to conventional MEA operation. Amine blends exhibited CO_2 capture performance comparable to MEA, while significantly improving desorption behavior. In particular, selected formulations showed desorption rates up to 3 times higher than MEA and reductions in regeneration energy up to 60-70%, depending on composition. Similarly, the use of solid acid catalysts markedly enhanced desorption kinetics and reduced heat duty by similar extents relative to MEA, while enabling operation at lower temperatures. Waste-derived materials such as fly ash and modified sepiolite showed particularly promising performance, combining catalytic efficiency with low cost and scalability. These results demonstrate that both sorbent design and catalytic promotion can effectively reduce the energy penalty of CO_2 capture. Amine blending modifies reaction pathways, favoring less stable species that are easier to decompose, while solid acid catalysts accelerate carbamate breakdown through acid-mediated mechanisms. Together, these approaches provide complementary and scalable strategies for the development of low-energy CO_2 capture technologies.

Acknowledgements: the work was partially supported by the CNR/HCST/NCRD bilateral Italy-Jordan project (2021-2023) and the CNR Short Term Mobility (STM) program (2025).

OA4

Bismuth titanate and copper oxide heterostructured photoelectrodes for ferroelectric-enhanced carbon dioxide reduction

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Photo-Electrochemical Cell (PEC) represents one of the most sustainable technologies for solar fuels production by carbon dioxide reduction reaction (CO2RR). In a PEC, rapid spatial separation of the photo-generated carriers and their transport kinetics within the photo-electrodes materials are fundamental for achieving high-performance devices avoiding charges recombination. Recently, the use of ferroelectric potential in ferroelectric photo-active semiconductors has shown to be an effective strategy to modulate the charge transfer properties both in the bulk and at the surface of semiconductors. In this perspective, the Aurivillius perovskite $Bi_4Ti_3O_{12}$ (BiTO) is of great interest due to its excellent photocatalytic activity and strong spontaneous ferroelectric polarization. Thin-film BiTO photocathodes were fabricated via a sol-gel/spin coating coupled process on FTO substrates (2.5 cm2). The deposition steps were optimized and the obtained film annealed in air at 250°C and 500°C for 30 min to allow the formation of the BiTO crystal phase. Cu_2O nanocubes (NCs) co-catalysts were synthesised via a simple wet-chemical water-based ligand-free method at room temperature and deposited on BiTO thin film by spin coating. BiTO optimal thickness in terms of photoelectrochemical properties was identified and fully characterized. The effect of the ferroelectric polarization on the performances of BiTO photo-electrode was then investigated, showing, under negative polarization, an increase of about 50% of the current density and reduction of the charge transfer resistance. To further enhance these properties, Cu_2O nanocubes were deposited on BiTO. Electrochemical characterization confirmed the formation of a direct Z-scheme heterojunction, which significantly improved charge separation and multielectron transfer. Finally, the influence of polarization also on CO2RR was observed, with an increment of faradic efficiencies related to the production of liquid products. The effect of the polarization on BiTO heterostructured photoelectrode which could be explained based on the band banding at the photo-electrode interface caused by the superimposition of the generated ferroelectric potential to the applied external bias. Moreover, heterostructured photoelectrodes demonstrate that the synergistic combination of BiTO thin films and Cu_2O via Z-scheme strategy, experimentally verified, efficiently channels CO_2 reduction toward high-value multielectron products, leveraging both the high catalytic activity of Cu_2O and the intrinsic performance of the BiTO electrode. This work was supported by the Research Program Progetti@CNR "RIPRESA Project" (CUP B53C20040460005) and European Union–Next Generation EU and the Italian Ministry of Environment and Energy Security (POR H2 AdP MMES/ENEA-CNR-RSE, PNRR–Mission 2, Component 2, Investment 3.5 "Ricerca e sviluppo sull'idrogeno", CUP: B93C22000630006).

OA5

Closing the loop: synthesis and properties of CO_2-based polymers

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The catalytic conversion of CO_2 into valuable polymeric materials has gained significant attention from both academia and industry. In particular, extensive research has focused on the copolymerization of CO_2 with epoxides to produce polycarbonates and polyols. The catalyst plays a crucial role in determining rate, productivity, selectivity, composition, and molecular weight of the copolymers, as well as the regio- and stereoselectivity of epoxide ring-opening. In recent decades, many catalytic systems have been developed, with well-defined metal catalysts significantly improving activity, selectivity, and mechanistic understanding. Only a limited number of studies have explored potential new families of cocatalysts as alternatives to PPN^+X^- salts ($PPN^+ = (Ph_3P)_2N^+$; X = halide, azide, acetate, or nitrate) or to aromatic Lewis bases such as DMAP and N-methylimidazole. The copolymerization of carbon dioxide with cyclohexene oxide (CHO) or propylene oxide (PO) was investigated using salen-type chromium complexes, among the most widely studied catalysts, in the presence of different cocatalysts. These included (i) quaternary phosphonium halide salts (chloride or bromide) exhibiting varying degrees of nucleophilicity and polarizability, and (ii) bulky branched phosphazenium salts of general formula $[(Me_2N)_3P{=}N]_4P^+X^-$, where X = chloride or azide. For PO copolymerization, cobalt(III) porphyrin catalysts were also employed. With quaternary phosphonium salts, FTIR/ATR spectroscopy on the pretreated catalytic system was used to predict the success of the copolymerization before the introduction of the epoxide. A detailed end-group analysis via MALDI-TOF was performed for the synthesized poly (cyclohexene carbonate)s. Phosphonium salts such as triphenyl(4-pyridinylmethyl)phosphonium chloride hydrochloride (UHFFA) and tetraphenylphosphonium chloride (TPPCl) proved to be effective cocatalysts for epoxide/CO_2 copolymerization, affording polycarbonates with molar masses comparable to, or even exceeding, those obtained with PPN^+ salts. Similarly, phosphazenium salts, PPZCl and its azide analogue ($PPZN_3$), exhibited versatile activity in polycarbonate synthesis, outperforming PPNCl in terms of efficiency. Notably, when combined with porphyrin-based catalysts, PPZX cocatalysts enabled the formation of polymers with molar masses exceeding 50,000 $g{\cdot}mol^{-1}$. For CHO-based copolymers, a structure–property correlation can be observed: the Tg value seems to be related both to the amount of ether linkages and to the molecular weight. The complex patterns observed in MALDI-TOF spectra of the resulting copolymers, together with results from ^{1}H-NMR spectroscopy, FTIR/ATR spectroscopy, catalytic performance, and polymer characteristics (including selectivity and molar mass), highlight that not only the anion but the entire cocatalyst structure must be considered in the rational design of polycarbonates. In particular, the superior performance of PPZX catalysts appears to be associated with the enhanced ability of phosphazenium cations to delocalize the positive charge due to their conjugated double bond structure. In addition, the great steric hindrance of the bulky structure likely contributes to their ability to outperform traditional onium cations.

Acknowledgements: the authors thank Eni S.p.A. (Rome, Italy) for the financial support, contract No. 3500042562 (2016-2018) and No. 3500048631 (2019-2020).

SHORT ORAL

SO1

Synthesis and characterization of multi-layer graphene (MLG) for nuclear physics application

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Graphene research is of high interest among researchers since its discovery in 2004. Graphene is a two-dimensional carbon allotrope consisting of atoms placed in a hexagonal honeycomb lattice arrangement. Multi-layer graphene (MLG) prepared by different routes can have excellent properties like mechanical strength, high thermal and electrical conductivities that finds many applications in advanced electronics systems. MLG is also of special interest in the field of nuclear physics due to their excellent physical properties making them significant for charge stripping foil applications for particle accelerators. MLG can serve as a substrate for nuclear target deposition where a large amount of power is released by an intense particle beam. It acts as a thermal bridge to a heat sink at cryogenic temperature for cooling the front-end electronics of the detectors and additionally, it becomes a new type of stripper for ion beams. Thereby, MLG with high carbon purity, thermal diffusivity, and exceptional mechanical properties has great potential for use as charge stripping foils/substrates in particle accelerators helping to reduce the material costs in the sensitive areas of the detectors. MLGs are prepared by three distinctive pathways. 1. Filtration of a e-graphene dispersion (Sixonia Tech) with a concentration of 2.1 mg/ml. The e-graphene solutions are vacuum/pressure filtered on different membranes to form MLG films that are separated from membranes to obtain free-standing MLGs. 2. Reduction of graphene oxide (GO) dispersion (Graphenea-concentration of 0.4 wt%) to reduced graphene oxide (rGO) using chemical/ thermal treatments. 3. Carbonisation of Kapton (a polyimide film) between graphite rods at 700 °C for 1 hr in nitrogen atmosphere followed by graphitization at higher temperature. Free-standing MLGs produced are characterised by Raman spectroscopy, x-ray diffraction (XRD), scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), and electrical conductivity. Raman spectra of MLG showed D, G and 2D peaks arising from the presence of defects, in-plane vibrations of sp^2 hybridized carbon atoms and formation of graphene multi-layers, respectively. XRD of MLG from e-graphene and rGO showed (002) peak at 2θ of 26.6º, similar to that of pristine graphite. FTIR of MLG produced by different pathways showed either no or reduced intrinsic absorption features, indicating the absence/very low presence of residual functional groups. Further characterisation to determine the thermal conductivity of the MLGs would be significant to understand the microstructural and heat disssipation properties of the synthesized films.

SO2

Ablative thermal protection systems for re-entry vehicles with nanostructured polymeric matrices

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The continuous evolution of space exploration requires the development of advanced Ablative Thermal Protection Systems (A-TPS) to protect vehicles from the intense heating encountered during planetary entry. A-TPS usually consist of a carbon reinforcement impregnated with a phenolic matrix, employed for its excellent thermal stability, low thermal conductivity, and ability to form a protective char layer during pyrolysis. Traditional carbon-phenolic ablators, though effective, face performance limitations under the increasingly severe conditions of future missions. With the aim of improving their performances, this work focuses on the development of nanostructured and higly porous ablators with two different matrices: state-of-the-art phenolic and cyanate ester. Phenolic-ablators were manufactured with a well-established procedure developed in numerous previous works by the authors and used as reference material. Different solvents and manufacturing strategies were explored for the cyanate-ablators to obatin homogeneus infiltration and resin distribution inside the carbon felt. Different additives were tested to modify the resins' microstructures and obtain highly porous, nanostructured matrices and the resulting morphologies were observed with SEM. FTIR and TGA were performed to investigate the effects of the additives on the chemical structure and thermal decomposition of the matrices. The mechanical properties were evaluated through compression tests up to 2000°C. Thermo-ablative performances were assessed with oxyacetylene flame tests, exposing the samples to a heat flux of 4MW/m^2. A novel cyanate-ablator was developed and the nanostructuration of its matrix was obtained with hexamethylentetrammine. Different nanostructured ablators were obatined for the phenolic matrix using hexametiltetrammine and two polymeric additives. FTIR and TGA analysis indicated that the additives were incorporated in the matrices, affecting their chemical structure, thermal curing and decomposition. Compared to the reference ablator, the nanostructured-phenolic-ablators obtained with polymeric additives showed higher compressive properties (from 1.9 to 3.2MPa). The cyanate-ablators showed lower mechanical properties, conversely, their nanostructured modification led to the highest resistance (11.5 MPa). All ablators showed improved ablation performances during flame exposure, with much lower temperatures inside the materials (from ~750°C to ~550°C), lower mass loss (from 37% to 25%) and recession (from 1.6mm to 0.2mm). Effective enhancment of A-TPS performances was obtained trough additive-driven modification of two resin matrices: phenolic and cyanate ester. The additives affect the chemistry and thermal behavior of the materials and lead to the formation of highly porous ablators, which resulted in much more efficient A-TPS with improved mechanical properties and thermo-ablative behavior when exposed to high heat fluxes.

SO3

Sustainable polyimide-based nanocomposite materials for space antenna applications

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Advanced polymeric materials for space applications must ensure high thermal stability, chemical resistance, controlled surface properties and reliable adhesion to inorganic substrates, while minimizing environmental impact. Polyimides represent a promising class of materials due to their intrinsic thermal and mechanical performance. This work investigates nanocomposite materials based on purified polyimide P84, re-solubilized in a green solvent, dimethyl isosorbide, and reinforced with two-dimensional nanofillers, with the aim of tailoring their thermal and surface properties for potential use in coating applications for antenna components. Commercial P84 polyimide was purified and re-dissolved in DMI to obtain homogeneous polymer solutions. Two-dimensional fillers, graphene and hexagonal boron nitride, and their hybrid combinations were added at 1, 3 and 5 wt%. Nanocomposite samples (average thickness ~80 μm) were obtained by solution casting followed by solvent evaporation in oven. A multistep thermal drying protocol was optimized, including degassing under vacuum, stepwise air drying from 60 °C to 110 °C, and a final vacuum treatment to avoid solvent entrapment and bulk inhomogeneities. Nanocomposites were characterized by FTIR spectroscopy, differential scanning calorimetry, water contact angle and surface free energy analysis. FTIR analysis confirmed the characteristic functional groups of aromatic polyimides and the absence of new chemical bonds upon filler addition. DSC measurements demonstrated that the incorporation of graphene, h-BN and hybrid fillers increases the glass transition temperature (Tg), with values ranging from 240 °C to 253 °C, well above the typical space mission thermal window (−220 °C to +190 °C). This confirms the thermal stability of the nanocomposites under relevant operating conditions. The observed variations in Tg and in heat capacity values can be ascribed to the filler-induced restriction of polymer chain mobility. Surface analyses revealed decreasing water contact angles and total surface free energy with increasing filler content. The SFE values (32–38 mJ m^{-2}) are suitable for effective substrate wetting and adhesion to inorganic substrates such as glass and quartz. Overall, the incorporation of 2D nanofillers enables effective tuning of the thermo-physical properties of P84-based nanocomposites, highlighting their strong potential for space applications.

SO4

Upcycling innovations: converting waste into high-performance bio-based monomers for a sustainable future

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In the quest for sustainability, upcycling waste materials into high-performance bio-based polymers has emerged as a game-changing strategy. This talk unveils exciting advancements in utilizing commercially available agricultural byproducts and industrial waste to create innovative materials that reduce environmental impact. The epoxidized soybean oil (ESO) was provided by Cargill Bioindustrial and used without further modification. Protobind® 1000 (a mixed wheat straw/Sarkanda grass lignin from soda pulping of non-woody biomass) was purchased from Tanovis. Triarylsulfonium hexafluorophosphate salt, vanillin derived from rice bran ferulic acid, glycerol 1,3-diglycerolate diacrylate (Gly), and acrylated epoxydized soybean oil (AESO) were purchased from Merck. (Ethyl(2,4,6-Trimethylbenzoyl)-phenyl phosphinate) Omnirad TPO-L was purchased from Sartomer; Phosphate methacrylate (Miramer A99) was purchased from Miwon Europe GmbH, Mainz, Germany. The UV-curable coating based on lignin and ESO showed high reactivity and excellent film properties, including enhanced hardness, adhesion, and hydrophobicity. It demonstrated strong antibacterial activity and provided effective corrosion protection for over two weeks in a saline environment, confirming its potential as a sustainable, high-performance anticorrosion material. The vanillin-based covalent adaptable network (CAN) exhibited impressive thermomechanical properties (Tg > 200 °C), high chemical stability and good reprocessability, making it a promising candidate for applications in high-performance sectors such as aerospace and automotive. The biodiesel byproduct Gly was mixed with AESO at varying contents to formulate visible-light 3D-printable, reprocessable materials with high self-healing capabilities, exhibiting low viscosity, high photoreactivity, and good shape memory properties, weldability, and repairability, indicating promising applicability in fields such as soft robotics. These results highlight how waste upcycling can yield high-performance materials. The anticorrosion, reprocessable, and self-healing functionalities address key industrial needs while utilizing discarded resources. This approach not only reduces environmental impact but also demonstrates the practical viability of creating a more sustainable and circular economy through innovative materials science and technology.

SO5

Amine-functionalized MCM-41 for CO_2 capture in diluted and humid CO_2 streams

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Within the Carbon Capture and Utilization technologies framework, porous materials such as Ordered Mesostructured Silicas are promising sorbents for CO_2 capture due to their high adsorption capacities, ease of regeneration, and stability. In this work, two MCM-41 samples were synthesized using different silicon sources: TEOS (tetraethyl orthosilicate) and industrial waste FSA (fluorosilicic acid), a hazardous byproduct of the production of hydrogen fluoride and phosphate-containing fertilizers. Owing to their high surface area resulting from their mesostructure, these materials are well-suited for surface functionalization to improve CO_2 adsorption. In this study, both samples were functionalized with (3-aminopropyl)triethoxysilane, yielding NH_2@TEOS-MCM-41 and NH_2@FSA-MCM-41. CO_2 capture performances of the sorbents were assessed using multiple techniques under dry and humid conditions. All materials were characterized using powder X-ray diffraction, N2 physisorption, thermogravimetric analysis, Transmission Electron Microscopy and Solid State NMR. CO_2 adsorption tests were carried out at 30 °C under static, dynamic and hybrid conditions using multiple techniques: a modified TPD-R/O setup (dynamic, home-built); a Breakthrough Analyzer (dynamic, Micromeritics); thermogravimetric analysis (TGA, hybrid static-dynamic); microcalorimetry and in situ FTIR (static). Dynamic adsorption tests showed that NH_2@FSA-MCM-41 exhibits higher CO_2 uptake than NH_2@TEOS-MCM-41 at both 10% CO_2 (~1.2 vs ~1.0 mmol g^{-1}) and 5% CO_2 (~1.0 vs ~0.8 mmol g^{-1}). For this reason, NH_2@FSA-MCM-41 was further evaluated at lower CO_2 concentrations, maintaining high performance with uptakes of ~0.9 mmol g^{-1} at 2% CO_2 and ~0.7 mmol g^{-1} at 0.5% CO_2. Notably, these values are comparable to those achieved by NH_2@TEOS-MCM-41 at higher CO_2 concentrations, highlighting the superior efficiency of the FSA-derived material under diluted conditions. To investigate NH_2@FSA-MCM-41 performances under realistic conditions, dynamic adsorption tests were carried out using 2/10% CO_2, with a Relative Humidity (RH) of 33%. The presence of moisture resulted in a increase of CO_2 uptake, with an improvement of ~20% in both cases. Dry TGA adsorption tests are consistent with the trend observed in dynamic conditions. The adsorption heats derived from microcalorimetry and in situ FTIR using CO_2 as probe molecule revelaed that that adsorption occurs through two main processes for both samples: (i) chemisorption, involving the formation of ammonium carbamates on -NH_2 groups, and (ii) physisorption arising from weaker interactions with the silica surface. Notably, most of the carbamate species are reversible and can be removed by simple degassing at room temperature, whereas only a minor fraction requires mild heating (60 °C) to achieve complete regeneration.

SO6

Ultraporous activated carbons derived from exausted resins for H_2 storage

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Hydrogen production and storage are considered two of the most challenging aspects that scientific community have to face for contributing to the energy transition. One of the best methods to increase the H2 storing capacity is the adsorption in porous solids where the gas density can be largely increased especially if the molecules are entrapped within micropores. Thanks to their high specific surface area and pore volumes, activated carbons (ACs) represent excellent low-cost candidates for this application. Ultra-porous ACs derived from a hyper-cross-linked polystyrene-divinylbenzene resin were prepared and tested as model system of exhausted resins widely employed in the industrial sectors for water cleaning. Activated carbons (ACs) were prepared by pyrolysis using KOH as activator. Exploiting a solvent-free procedure, different mixtures with resin: KOH weight ratios from 1:0.25 to 1:4 were pyrolysed under N_2 at 800°C. An in-depth physico-chemical characterization of the ACs was obtained from N_2 and CO_2 physisorption analyses at 77K and 273K, FESEM analyses and Raman spectroscopy, whereas the H_2 adsorption capacity at 77K was evaluated up to 100 bar through an adsorption differential volumetric apparatus (ADVA). An innovative method called PoLA (porosity local analysis) was adopted for the determination of the porous volume distribution (PVD), and for simulating H_2 adsorption isotherms. The obtained ACs show remarkably high specific surface area and pore volume (up to 3400 m^2/g and 1.40 cc/g) that gradually increase with the resin:KOH weight ratio. The highest excess volumetric H_2 adsorption of 35 g/L is found at 40 bar for the 1:2 sample. An absolute volumetric capacity at 100 bar of 48 g/L, which takes into account also the gas phase, was determined by PoLA computational tools. Non-regenerable end-of-life resins can be employed as low-cost precursor for the preparation of highly-porous ACs with remarkable H_2 adsorption absolute volumetric capacity exceeding the US Department of Energy (DOE) target of 40 g/L.

SO7

Study of hydrogen embrittlement of steels for the oil & gas sector through electrochemical methods

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The objective of this study is to investigate hydrogen embrittlement in steels used in the Oil & Gas sector, with the aim of ensuring the safe transportation and storage of hydrogen gas within existing infrastructures. The materials examined are T95 and P110 steel grades manufactured according to the API 5CT specification for casing and tubing applications. These low-alloy and micro-alloyed steels exhibit a tempered martensitic microstructure and high resistance to severe service environments due to their low impurity content. Understanding their susceptibility to hydrogen-assisted damage is essential for the transition toward hydrogen-based energy systems and for assessing the compatibility of current infrastructure with hydrogen service. A comprehensive characterization of the steels was performed, including microstructural analysis, hardness measurements, tensile testing, and fracture mechanics characterization. Hydrogen diffusion was measured using the Devanathan–Stachurski electrochemical permeation method. The experimentally determined hydrogen diffusion coefficients were implemented in a Finite Element Model to define the optimal pre-charging conditions required to achieve a uniform hydrogen concentration prior to mechanical testing. Subsequently, tensile and J-integral tests were conducted on hydrogen pre-charged specimens to evaluate the influence of hydrogen on strength and fracture toughness. Fractographic analyses were carried out to correlate mechanical performance with fracture morphology and microstructural features. Hydrogen diffusion coefficients were successfully determined for both steel grades, enabling the identification of suitable charging conditions. Mechanical testing revealed a reduction in ductility and fracture toughness in hydrogen pre-charged samples compared to uncharged conditions. The extent of degradation differed between T95 and P110, reflecting microstructural and compositional variations. Fractographic observations highlighted a transition toward more brittle fracture features in the presence of hydrogen. The experimental findings demonstrated a clear correlation between hydrogen content, microstructure, and mechanical response. The results confirm the susceptibility of tempered martensitic steels to hydrogen-assisted degradation, with differences attributable to microstructural characteristics and alloying content. The integration of experimental diffusion data with numerical modelling proved effective in defining reliable pre-charging procedures. A comparison with X60 steel, characterized by a different microstructure and widely employed in the Oil & Gas sector, further emphasized the role of microstructure in hydrogen embrittlement resistance. This study provides insights into the mechanical behaviour of pipeline steels in hydrogen environments, supporting the assessment of structural integrity and contributing to improved safety and reliability of oil and gas infrastructures.

SO8

Bimetallic Fe-Ni exsolution from A site deficient $SrTiO_3$: insight into the reciprocal role of metal active centers

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Redox exsolution from doped perovskites has emerged as a powerful strategy to generate stable, regenerable "socketed" metal nanoparticles under reducing conditions. During high-temperature reduction, oxygen vacancies form and transition-metal dopants are reduced, migrate, and nucleate at the surface. While Ni readily exsolves, Fe alone is less prone to segregation due to its higher segregation energy; however, co-doping with a more reducible metal such as Ni can promote Fe–Ni alloy exsolution by lowering the overall reduction barrier. These bimetallic systems have shown promising performance in thermochemical and electrocatalytic processes, including the RWGS reaction, yet the mutual roles of Ni and Fe in governing reduction, vacancy formation, and nanoparticle growth remain insufficiently understood. In this study, we investigate the redox properties and exsolution kinetics of Ni and Fe in A-site-deficient $Sr_{0.95}Ti_{1-x+y}Fe_xNi_yO_{3\pm\delta}$ by integrating multiple spectroscopic techniques to disentangle the dopant-specific roles in defect chemistry and metal nucleation. TPR results reveal that Fe primarily controls the formation and reducibility of oxygen-vacancy-related defects, leading to the generation of reduced Fe species at relatively low temperatures, whereas Ni determines the overall extent of reduction. Consistently, XAS shows that Ni-only compositions display limited conversion to Ni(0), while Fe co-doping markedly enhances Ni exsolution. Furthermore, EXAFS demonstrates that even small amounts of Ni facilitate Fe reduction.STEM analysis confirms the surface segregation of well-anchored Fe–Ni co-exsolved nanoparticles in co-doped perovskites, whereas Fe-only samples exhibit minimal exsolution. EPR findings further clarify that Fe is incorporated into the perovskite lattice predominantly as stable Fe(III) substitutional defects, which are less reducible and less mobile than Ni species that mainly occupy intercalated sites. Notably, Fe defects become mobile and segregate to the surface only in the presence of Ni. These structure–property correlations translate into improved performance in the RWGS reaction for co-doped perovskites, where Fe facilitates vacancy-mediated redox processes and Ni enhances H_2 dissociation. Overall, the methodological framework established here can be extended to other exsolvable dopants, providing a rational strategy for designing exsolved catalysts with tailored structures and compositions for advanced energy conversion applications.

SO9

Vapor-phase deposition strategies for perovskite and perovskite-inspired materials

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Controlled vapor-phase deposition of functional thin films plays a key role in the development of next-generation materials for energy conversion and advanced optical and chiro-optical applications. The main objective of this work is to achieve precise control over structural and compositional parameters during thin-film growth to tailor material functionalities and enhance device-relevant properties. In this context, the present study focuses on the development of thin films based on hybrid chiral metal halides, where vapor-phase deposition approaches enable the fabrication of highly uniform thin films with enhanced chiro-optical response. Hybrid chiral metal halide thin films are grown using vacuum-based deposition techniques, with particular emphasis on RF magnetron sputtering and hybrid approaches combining sputtering and thermal evaporation. Preliminary results highlight the potential of sputtering-based approaches for the fabrication of highly uniform hybrid chiral thin films. However, the incorporation of the organic component remains challenging due to its intrinsically low deposition rate and its susceptibility to degradation under sputtering conditions. In this context, combined deposition strategies integrating sputtering and thermal evaporation enable the successful formation of hybrid chiral perovskite thin films with strong chiro-optical response and excellent film uniformity. Overall, vapor-phase deposition strategies offer a promising route for the controlled and scalable fabrication of hybrid chiral perovskite thin films. This approach could enable the development of chiral materials with improved chiro-optical performance for advanced optoelectronic devices.

SO10

Biopolymer composites reinforced with mediterranean agricultural residues for biodegradable food packaging: an insight in the PLAMINPACK project

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The transition toward sustainable food packaging requires materials that are biobased, biodegradable, and recyclable, ensuring adequate preservation of perishable products. In a circular economy framework, agricultural wastes from the Mediterranean area represent promising resources to develop functional biopolymer composites. Within the PLAMINPACK project, this study focuses on selecting materials suitable for biodegradable fruit packaging applications (nets for tangerines, trays for dates and strawberries and a film to seal onto the trays) by valorizing agricultural residues as fillers and sources of antioxidant compounds. Poly(lactic acid) (PLA) and Poly(butylene succinate-co-adipate) (PBSA) biopolymers were selected as components for blends formulation and production through extrusion compounding. Agricultural wastes, both before and after extraction, were incorporated as fillers to obtain composites and to assess their properties. The produced samples were characterized for physical and mechanical properties, considering variations in matrix composition, filler type (raw vs. extracted residue), and incorporation of antioxidant extracts. Characterization tests highlighted that the addition of the tangerine powder in the composites for nets (both before and after the extraction) led to a decline in the performance of the final blend, indicating that the powder was not suitable to be directly incorporated into the formulation. Successful routes for material formulations and processing for both flexible films and rigid trays have been investigated. PLA/PBSA blends, modified with low concentrations of strawberry extracts, demonstrated a strong balance between processability and sustainability, maintaining acceptable mechanical performance for packaging applications. Formulations containing antioxidant extracts demonstrated variations in color and functional properties, suggesting potential added value for active packaging. Moreover, differences in processability and performance were observed according to biopolymer matrix composition and the treatment applied to the residues. The results provide a solid foundation for scale-up, film extrusion, and prototype manufacturing in subsequent project phases, advancing the development of fully bio-based, circular packaging solutions for fresh produce. The most promising formulations identified in this study will be further optimized to produce packaging prototypes, considering also the addition of dates residues.

SO11

Hydropellets: water-soluble composite with high environmental sustainability

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HydroPellets is a water-soluble composite for injection molding with low environmental impact. Is produced with an innovative patented cold granulation technology, characterized by low energy and water consumption. It consists of a PVA matrix, loaded with inert mineral fillers and plasticizers. For the moment, its application properties have been examined. The main features are listed below.

- Save The Sea: dissolves completely in water without releasing microplastics.
- Low Carbon Footprint: has a value of 1.40 kg/kgCO2e compared to more than 3.40 kg/kgCO2e for traditional water-soluble polymers.
- Pellets & Paper: integrated with paper/cardboard/corrugated cardboard, it is perfectly recyclable in the paper supply chain.
- Low Cost: it costs less than traditional water-soluble and compostable polymers.
- Wet Compression: after simply wetting with water, HydroPellets granules can be wet-compressed into a wide variety of shapes, acquiring extraordinary toughness.
- Shape Memory Forming: tapes produced by compression or flat pieces produced by 3D printing can be shaped and stabilized by heat treatment, maintaining the desired shape over time.
- Hand Smoothing: one of the main limitations of 3D printing is poor surface finish. HydroPellets can be smoothed by simply rubbing with a damp cloth.
- Self Healing: HydroPellets can be strongly bonded to itself, cardboard, and wood in a matter of seconds by wetting it with water.

Although still in the characterization phase, HydroPellets is certainly a highly environmentally sustainable material, characterized in particular by a very low carbon footprint and by the capability to dissolve quickly in water without releasing microplastics. Integrated with paper, cardboard, and corrugated cardboard, it allows for the creation of new solutions and packaging completely recyclable in the paper supply chain.

SO12

Recyclability assessment of AlO_x-coated MDOPE monomaterial films for flexible food packaging applications

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Multilayer flexible packaging ensures high barrier performance but is generally incompatible with mechanical recycling due to material heterogeneity. In the framework of the RE.MO.PACK project, a design-for-recycling approach was adopted to develop high-performance monomaterial polyethylene (PE) structures. MDOPE film functionalized with an ultrathin AlO_x + lacquering coating were investigated as a strategy to enhance oxygen and water vapour barrier properties while maintaining compatibility with established PE recycling streams. The study focuses on assessing the recyclability of such innovative structures according to the RecyClass protocol for PE films. The investigated materials consisted of a 25 µm MDOPE film (control) and a 25 µm MDOPE film coated with ~ 10 nm AlO_x and lacquering via reactive roll-to-roll vacuum deposition (innovation). Laboratory-scale mechanical recycling was performed, including grinding, drying, blending and extrusion using a single screw extruder and a co-rotating twin-screw extruder. Blends containing increasing amounts of innovation film (0–100 wt%) were processed to simulate potential contamination scenarios. Reprocessed materials were characterized by FTIR, DSC, density measurements, melt flow rate (MFR), colorimetric analysis and mechanical tensile tests, in accordance with the RecyClass evaluation protocol. Preliminary results indicate that all blends were successfully processed without evident macroscopic defects during grinding and extrusion. Spectroscopic and thermal analyses suggest substantial chemical and thermal stability of the PE matrix after reprocessing. Density and MFR values appear comparable to those of the control sample and within the limits defined by the reference protocol. Mechanical properties of reprocessed blends show trends consistent with PE-based systems, while colorimetric analysis indicates progressive chromatic variations with increasing AlO_x-coated content. Preliminary results support the potential compatibility of AlO_x-coated MDOPE films with conventional PE mechanical recycling processes, provided that the inorganic layer remains below critical thresholds. Processability and key functional parameters are preserved after reprocessing. Furthermore, no significant differences in the chemical-physical and mechanical properties of the reprocessed materials emerged from the comparison between single-screw and twin-screw extrusion. This result suggests that single-screw extrusion can also potentially be used in the recycling flow of such structures, allowing for a simplification of the industrial process and a possible increase in productivity. However, some aesthetic issues remain, particularly related to colour variations, which could be a limiting factor depending on the final application of the recycled material. The study contributes to the development of recyclable high-barrier single-material solutions, in line with circular economy strategies in flexible food packaging.
Acknowledgements: the authors wish to acknowledge the funding from "Risorse del Piano nazionale per gli investimenti complementari al PNRR" Ministero dell Imprese e del Made in Italy within the project "RE.MO.PACK - Study and development of an innovative REcyclable MOnomaterial film and its introduction into the food PACKaging processes" (n° F/310061/01-02/X56).

SO13

Performance and degradation behavior of biocomposite films based on biopolysaccharide and hydrothermal carbonised waste sawdust

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Researchers increasingly promote renewable resources and waste valorisation to produce advanced materials within a circular economic framework. In this context, cellulose-based particles are widely incorporated into polymer and biopolymer matrices to improve mechanical properties, UV shielding, and processability. Sawdust wood waste is an attractive, low-cost, and sustainable filler, though it typically remains micrometric in size. Alternatively, microcrystalline cellulose can be extracted, but this approach involves solvents and higher processing costs. Aiming to reduce waste and promote the use of renewable materials, sawdust wood waste was treated using hydrothermal carbonisation (HTC) as an alternative to conventional biomass pretreatments. Traditional treatments, mainly chemical, physical, or physicochemical, often present several drawbacks, including the use of toxic and corrosive solvents, high energy consumption, and the generation of waste requiring additional treatment. Chitosan-based films (Chit), incorporating hydrochar (HTC-WS; from pine sawdust wood) or microcrystalline cellulose (MCC) were produced by the solvent-casting technique; a neat chitosan film was prepared for comparison. Produced chitosan-based films were subjected to accurate spectroscopy (UB-visible, FTIR) analysis, morphological, rheological and mechanical tests. The degradation was monitored in different environments, such as fresh water, simulated seawater and under UVB exposure. The Chit/HTC-WS and Chit/MCC films exhibit effective UVB-shielding properties, which are likely to contribute to their enhanced resistance to photo-oxidative degradation. Notably, the incorporation of HTC-WS and MCC reduces the rigidity of the chitosan matrix, as reflected by the lower elastic modulus values. At the same time, both additives improve the ductility of the system, evidenced by slight increases in tensile strength and elongation at break. Both modified films show a markedly lower rate of hydrolytic degradation in freshwater compared to the neat Chit film. In simulated seawater, Chit/HTC-WS and Chit/MCC demonstrate even greater stability, with no observable dissolution after 120 h. In contrast, the unmodified Chit film clearly undergoes hydrolytic degradation, strongly influenced by the surrounding medium: it rapidly disintegrates in freshwater within 120 h, while remaining insoluble in simulated seawater. Furthermore, although the neat Chit film typically disappears within approximately 15 days during soil burial, significantly longer degradation times are required for the Chit/HTC-WS and Chit/MCC films, confirming their enhanced environmental stability.

SO14

Efficient valorization of waste surgical masks for activated carbon-like sorbent production and phthalates analysis in water

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Plastic pollution, exacerbated by the widespread use of personal protective equipment like surgical masks, is a major environmental challenge. These masks, mainly composed of polypropylene (PP), require sustainable disposal and valorization strategies. Concurrently, monitoring phthalic acid esters (PAEs) in water is critical due to their toxicity and migration from plastics. This work proposes upcycling waste masks into a carbon-based sorbent for the solid-phase extraction (SPE) of PAEs. Masks were treated with sulfuric acid at 120 °C to sulfonate and crosslink the PP backbone, enhancing its thermal stability. The material was then calcined under nitrogen flow at 650 °C and mechanically ground. The resulting sorbent was characterized via SEM, TGA, Raman, and FTIR spectroscopy. SPE optimal conditions (sorbent amount, pH, organic modifier, and elution solvent) were systematically evaluated. PAEs from bottled water were quantified via UHPLC-PDA. Characterization confirmed the conversion of PP into an amorphous carbon-like material with preserved fibrous morphology and high thermal stability (>85% residual mass at 900 °C in N2). The optimized SPE procedure utilized 100 mg of sorbent, sample loading at pH 7 with 7.5% v/v acetonitrile, and elution with an acetonitrile/isopropanol mixture. The UHPLC-PDA method exhibited excellent linearity (0.25–1000 ng/mL), low limits of detection (0.003–0.008 ng/mL), and optimal recoveries in bottled water ranging between 95.9% and 104.7%, with enrichment factors up to 156. Solvothermal sulfonation successfully prevented PP thermoplastic softening during calcination, yielding a highly efficient sorbent with strong affinity for PAEs of varying polarities. This simple, low-cost upcycling strategy effectively addresses both the environmental burden of short-cycle PPE plastic waste and the analytical need for sensitive monitoring of chemical contaminants in drinking water, aligning perfectly with circular economy principles.

SO15

CNC-lignin bio-nanocomposites: explosring structure–property relationship for functional biopolymer film

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The growing demand for sustainable materials has driven the development of bio-based nanocomposites as alternatives to fossil-derived plastics. Cellulose nanocrystals (CNC) are promising nanomaterials due to their high crystallinity, mechanical strength, and self-assembly capability. Lignin represents an underutilized aromatic biopolymer with functional properties. This study explores the incorporation of organosolv-fractionated lignin from cardoon waste into CNC matrices to develop sustainable composite films and to evaluate the influence of lignin type on morphology and chemical interactions. CNC were supplied as a gel suspension (7–10 wt% solids) produced by sulfuric acid hydrolysis of wood pulp (CelluRod, Canada). Lignin was extracted from milled cardoon stems (2 mm) via an acid-catalyzed organosolv fractionation process using acetone/water or ethanol/water mixtures acidified with H_2SO_4 (solid-to-liquid ratio 1:10). CNC–lignin nanocomposite films were fabricated by solvent casting, with lignin content at 0.5 or 1.0 wt%. The morphology and dispersion of CNC and lignin were analyzed by TEM and SEM. The self-assembly behavior of the films was investigated using POM. Thermal stability was evaluated by TGA. TEM confirmed the rod-like morphology and high aspect ratio of CNC. The lignin fractions exhibited solvent-dependent morphology: acetone-derived lignin formed spherical particles with heterogeneous sizes, whereas ethanol-derived lignin showed smaller, irregular nanosized particles. Neat CNC films displayed differences in birefringence, with more ordered domains at the edges due to evaporation-induced particle migration. In nanocomposite films, acetone-lignin samples showed heterogeneous textures and uneven surface morphology, while ethanol-lignin films exhibited more continuous birefringent domains and well-defined lamellar stacking, especially at 1.0 wt%. CNC degraded at 273 °C. After incorporation of 0.5 wt% lignin, the Td increased to 279 °C for acetone-fractionated and 281 °C for ethanol-fractionated lignin. The morphological differences highlight the CNC self-assembly and interfacial interactions. The coffee-ring effect explains the structural variation between the center and edge of neat CNC films due to particle migration during solvent evaporation. In nanocomposite films, the smaller particle size and higher hydrophilicity of ethanol-fractionated lignin likely enhance hydrogen bonding and interfacial compatibility with CNC. This promotes more uniform anisotropic domains and improved lamellar organization compared to acetone-derived lignin, which shows weaker interfacial integration and less ordered structures. The shift toward higher Td suggests that lignin improves thermal stability due to its aromatic structure and phenolic hydroxyl groups. The slightly higher Td observed for ethanol-derived lignin may be associated with better dispersion and stronger compatibility with CNC.

SO16

Development of extruded foams from mixed polyolefin recyclates via compatibilization and process optimization

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Within the framework of sustainable plastic waste management, this research evaluates the potential of mixed polyolefins - derived from post-consumer flexible packaging - for the production of extruded foams. By transforming these complex waste streams into 'fit-for-use' materials for rigid foam applications, this functional upcycling approach supports the ambitious 2030 European recycling targets while maximizing added value through cost-effective and low-impact processes. The recycled material (HW Fil-s) was supplied in pellet form by COREPLA, the Italian consortium for plastic packaging recycling. The chemical foaming agent, Ecocell® P, was kindly provided by CONSTAB (Polyolefin Additives GmbH, Germany), a member of the KAFRIT Group (Israel) together with its developer, POLYFIL USA. To enhance the flow properties and melt strength of the recyclate, a ready-to-use masterbatch (Nexamite® R305 by Nexam Chemical) was employed as a compatibilizer. The investigation was conducted in three main phases:

- chemical, thermal, and rheological characterization of the recyclate, with and without the compatibilizer;
- optimization of the formulation and processing conditions (die temperature and extrusion speed) via a Design of Experiments (DOE) approach;
- morphological and mechanical analysis of the resulting foams.

The results demonstrated that the synergy between compatibilization and rigorous extrusion control enables the attainment of significantly reduced density paired with a uniform cellular morphology. The blowing agent concentration was the primary driver for density reduction, consistently yielding weight savings of over 50% compared to the raw recyclate. Specifically, increasing the Ecocell content lowered density values across all tested formulations, with the most pronounced effects observed at low processing speeds. Additionally, the compatibilizer improved melt strength via strain hardening, stabilizing the cellular structure. This led to a more uniform distribution of smaller cells and a superior surface finish, effectively preventing cell rupture during extrusion and ensuring a high-quality final product.

SO17

Synthesis of chiral metal-organic frameworks embedding perovskite nanocrystals for enhanced optoelectronic properties

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Chirality, a fundamental property of asymmetry widely found in nature, has become a key concept in the design of advanced functional materials because exhibit unique properties such as circularly polarized light (CPL) emission, spin-selective charge transport, and enantioselective catalysis, making them attractive for applications in photonics, spintronics, and sensing. Perovskite nanocrystals (PNCs) have recently attracted significant attention because of their outstanding optoelectronic properties (high PLQY, tunable bandgaps, excellent charge-carrier mobility). These characteristics make them promising materials for applications in solar cells, light-emitting diodes, lasers, and photodetectors. However, their practical implementation is still limited by issues such as environmental instability, lead toxicity, and challenges in large-scale production. Metal–Organic Frameworks (MOFs), a class of highly porous and structurally tunable materials, offer an appealing strategy to address these limitations by providing a host matrix capable of stabilizing nanocrystals and introducing additional functionalities such as chirality. In this work, different chiral MOFs systems (ZIF-8, MOF-808, UiO-66) were investigated. The chiral agents are histidine, tartaric acid and proline, respectively. The CsPbBr3 nanocrystals were incorporated within the MOF structure through a modified LARP method. Structural and chemical characterization was carried out using X-ray diffraction (XRD), scanning electron microscopy with energy-dispersive X-ray analysis (SEM-EDX), and Fourier transform infrared spectroscopy (FT-IR) and Brunauer-Emmett-Teller (BET) surface area analysis. Optical properties were investigated through UV-VIS absorption spectroscopy, photoluminescence (PL) spectroscopy and circularly polarized luminescence (CPL) measurements.Structural analyses confirmed the successful formation of the MOF–perovskite composite. XRD and SEM–EDX and BET analysis results demonstrated the incorporation of $CsPbBr_3$ nanocrystals within the MOF framework, while FT-IR spectra verified the presence of the chiral ligand inside the MOF structure. Optical characterization revealed enhanced photoluminescence and the appearance of circularly polarized luminescence signals, indicating that the chiral environment of the MOF influences the optical behavior of the embedded nanocrystals.The observed CPL emission suggests an effective transfer of chirality from the chiral MOF to the $CsPbBr_3$ nanocrystals confined within the framework. The real chirality transfer mechanism is still under investigation. The MOF not only stabilizes the nanocrystals from aqueous but also provides a chiral environment that modulates their optoelectronic properties. This hybrid system demonstrates a promising strategy for combining structural stabilization with chiroptical functionality. The integration of chiral MOFs and perovskite nanocrystals therefore offers a versatile platform for the development of advanced materials for optoelectronic, spintronic, and sensing applications.

SO18

Multi-material 3D printing for external ear reconstruction

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Microtia and trauma are major causes of external ear absence or malformation. Among one million newborns over ten years, 1.46 per 10,000 are affected by microtia, with 22.1% presenting complete anotia. These anomalies have significant physical and psychological impacts. Current reconstruction techniques include autologous rib cartilage grafts, silicone prostheses, and polymeric implants with tissue engineering. Autologous rib cartilage remains the gold standard but requires multiple invasive surgeries and depends heavily on surgical expertise. Silicone prostheses offer simpler solutions but lack durability and require frequent maintenance. Medpor® implants are biocompatible but have mechanical properties different from natural cartilage, leading to complications such as skin laceration and infection. This study proposes a patient-specific approach using a 3D-printed porous scaffold composed of thermoplastic polyurethane (TPU) and polycaprolactone (PCL), based on laser-scanned images of the patient's healthy ear. TPU and PCL were selected for their biocompatibility, non-cytotoxicity, and mechanical properties resembling ear tissues. PCL mimics auricular cartilage, while elastomeric TPU reproduces adipose tissue of the ear lobe. Printing parameters were optimized to obtain suitable scaffold porosity. A laser scanner (Thunk 3D Archer) captured the healthy ear geometry in approximately five minutes, without radiation exposure. The digital model was processed using Autodesk Fusion360® and divided into two regions: ear lobe and base (TPU) and helix, anti-helix, and concha (PCL). Micro-computed tomography (microCT) assessed pore morphology and interconnectivity. Mechanical properties were evaluated using compression and torsion tests at 37°C. Cytotoxicity was tested using L929 fibroblasts and AlamarBlue assays. Cytocompatibility was assessed by culturing chondrocytes on PCL and 3T3-L1 pre-adipocytes on TPU for up to 21 days, analyzing viability, proliferation, morphology, and differentiation. Optimized printing produced accurate filament dimensions, although pore size slightly deviated from the digital model. TPU filaments averaged 330 µm, while PCL averaged 490 µm. Pore sizes averaged 320 µm for TPU and 460 µm for PCL, supporting cell growth with homogeneous interconnection. Compression tests showed TPU was the most flexible, while PCL and the combined scaffold had elastic moduli (~1.4 MPa) comparable to human auricular cartilage. Torsion tests confirmed TPU's flexibility and PCL's higher resistance. Cytotoxicity assays showed excellent cell viability (>70%) for both materials. Adipocytes on TPU displayed increasing viability and lipid droplet formation from day 14. Chondrocytes on PCL showed rising viability until day 7, followed by decline, likely due to limited mechanical stimulation. Live/dead assays confirmed good cytocompatibility. Current reconstruction techniques inadequately replicate natural ear mechanics. The proposed dual-material scaffold successfully mimics physiological mechanical behavior while supporting cell viability and differentiation. This patient-specific 3D-printed approach offers a promising alternative for microtia and anotia reconstruction, potentially improving both aesthetic and functional outcomes.

SO19

3D-printed liquid crystalline elastomers for soft biomedical systems

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Liquid Crystalline Elastomers (LCEs) represent a versatile class of smart materials that combine the anisotropic ordering of liquis crystal phase with elastomers mechanical properties, enabling reversible and programmable shape changing under external stimuli. In this work, we report the fabrication of LCE structures via Direct Ink Writing (DIW), a 3D printing extrusion technique that enables in situ programming of molecular alignment through shear-induced orientation along the printing path. This approach allows precise control over the actuation direction and magnitude. Their ability to directly convert thermal or light energy into mechanical work makes them highly attractive for several fields such as soft robotics, optics devices and biomedical applications, specifically in artificial muscles and cell scaffolding. Inks are synthetized via Michael thiol-acrylate reaction, mixing a diacrylate mesogen (RM82, RM257), a dithiol chain extender and a photo-switch molecule (Disperse Red 1 Acrylate) to provide photoreponsiveness. The LC mixture is printed with Hyrel 3D Engine Standard Resolution in a range of temperature where it showed a nematic phase then cured using a 385nm UV lamp. LCEs thermo-mechanical performances were characterized through Dynamic Mechanical Analysis (DMA) and Differential Scanning Calorimetry (DSC). Finaly, the LCEs were photo-actuated in a homemade set-up with a light source of 470nm (blue light) to measure the tension developed under the light-irradiation. The nematic–isotropic transition temperature of the ink can be tuned by varying the composition of the diacrylate mesogen mixture. The resulting LCEs exhibit typical elastomeric behaviour, with a storage modulus in the MPa range and complete shape recovery upon removal of the applied stimulus. The tension generated during photo-actuation under isometric conditions ranges from 18 kPa to 350 kPa, depending on light intensity and irradiation time, demonstrating the potential of these materials to mimic artificial muscle behavior. Preliminary cell-scaffolding studies were also conducted to evaluate biocompatibility and support cell growth. This study demonstrates how 3D printed Liquid Crystalline Elastomers can be employed in biomedical applications. To date, these results are the first that show photo-actuations of LCE obtained with 3D printing in activation times in the scale of milliseconds, obtaining value of tension developed (kPa) comparable with of those of human myocardium. Moreover, a biocompatibility test was conducted to pave the way for applications in the field of cell scaffolding.

SO20

Mechanosynthesis of macro-mesoporous ZnO-SiO_2 nanocomposites: a green synthetic approach for the preparation of antimicrobial agents

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Recent decades have seen increased concern over microbial infections, especially post-pandemic, highlighting the need for better prevention and control strategies. The scientific community is exploring new antimicrobial materials in response to rising antimicrobial resistance and emerging pathogens. Hence, nanotechnology emerges as a promising field for developing antimicrobial agents, either inorganic ones such as metal nanoparticles (e.g., silver, zinc, copper, or gold), or hybrid organic-inorganic nanomaterials. They can provide a wide spectrum of antimicrobial activity, tackling antibiotic resistance. A way of enhancing their efficacy, biocompatibility, and application range is to incorporate these antimicrobial agents into composite matrices like mesoporous silica, whose ordered and tunable mesoporous structure, as well as high surface area, make it a promising material for this scope. Overcoming the conventional synthesis methods, this research aims to prepare a ZnO-SiO2 nanocomposite with an easy, rapid, and sustainable synthetic approach via mechanochemistry. Experiments were performed with a planetary mill, obtaining a silica-based porous material incorporating zinc oxide nanoparticles by using a two-step strategy or a one-pot strategy. Structural, morphological, thermal, and textural characterizations were performed using X-ray powder diffraction, transmission electron microscopy, thermogravimetric, and nitrogen physisorption analysis. Although both materials were silica-based macro-mesoporous systems, they exhibited notable differences in structural organization, dopant dispersion, and morphological characteristics. Despite these differences, both nanocomposites demonstrated effective antimicrobial and antiviral activity, confirming the successful integration and functional performance of zinc oxide within the macro-mesoporous silica framework. These findings highlight mechanochemistry as a promising and sustainable approach for the preparation of advanced antimicrobial agents with potential applications in healthcare, surface coating, and environmental protection. In this regard, these nanocomposites have been incorporated into mixed-matrix membranes for the development of smart antimicrobial face masks.

SO21

Beyond hardness: balancing mechanical, tribological and corrosion properties of electroless Ni-P-ZrO_2 nanocomposite coatings via controlled annealing

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High-P electroless Ni–P coatings are widely used in the energy production sector to protect steel components against corrosion and wear. Their performance can be enhanced by (i) heat treatment and (ii) incorporation of functional second-phase particles. Although annealing increases hardness, crystallization may compromise corrosion resistance and fracture toughness. To address these trade-offs, this study investigates High-P Ni–P coatings reinforced with ZrO_2 nanoparticles and subjected to different annealing schedules, to identify conditions where nanoparticle and thermal-treatment act synergistically to maximize performance. High-phosphorus Ni–P–ZrO_2 nanocomposite coatings were deposited on steel substrates via electroless plating. The quantity of ZrO_2 nanoparticles was systematically optimized by varying their concentration in solution (4.5, 7, 13.5 and 18 g/L). Post-deposition annealing was performed at two temperatures: the conventional 400 °C for 0.5, 1, 2 and 4 h, and the near-crystallization 340 °C for 1, 2, 4, 6 and 8 h, resulting in nine time-temperature schedules applied to both standard and optimized nanocomposite coatings. Microstructural evolution was analyzed via XRD and SEM/EDS. Functional properties were assessed using Vickers microhardness and instrumented indentation for hardness and fracture toughness (Kc), ball-on-disk tribometry for wear behavior and potentiodynamic-polarization for corrosion resistance. Higher hardness improvement was achieved introducing 13.5 g/l of ZrO_2. Annealing at 400°C promoted rapid crystallization and grain coarsening, whereas 340°C led to slower transformation kinetics and a finer nanocrystalline matrix. Hardness increased for all annealed coatings, with peak values at 400 °C/1 h and 340 °C/8 h (≈80% higher than unreinforced Ni–P). Importantly, the 340 °C/8 h condition preserved significantly higher fracture toughness (2.11 $MPa \cdot m^{0.5}$) than the conventional 400 °C/1 h treatment (1.23 $MPa \cdot m^{0.5}$). The lowest friction coefficient was observed after 400°C/1 h, while 340 °C/8 h provided superior wear resistance. Corrosion resistance improved after annealing, providing both higher Ecorr and lower Icorr. ZrO_2 nanoparticles improved hardness and KI through dispersion hardening and crack deflection. These are further enhanced by 340°C/8h annealing, which promotes slower transformation kinetics compared to 400°C/1h, yielding finer nanocrystalline matrix with slow-growing Ni_3P precipitates. The superior wear resistance of the 340°C/8 h samples suggests that performance is not governed by hardness alone, but by a synergistic balance of hardness, elastic compliance and fracture toughness. Furthermore, both nanoparticle incorporation and thermal-treatment improve corrosion resistance due to the chemical inertness of particles and the formation of a protective NiO film. Consequently, the 340°C/8h schedule represents the best processing strategy for demanding engineering applications.

SO22

Process parameter optimization and mechanical reliability of polypropylene in fused filament fabrication

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Polypropylene (PP) is an attractive material for additive manufacturing due to its low density, chemical resistance, toughness, and cost-effectiveness. Nevertheless, its application in Fused Filament Fabrication (FFF) is still limited by severe processing issues, including shrinkage, warpage, and weak interlayer adhesion, which result in poor dimensional stability and anisotropic mechanical properties. While individual printing parameters are known to influence PP performance, their combined and non-linear effects remain insufficiently understood. Moreover, the lack of standardized specimen preparation methods often compromises the reproducibility of mechanical characterization. This work addresses these limitations by combining a statistically driven optimization of FFF process parameters with an alternative and more reliable approach to tensile specimen fabrication. Commercial polypropylene filament was processed via FFF using a desktop industrial-grade printer. The influence of nozzle temperature, nozzle diameter, and layer height on tensile properties was systematically investigated through a Response Surface Methodology (RSM) design of experiments. Layer height was scaled proportionally to nozzle diameter to ensure realistic and printable configurations. Instead of directly printing dogbone specimens - which are highly susceptible to warpage and interlayer defects - rectangular boxes were fabricated and subsequently die-cut into standardized tensile specimens. This strategy minimized thermal stresses during printing and ensured homogeneous material distribution. Tensile tests were performed along directions parallel and perpendicular to the deposition path to evaluate mechanical anisotropy. The results reveal a strong interaction between nozzle temperature and geometrical printing parameters, significantly affecting elastic modulus, tensile strength, and strain at break. Higher nozzle temperatures promoted improved interlayer bonding, while excessive layer heights led to reduced mechanical performance due to incomplete fusion. The proposed specimen preparation method yielded mechanically consistent samples with reduced scatter compared to conventionally printed dogbones, enabling a more robust assessment of process–property relationships. RSM analysis identified a well-defined processing window that maximizes stiffness while preserving ductility. This study demonstrates that reliable mechanical performance of PP in FFF can be achieved through combined process optimization and appropriate specimen design. The novelty of the work lies in coupling RSM-based parameter optimization with an alternative tensile specimen preparation route that overcomes common limitations in PP printing. The findings provide practical guidelines for enhancing the mechanical reliability of FFF-printed PP and support its broader adoption in applications such as automotive components, packaging, and consumer goods.

SO23

Sustainable soybean oil-based 3D-printed conductive composites filled with recycled carbon fibers derived from prepreg waste

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Additive manufacturing (AM) technologies are increasingly recognized as environmentally friendly production methods due to their high precision, reduced material consumption, and minimal waste generation. Among these, vat photopolymerization (VPP) enables the fabrication of complex geometries with excellent dimensional accuracy through the layer-by-layer UV curing of liquid photo-curable materials. In parallel, the growing demand for sustainable manufacturing has driven the development of bio-based polymers and related composites modified with sustainable fillers. In this framework, the incorporation of recycled carbon fibers (rCFs), derived from pre-impregnated fibers, into photocurable matrices represents a promising strategy to enhance conductive properties while promoting circular economy principles. However, the limited availability of sustainable photocurable resins suitable for VPP remains a key challenge. This study addresses this limitation by developing novel sustainable polymer composites filled with rCFs, successfully processed via digital light processing (DLP) 3D printing, demonstrating their potential for high-performance and sustainable AM applications. The composites were prepared by incorporating different contents of rCFs. rCFs were obtained by mechanical recycling of prepreg scrap, and they were shorter than the originals. These were dispersed in a photopolymerizable acrylate epoxidized soybean oil (AESO) resin. Two reactive diluents, tetrahydrofurfuryl acrylate (THFA) and isobornyl methacrylate (IBOMA), were added to optimize the rheological properties of the photocurable resin, maintaining an AESO/diluent weight ratio of 60:40 and using 2 phr of the radical photoinitiator phenyl bis(2,4,6-trimethylbenzoyl) phosphine oxide (BAPO). Different mixing methods were explored to achieve effective dispersion and distribution of rCFs within the organic matrix. Various characterizations were carried out on the system to assess their rheological, morphological, mechanical, thermal, conductive, and viscoelastic properties. The choice of reactive diluent had a significant impact on the final composite properties: IBOMA led to stiffer and mechanically robust materials, whereas THFA yielded more flexible and deformable systems. Although the percolation threshold was similar for both systems, the conductivity values obtained above this threshold showed significant differences depending on the diluent; in particular, the A-TH formulation exhibited systematically higher conductivity values than the A-IB formulation. In conclusion, the developed AESO-based conductive composites demonstrated that material properties can be effectively tailored through the combined selection of reactive diluents and the incorporation of rCFs. This approach not only enables performance optimization but also supports the development of more sustainable and environmentally friendly composite systems through the use of green and sustainable technologies.

SO24

Natural fillers as alternatives to glass fibers in PA6-based composites for large-format additive manufacturing

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In recent years numerous industries, in the polymer field, have increasingly adopted Large-Format Additive Manufacturing (LFAM) to facilitate cost-effective mass customization and the production of structurally robust, large-scale components for aerospace, automotive, energy and buildings applications. Among engineering polymers suitable for LFAM, glass fibers (GF)-reinforced thermoplastic composites are widely employed in pellet-fed extrusion systems, providing excellent performance. However, the extensive use of GF presents several drawbacks, including increased material density, high processing energy, elevated nozzle wear, limited recyclability, and sustainability concerns. This study systematically investigates the potential of natural fillers – including montmorillonite, calcium carbonate and silica – as alternative reinforcement for PA6-based composited in LFAM applications. Three different PA6-based composites were produced by melt-compounding at 235 °C. Specifically, formulations containing 10 wt% of organo-modified clay, 10 wt% calcium carbonate and 5 wt% of organo-modified silica were developed and compared with a conventional 30 wt% GF-reinforced PA6 system from rheological, morphological and thermo-mechanical perspectives. From rheological analysis, GF-reinforced samples showed the highest viscosity and lowest melt flow index due to the combined effect of high fiber aspect ratio and high filler loading. Clay and silica also displayed an increase in melt viscosity as a result of their agglomerated morphology and higher particle size, whereas calcium carbonate showed a limited effect on rheological properties due the smaller particle size. TGA and DSC analysis revealed that the thermal decomposition and melting behavior of the samples were not significantly affected by the filler addition, with variations observed only in the residual mass at 700 °C (due to filler content) and in the slight increase in crystallinity due to nucleating effect of the filler. The selected compositions were used for preliminarily print LFAM components. Qualitative and morphological analysis revealed a good filler dispersion of natural-reinforced composites and better printing quality compared to GF-reinforced sample. Flexural tests showed that silica and calcium carbonate could provide a more balanced mechanical response both parallelly and perpendicularly to the printing direction, thereby reducing anisotropy. These results are especially promising considering that the natural fillers were used at significantly lower loadings (≤ 10 wt%) compared to the 30 wt% glass fibers reference, yet they were still able to provide competitive mechanical performance. This highlights the potential of selected natural fillers as viable and lightweight alternative to conventional GF reinforcement in LFAM applications. Acknowledgments: This work is conducted inside the MAGRITTE project, financed under the LP6/2023 by the Autonomous Province of Trento with determination no. 562 of 17 October 2024 of the Director of the Facilitation and Economic Incentives Service.

SO25

Morphology-driven and surface hydrophilicity effects in plasmonic humidity sensors

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Plasmonic nanoparticles are extremely sensitive to changes in the local refractive index, making them promising platforms for humidity sensing. In this work, we investigate how nanoparticle morphology and surface hydrophilicity influence the plasmon resonance (LSPR) response of silver nanostructures exposed to water vapor. Silver nanoplates (Ag NPTs) grafted onto transparent substrates are studied to identify strategies for enhancing plasmonic humidity sensor performance through surface engineering. Ag NPTs were synthesized via a seed-mediated method and chemically immobilized on APTES-functionalized glass. Surface wettability was tuned through functionalization with different thiols (4-MBA, 11-MUA, 1-UDT, and benzyl mercaptan), covering a broad hydrophilicity range. Optical measurements were performed in situ in a vacuum chamber with controlled water vapor dosing, recording UV–Vis extinction spectra during adsorption/desorption cycles. Contact angle measurements quantified surface hydrophilicity. Finite-Difference Time-Domain simulations were used to model near-field enhancement, estimate plasmonic decay length, and correlate LSPR shifts with the thickness of the adsorbed water layer. All samples exhibited reversible LSPR shifts upon water vapor exposure. Ag NPTs showed significantly higher sensitivity than nanospheres, confirming the key role of morphology. Among functionalized nanoplates, 4-MBA produced the largest redshift (~15 nm), while benzyl mercaptan induced the smallest (~3 nm). Contact angle values ranged from ~56° for hydrophilic surfaces to ~86° for hydrophobic ones. Although refractive-index sensitivity slightly decreased after functionalization, humidity response strongly correlated with wettability: more hydrophilic surfaces promoted thicker adsorbed water layers (≈0.96 nm versus ≈0.22 nm). Simulations yielded a plasmonic decay length of ~8.8 nm, supporting the experimental estimation of water film thickness. The results demonstrate the interplay between morphology and surface chemistry in plasmonic humidity sensing. The sharp edges of Ag NPTs enhance near-field confinement, while polar thiol monolayers increase water adsorption, amplifying the plasmonic response. In contrast, hydrophobic ligands act as dielectric spacers that limit field–environment interaction. This combined experimental–numerical approach provides clear guidelines for optimizing LSPR-based humidity sensors through controlled nanoparticle geometry and tunable surface hydrophilicity.

SO26

Designing chemically stable photoanodes heterostructures for efficient solar to energy conversion in neutral electrolyte

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Designing chemically robust photoanodes capable of efficient oxygen evolution reaction (OER) in neutral media remains a central challenge for practical photoelectrochemical (PEC) water splitting applications. This work reports the design, synthesis, mechanistic elucidation, and DFT theoretical validation of a robust S-scheme $SnSe_2/TiO_2$ heterostructure photoanode, capable of driving the oxygen evolution reaction (OER) in neutral electrolyte, with excellent stability under prolonged solar light illumination. Highly crystalline $SnSe_2$ nanosheets were solvothermally grown over (110)-oriented mesoporous sol-gel prepared TiO_2 films, forming a layered $SnSe_2/TiO_2$ heterojunction, with efficient carrier transport and strong interfacial adhesion, solving the common delamination problem of $2D/TiO_2$ systems. The mesoporous TiO_2 framework (2-20 nm pore size) provides high surface area and nucleation sites that promote uniform $SnSe_2$ (1.8 ± 0.1 μm lateral size and 100 ± 5 nm thickness) nanoplatelets growth, yielding a homogeneous distribution of SnSe2 nanoplatelets, covering 8.1 ± 0.5% of the underlying TiO_2 surface. The final $SnSe_2/TiO_2$ heterostructure exhibits precise microstructural features, well-defined chemical composition, and clearly identified crystalline structures as demonstrated by AFM, SEM, XRD and XPS analysis. Under solar illumination, the $SnSe_2/TiO_2$ photoanode delivers a 16-fold higher current density than its single counterparts (0.80 mA cm^{-2} at 2.0 V vs RHE), together with excellent operational stability (<3% decay over 3 × 48 h continuous irradiation). Combining Mott–Schottky, valence-band XPS, and optical bandgap measurements with density functional theory (DFT), we reconstruct a defect-driven S-scheme charge-transfer mechanism, where oxygen vacancies in (110) TiO_2 shift band edges to promote selective electron–hole recombination at the interface. Finally, differential free adsorption energies calculations of the four OER intermediates over oxygen defective (110) TiO_2, indicate the OH* → O* transition as the potential-determining step. We established that the solvothermal growth route enables the formation of a uniform, strongly adhered $SnSe_2/TiO_2$ heterointerface, where mesoporous TiO_2 provides both high surface area and structurally defined sites that promote the growth of well-oriented 2D $SnSe_2$ nanoplatelets. This engineered laminar-interface results in efficient charge separation, enhanced visible-light absorption, and significantly improved PEC performance compared to the individual components. These results establish $SnSe_2/TiO_2$ as a stable, visible-light-responsive S-scheme heterostructure for neutral-pH OER, broadening the OER applications of group-IV chalcogenides MX2 (M = Sn, Ge; X = S, Se, Te)/TiO_2 photoanodes for solar water oxidation in neutral electrolytes.

SO27

Long-term outdoor performance of phase change material and expanded graphite composites for passive photovoltaic cooling

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Photovoltaic (PV) technology is a cornerstone of the global energy transition, experiencing exponential growth as a sustainable power source. However, PV systems suffer from significant efficiency degradation as operating temperatures rise. An emerging strategy for the passive thermal management of PV cells involves the integration of organic Phase Change Materials (PCM). These materials utilize their latent heat of fusion to absorb excess thermal energy during liquefaction. Despite their potential, the practical application of PCMs is often hindered by the risk of leakage during the liquid phase and their inherently low thermal conductivity. In this study, both challenges were addressed through the development of shape-stabilized PCM composites using Expanded Graphite (EG) as a conductive supporting matrix. Organic PCMs (paraffins, fatty acids, and fatty alcohols) with melting temperatures (T_m) of 25–50 °C were vacuum-impregnated into EG (10–13 wt.%). Following impregnation, cold compaction produced structural, heat-absorbing panels. These were configured into single, double, and triple-layer assemblies coupled to silicon PV mini-modules. Systems were monitored under continuous outdoor solar exposure for a full year (March 2025 – April 2026) to evaluate thermal behavior and resulting electrical performance. The resulting composite materials exhibit up to a 30-fold increase in thermal conductivity compared to neat PCMs while maintaining high latent heat capacities (150–220 J/g). Outdoor testing under real-world solar exposure demonstrated thermal mitigations of up to 40 °C, with cooling effects persisting from several hours to the entire day. Comprehensive comparative analysis reveals that the optimized triple-layer paraffin configuration, featuring a melting temperature of approximately 30 °C, can achieve a 10% net energy gain over the entire season. This combination of enhanced thermal transport and high energy density represents a superior approach for passive thermal management in PV applications. Furthermore, these composites demonstrated exceptional long-term reliability, opening promising new horizons for the integration of PCMs and the advancement of high-efficiency PV devices.

SO28

Highly stable MAPbI3 films by combining dicationic spacers and polymeric scaffolds in low-D/3D heterostructures

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Methylammonium lead iodide ($MAPbI_3$) has emerged as a frontline material for next-generation photovoltaics with high power conversion efficiencies. However, its susceptibility to thermal degradation and moisture remains a critical bottleneck for large-scale commercialization. One promising strategy for enhancing the operational longevity of $MAPbI_3$ active layers relies on the integration of Large Organic Cations (LOCs) within the perovskite domains and the usage of polymeric scaffolds. Deciphering the synergy between these additives and the perovskite framework is crucial not only to uncover the fundamental degradation pathways they inhibit, but also to clarify how these modifiers preserve photovoltaic performance. In this work we explore the $MAPbI_3$ films stability upon incorporation of dicationic spacers and polymers through a rigorous characterization of structural and morphological evolution during accelerated aging protocols. Dicationic spacers such as p-xylylenediammonium (XDA^{2+}), 1,3-bis(ammoniummethyl)cyclohexane (H_2BAC^{2+}) and cornstarch (up to 20 mol% LOCs, 5% w/w starch) were incorporated into spin-coated $MAPbI_3$ films. In-situ characterization was performed via synchrotron GIWAXS (XRD1@Elettra) and XRPD, utilizing a custom-integrated Anton-Paar DCS 500 chamber. This setup allowed for in-situ monitoring under carefully modulated thermal and humidity conditions (10–90% RH) to track the real-time evolution of the low-D/3D heterostructures. Absorption and emission properties in the UV/Vis/NIR range were also determined. At 90% RH, XDA^{2+} forms a protective hydrated perovskitoid phase that inhibits PbI_2 growth; GIWAXS confirms its incorporation into the 3D lattice, stabilizing the tetragonal phase. Conversely, H_2BAC^{2+} prevents PbI_2 formation for over five weeks at ambient conditions, highlighting the different behavior of the two cations. In both cases, the addition of starch enhances environmental stability. The progressive broadening of XRPD peaks, correlated with XDA^{2+} and H_2BAC^{2+} loading, indicates a concentration-dependent increase in lattice microstrain, confirming the successful incorporation of these dications into the perovskite framework. Such inclusion apparently inhibits defect migration and prevents the nucleation of degradation by-products. Notably, hybrid formulations containing both starch and dicationic spacers exhibit superior stability compared to samples utilizing either additive alone. This suggests a synergistic effect, where the polymeric matrix templates a favorable orientation of protective low-D phases, efficiently shielding the 3D framework.

SO29

Sustainable hydrogel-based films from marine biopolymers: processing, properties, and packaging performance

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Alginate and κ-carrageenan, derived from algae, and gelatin extracted from fish skin, are valuable marine-based biopolymers widely used in the food, cosmetic, and pharmaceutical industries due to their non-toxicity, biocompatibility, and biodegradability. Moreover, in recent years, gelatin-based materials have attracted increasing attention because of their high availability. However, poor mechanical properties and low thermal stability of neat gelatin significantly limit its application in food packaging. To overcome these drawbacks, growing research efforts have focused on improving the performance and stability of gelatin by combining it with anionic polysaccharides, such as alginate and κ-carrageenan, which interact with the cationic domain of gelatin molecules. Alginate, κ-carrageenan, and gelatin have been combined in various ratios to develop bioprintable solutions. The optimal printable formulations were also used to manufacture films by solvent casting, demonstrating that the same solution type can be used for different structural materials via different manufacturing methods. N-(3-Dimethylaminopropyl)-N'-ethylcarbodiimide and NHS (N-Hydroxysuccinimide) mixtures were used as crosslinkers to further stabilize the structures and form materials with desirable physicochemical properties. Characterization of the final materials, including morphological, swelling, mechanical, and vapour permeability analyses, was conducted to assess their potential food packaging applications. Alginate, κ-carrageenan, and gelatin were crosslinked with EDC/NHS to obtain hydrogel-based films. SEM analysis revealed compact rough surfaces, while FTIR confirmed successful interaction among the three components and the absence of new functional groups. The formed hydrogels are stable in water and can increase their initial weight by about 30 times and their volume by about 60 times. Mechanical properties analyses indicate that the compressive modulus of the crosslinked samples ranges from 7 to 23 kPa, whereas their Young's Modulus is lower than that of the non-crosslinked samples (from 1000 to 2500 MPa) with a higher elongation (from 8% to 3%). The Water Vapour Transmission Rate ranges from 2800 to 4200 g/(m^2*day). Morphological, spectroscopic, and mechanical tests confirm the quality of blending and crosslinking; the surface compactness is due to the crosslinking effect, and a decrease in the FTIR peaks of the crosslinked functional groups occurred, while the crosslinked samples' mechanical properties are similar to those of HDPE. The swelling value and water stability tests suggest a robust structure with very high volume expansion, bigger than that of the individual components. Finally, vapour permeation tests indicate that the developed materials provide the right level of breathability for fruits and vegetables.

SO30

Metal oxides-modified cellulose-based adsorbents for synergic adsorption and photocatalysis processes towards efficient water treatment

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The development of efficient and sustainable strategies for water remediation is a pressing global need. Adsorption has grabbed the attention as a versatile, cost-effective option for relatively effortless large-scale water treatment. Conventional adsorbents like activated carbons, characterized by high surface area, durability and high porosity require costly synthetic procedure and show challenging regeneration. Recently cellulose-based adsorbents represent an eco-friendly alternative addressing environmental concerns. However, their high performances in the removal of cationic dyes are limited in the case of anionic dyes. To fill this gap, here, cellulose-based adsorbents modified with metal oxides nanophotocatalysts are developed towards water treatment processes that synergistically combined adsorption and photocatalysis for efficient pollutants removal. Colloidal metal oxides nanoparticles, including TiO2 and CeO2, were synthesized by exploiting water-based procedures at low temperature. Cellulose-based adsorbents were prepared from carboxymethyl cellulose or cellulose fibrils and citric acid, used as cross-linking agent. Nanoparticles colloidal solutions were added to the reaction mixture for nanocomposites fabrication. Optical, structural, morphological properties of adsorbents, nanoparticles and composites were monitored. Adsorption and/or photocatalysis of the composites and each component were spectrophotometrically investigated using cationic and anionic dyes as model pollutants under selected pH condition. Adsorption isotherms and kinetic studies were performed as well as photocatalytic experiments to determine dyes removal performances. Cellulose-based adsorbents showed fast adsorption of cationic dyes, following Langmuir model, with kinetics fitted with the pseudo-second order model. Poor adsorption of anionic dyes like Methyl Orange was demonstrated. After testing the photocatalytic activity of TiO2 and CeO2 nanoparticles towards different dyes, cellulose-based composites, obtained by adding nanoparticles at different loading to the cellulose adsorbent reaction mixture have been prepared. Homogenous nanoparticle dispersions have been obtained by sonication. Nanocomposites confirm their transparency in the visible range, allowing prompt spectrophotometric characterization. They show fast adsorption of cationic dyes and concomitant photocatalytic decolouration of anion dye in solution upon light irradiation, also demonstrated for dyes mixture. The results demonstrate that cellulose-based adsorbents are efficient in the fast adsorption of cationic dye thanks to robust electrostatic interactions among dye and abundant surface hydroxyl and carboxylic groups of cellulose. The poor removal of anionic dyes by these adsorbents is addressed by combining them with photocatalytic nanoparticles, able to remove anionic dyes through photoactivated photocatalysis. The resulting composite shows adsorption performances of the cellulose-based adsorbent with the photocatalytic activity of the metal oxide nanoparticles for effective dyes romaval from aqueous medium.

SO31

Blends of poly(butylene succinate) and poly(butylene furanoate): compatibilization by equimolar block P(BF-*b*-BS) and random P(BF-*co*-BS) copolymers

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Biopolymers, which are sourced from renewable bio-based chemical building blocks and are or not biodegradable, have become promising sustainable alternatives to traditional plastics in various fields. Nonetheless, challenges such as brittleness, high costs, and limited processability have limited their broad use. Blending is an effective method to merge the advantages of different polymers and address these issues. In this view, blends based on poly(butylene succinate) (PBS) and poly(butylene furanoate) (PBF) have been compatibilized by melt mixing the homopolymers with different amount of equimolar block or random copolymers of PBS and PBF with the main aim of tuning their mechanical behaviour (from stiff/high-strength typical of PBS to flexible of PBF), by mantaining at the same time outstanding barrier properties. Poly(butylene furanoate) (PBF) was synthesised by two-stage bulk polycondensation, starting from the dimethyl ester of 2,5-furandicarboxylic acid, 1,4-butanediol (BD) and the catalyst, titanium (IV) tetrabutoxide (TBT). A random copolymer (COr) poly(butylene furanoate/succinate), P(BF-co-BS) was also synthesised by two-stage bulk polycondensation starting from DMF and dimethyl succinate (DMS), in the appropriate molar ratio, 1,4-butanediol (BD), in a molar excess of 30% with respect to the total moles of the two diesters, and the catalyst, TBT. A poly(butylene furanoate-b-succinate) block copolymer, P(BF-b-BS) (Cob), was synthesised from the previously synthesised PBF and a commercial high molecular weight poly(butylene succinate) by reactive blending at high temperature (225°C) for short mixing time. Blends at different weight amounts PBF:PBS were prepared (75:25, 50:50, 25:75) and the effect of copolymer addition on mechanical, thermal and barrier to oxygen behaviour of cast extruded films was studied. In this research, we explored the combination of the favourable thermo-mechanical properties of PBS with the excellent barrier properties and elastic behavior of PBF, both polymers being fully biobased. The addition of block or random copolymer to the blend improved the compatibility, the final functional properties depending on the blend composition, molecular architecture and amount of copolymer added as compatibilizer.

SO32

A water-based synthetic route to the metal-organic framework UiO-66 starting from pet derived terephthalate esters

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The Zr-terephthalate MOF UiO-66 was discovered in 2008, and it has rapidly become a benchmark, owing to its high thermal, chemical and mechanical stability. UiO-66 is typically prepared by solvothermal synthesis in N,N-dimethylformamide (DMF), which is also involved in the workup stage. This is necessary because of the limited solubility of terephthalic acid in the most common organic solvents and in water. The use of DMF is one of the major drawbacks for the transfer of UiO-66 in applications since DMF is flammable, toxic and teratogenic. Furthermore, DMF has a high boiling point (153 °C), and its removal from the product requires many washes with more volatile organic solvents, like methanol, or water. Besides this, the European Commission has recently proposed to restrict the industrial use of DMF because of its toxicity. Thus, the development of a DMF-free process to synthesise and purify UiO-66 is a topic of interest to enable commercial deployment of this MOF. In this work, we propose a water-based route to synthesise UiO-66 through the in situ hydrolysis of terephthalate esters obtainable from the chemical recycling of waste polyethyleneterephthalate as precursors of the linker. $ZrOCl_2{\cdot}8H_2O$ was used as ZrIV precursor. Dimethylterephthalate and bis(2-hydroxyethyl)terephthalate were employed as sources of the linker. Hydrochloric acid and acetic acid were used as modulators during the synthesis to control the kinetics of ester hydrolysis and MOF crystallisation. The products were characterised by powder X-ray diffraction, thermogravimetric analysis, gas sorption analysis, and nuclear magnetic resonance spectroscopy. A chemometric design of experiments was employed to optimise the reaction parameters, finding that 15 molar equivalents of hydrochloric acid enable hydrolysis without inhibiting crystallisation, while acetic acid controls which phase is obtained, favouring the desired fcu topology at 15 molar equivalents. The optimised conditions afford UiO-66 with high crystallinity and porosity in just 2 hours at 90 °C. A crucial role in the process is played by the monoester, which is more soluble than both the diester and the diacid in the reaction environment and can be involved in the formation of secondary building units. We also developed a DMF-free workup protocol based on the use of ethanol/dimethylsulfoxide mixtures and water. 50-fold scale up (500 mL) was demonstrated using a round bottom flask, producing UiO-66 with properties comparable to the product of the small-scale synthesis and with a space-time yield > 200 kg m-3 d-1.

SO33

Double-layered superhydrophobic coating for personalized bioleather in a closed-loop circular economy perspective

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Bacterial cellulose is a by-product of kombucha fermentation, which uses tea infusions. This biopolymer is employed in 3D-printed leather alternatives that face issues with adhesion between the printed personalization and the substrate, as well as moisture sensitivity. Nowadays, adhesion is improved through post-processing coatings with synthetic chemicals, limiting environmental benefits. Moreover, although innovation on bio-based hydrophobic coatings is scarce, lignin offers a bio-based route to water-repellent surfaces. We propose a double-layer coating: a gelatin-based primer to enhance adhesion of printed personalization, followed by a superhydrophobic topcoat of beeswax and lignin extracted from spent tea waste produced during bacterial cellulose biosynthesis. A gelatin–glycerol coating (1:1.2 ratio) was applied to the personalized sheet by dip coating. Lignin was extracted from spent tea using organosolv process. The lignin-beeswax (1:2 ratio) coating was applied by spray coating with hexane as the solvent. To assess the adhesion durability of the printed personalization on the bio-leather sheet, both static and dynamic adhesion tests were performed. Surface wettability measurements and tensile tests were carried out under both dry and wet conditions, comparing three material configurations: uncoated samples, samples coated with beeswax only, and samples coated with a beeswax–lignin formulation. The gelatin-based formulation doubled the static adhesion strength from 8 N to 16 N. During the torsion tests, the 3D-printed customization without the gelatin coating withstood approximately 170 cycles, whereas the gelatin-coated samples resisted up to 1000 cycles. Lignin extraction from spent tea yielded about 10% with particle sizes of about 10 µm. The beeswax-only coating exhibited contact angles of approximately 110°, while the beeswax-lignin coating reached values within the superhydrophobic range (160°). Finally, tensile tests performed in both dry and wet conditions showed improved mechanical performance for samples coated with beeswax and lignin compared with those coated with beeswax only. The significant increase in both static and dynamic strength of the 3D-printed customization bonded to the bio-leather substrate indicates that gelatin coating applied after printing likely filled interfacial defects and homogenized the substrate–customization interface, improving load transfer and adhesion durability. Finally, both water contact angle measurements and tensile mechanical tests showed that lignin provides a stronger moisture barrier than beeswax alone, thereby enhancing the material's resistance to water and humidity. Overall, this project aims to support the fashion industry's transition toward a more sustainable future by enabling the development of next-generation materials with improved performance and durability. This study was carried out within the MICS (Made in Italy–Circular and Sustainable) Extended Partnership and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR)–MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.3–D.D. 1551.11-10-2022, PE00000004). This manuscript reflects only the authors' views and opinions; neither the European Union nor the European Commission can be considered responsible for them.

SO34

Textile recycle to fibers

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The aim of the project is therefore to reuse textile waste in order to obtain a secondary raw material, cellulose acetate, with high commercial value capable of having the physical-chemical properties required by the market. Industrially, the acetylation of cellulose is carried out in a heterogeneous phase, using acetic acid as a reaction medium, acetic anhydride as an acetylating agent and sulfuric acid as a catalyst, starting from lignocellulose and cellulose pulp. Starting from textile waste, i.e. mostly cotton, led to the need to change the approach, opting for a homogeneous phase process that involves the solubilization of cellulose in a low-melting ionic solvent, but with high thermal stability, which also plays the role of reaction medium, favouring acetylation without the use of catalysts using acetic anhydride as the acetylating agent. To solubilize the cotton, 1-allyl-3-methylimidazolium chloride was used, synthesized from 1- methylimidazolium and 98% allyl chloride. Acetic anhydride 98% was used as the acetylating agent. The ionic liquid was synthesized by mixing 1-methylimidazole and allyl chloride under inert reflux, stirred at 55°C for 8 hours, and then purified by vacuum distillation. The cotton was then solubilized at 80°C and reacted with acetic anhydride at 80°C for various times and precipitated by the addition of water. The ionic liquid was successfully synthesized and separated. The acetylation of cellulose in the homogeneous phase, as seen in the literature, is feasible, and optimizations are underway regarding time and temperature due to the different starting matrix compared to what is reported in published studies. For example, the presence of degradation products is found using the times reported for cellulose because cotton has a higher degree of crystallinity and therefore greater reactivity. The reusability of the ionic liquid and the absence of acids in the process allow for virtually infinite recirculation, minimizing waste. Homogeneous acetylation allows for the synthesis of disubstituted cellulose acetate, unlike heterogeneous acetylation, which produces trisubstituted acetate that must then be hydrolyzed, creating a higher-value product with fewer steps. Considering the process as a whole, it has a lower environmental impact thanks to the absence of acids and the use of non-toxic and regenerable substances such as the ionic liquid and water, used to precipitate the final product.

SO35

True-to-life microplastics as carriers of co-contamination and their solvent free removal from aquatic systems

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Microplastic pollution is one of the most discussed environmental issues. The scarcity of information regarding the properties of real microplastics in aquatic systems and their interactions with other pollutants remains a significant challenge, making it vitally important to find methods for their efficient and effective removal. True-to-life microplastics were obtained by subjecting polypropylene (PP) pasta bags to accelerated aging and mechanical fragmentation, typical environmental conditions of improperly managed and/or disposed plastic waste. The microplastics produced were analyzed at a morphological and physico-chemical level, and their interaction with pharmaceutical pollutants typically found in aquatic environments was evaluated. Subsequently, a 3D PP fibrous filter, bio-inspired, was created. The fluff was produced by combining a melt-spinning process and a vortex motion field in simple distilled water. The efficiency of microplastic removal (RE) was evaluated over multiple cycles of use. The photo-oxidation process caused a change in the properties of PP films, resulting in increased hydrophilicity, cristallinity and density, and a loss of mechanical properties. The latter aspect allowed rapid fragmentation of the film, resulting in a wide range of particle dimensions, from nano to micro-sized. Microplastics showed a high level of interaction with pharmaceuticals in water, acting as a vector for pollutants. The fluff presents a spherical, fibrous, and homogeneous structure, comparable to Posidonia oceanica Egagropiles (EGs), well known for their ability to trap microplastics from the sea. The filtration system designed presents porous structure and high SSA, and it has achieved RE values >99% for up to 10 cycles of reuse. The change in properties caused by the photo-oxidative process generates a change in the behavior of microplastics: their higher density will cause changes in their settling behaviour in water, and the new functional groups, as well as the increase in hydrophilicity, increase the particles ability to adsorb pharmaceuticals. This condition must be taken into account, as it can generate co-toxicity in vitro and in vivo systems. However, the possibility of predicting this interaction could make microplastics effective sorbents for pollutants. The fluff produced has a fibrous structure suitable for a filtering system, and the possibility of obtaining it by a solvent-free process makes it a good candidate in the field of environmental sustainability. The fluff is able to effectively block particles for multiple cycles of use, maintaining high performance, especially for larger particles. Finanziato dall'Unione Europea - Next Generation EU, Missione 4 Componente 2 Progetto SAMOTHRACE CUP B73C22000810001.

SO36

Probiotic-loaded electrospun fibers as antibiotic-free topical antibacterial treatment for chronic suppurative otitis media

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Chronic Suppurative Otitis Media (CSOM) is a persistent middle ear infection characterized by tympanic membrane perforation, chronic inflammation and biofilm formation caused by pathogens, such as Streptococcus pneumoniae, Haemophilus influenzae and Moraxella catarrhalis. Conventional antibiotic therapy often fails due to poor biofilm penetration and increasing antimicrobial resistance, highlighting the need for alternative strategies. Probiotics have emerged as promising therapeutic agents owing to their ability to inhibit pathogen growth through competitive exclusion, antimicrobial production, and immune modulation. However, their clinical application is limited by environmental instability and reduced viability. Protective encapsulation systems are required to overcome these challenges. This study aimed to develop and optimize an electrospun probiotic formulation as a potential therapeutic approach for CSOM management. Sodium alginate (SA) and polyethylene oxide (PEO) (70:30 v/v) were used as polymers to produce electrospun fibers able to encapsulate live probiotic cells. Triton X-100 (1%) was applied to improve electrospinability, while alpha-lactalbumin (3%) and glucose (2%) were included as prebiotic compounds. Probiotics (10^9 CFU/mL) were incorporated in the sterile polymer solution contained prebiotics before electrospinning. The fibers were crosslinked with 2% $CaCl_2$ (ethanol/water 30:70 v/v). Scanning Electron Microscopy (SEM) was used to evaluate fiber morphology, DAPI staining to assess encapsulation and a resazurin assay to measure probiotic metabolic activity. SEM micrographs showed uniform, bead-free fibers (1,037±0.151 µm) with evenly distributed probiotics. DAPI staining confirmed successful probiotic encapsulation in the polymer network. Resazurin reduction demonstrated sustained metabolic activity after electrospinning and crosslinking of the scaffolds. Electrospinning provided an advanced platform for developing probiotic-loaded fiber meshes with potential for enhanced stability and improved targeted delivery of probiotics and post-biotics. The optimized formulation produced structurally stable fibers. Encapsulation preserved the post-processing bacterial viability and metabolic function. This electrospun system demonstrated potential as an alternative therapeutic strategy for the topical treatment of CSOM.

Acknowledgments: This research was funded by the Italian Ministry of University and Research through NextGenerationEU, under PRIN 2022, project “Site-directed bacteriotherapy to prevent or treat infections in the era of multidrug-resistance (BENEFIT)” (code 2022M7PFZS, CUP I53C24002820006).

SO37

Osmotic engineering of cell-derived nanomaterials for precision medicine

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Extracellular vesicles (EVs) are naturally occurring cell-derived nanomaterials gaining traction in life sciences for their intrinsic biocompatibility. However, their clinical translation is often hampered by heterogeneous and potentially hazardous biological cargo. In this study, we propose a "top-down" engineering approach to transform native EVs into standardized, safe-by-design nanomaterials, bridging the gap between biological entities and synthetic drug delivery systems for precision medicine. Naïve EVs (nEVs) were isolated from immortalized B lymphocytes by differential ultracentrifugation. Osmotically remodeled EVs (EVsLysed) were produced by 1:50 dilution in bidistilled water, brief vortexing/incubation, and reconcentration through 50 kDa ultrafiltration; saline-treated vesicles (EVsCtrl) were used as process controls. Samples were characterized by nanoparticle tracking analysis, protein and tetraspanin assays, Western/dot blot, transmission and scanning electron microscopy, atomic force microscopy, untargeted lipidomics and proteomics, nucleic acid release assays, nanoparticle-association tests, and cell-uptake studies in healthy B lymphocytes and Raji lymphoma cells. EVsLysed showed increased particle abundance versus controls, a predominant small-vesicle profile, preserved vesicular morphology, and higher mechanical stiffness. Quantitative analyses supported substantial depletion of intraluminal cargo (proteins and nucleic acids) with concurrent membrane remodeling, including enrichment of structural lipid classes and membrane-associated/transmembrane proteins linked to vesicle trafficking and cell interaction pathways. EVsLysed also displayed stronger association with model gold nanoparticles and significantly higher uptake in Raji cells compared with healthy B lymphocytes. These findings support osmotic remodeling as a simple and potentially scalable EV engineering strategy that combines cargo depletion with preservation of a biologically competent membrane interface, enabling proof-of-concept exogenous loading and improved tumor-cell interaction in vitro. The approach appears compatible with translational manufacturing logic, although its clinical relevance requires source-specific optimization and dedicated in vivo evaluation of biodistribution, immunogenicity, efficacy, and safety.

SO38

New approach to tune the composition of laser powder bed fusion structures

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Laser Powder Bed Fusion (LPBF) is an additive manufacturing process that enables the production of functional metallic components by selectively melting successive layers of metal powder using a high-power laser. The composition of the powder feedstock plays a critical role in determining the final chemical and physical properties of the manufactured parts; conventionally, alloys are first produced in bulk and subsequently atomized into powders suitable for LPBF. In this study, an alternative strategy is explored, in which elemental or pre-alloyed powders are blended before fabrication, allowing the alloy to be formed in situ during the laser melting process. This approach offers increased flexibility in tailoring the final composition. Two alloy systems were investigated: (1) Fe-13Mn-1.2C Hadfield steel, produced from a mixture of Fe, Mn, and graphite powders; and (2) a Fe-Cr-Mo-Ni-Cu alloy, obtained by blending AISI 316L stainless steel with Cu powders. Cube-shaped structures (≈0.01 m side length) were obtained after Fe, Mn, and graphite powders were mixed in suitable proportions to obtain Fe-13Mn-1.2C Hadfield steel, as well as from AISI 316L stainless steel and pure Cu powders blended in different ratios to produce Fe-Cr-Mo-Ni-Cu alloys. The sintering process was performed using an EOS M100 system. Microstructural and compositional characterizations were performed by scanning and transmission electron microscopy, energy-dispersive spectroscopy, and X-ray diffraction. Local mechanical properties were evaluated through Vickers microhardness testing. The LPBF process parameters were systematically varied to evaluate their influence on the final composition and mechanical properties of the printed structures. The experimental results demonstrate the feasibility of the proposed in situ alloying approach, confirming that homogeneous alloys can be successfully synthesized directly during the LPBF process. Microstructural and compositional analyses revealed that the fabricated samples exhibited well-defined crystallographic phases consistent with the targeted alloy systems. In particular, the Fe-13Mn-1.2C Hadfield steel showed an austenitic structure along with the formation of a high density of fine precipitates generated during LPBF thermal processes. These precipitates are likely associated with carbide or oxide phases. For the Fe-Cr-Mo-Ni-Cu alloy system, the distribution and solubility of copper were found to be strongly dependent on process parameters and initial composition. An optimal copper concentration was identified, providing the best balance between microstructural homogeneity and mechanical performance. These findings underline the potential of in situ alloying via LPBF as a flexible and efficient strategy for designing customized advanced metallic materials for applications in the biomedical field.

SO39

Bioactive glass nanoparticles for biomedical applications: from batch synthesis to an in-flow approach

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Silica-based bioactive glass nanoparticles combine high surface area and mesoporosity with compositional tunability, enabling therapeutic ion delivery and interfacial reactivity relevant to tissue regeneration. In this context, the study investigates complementary batch and microfluidic sol-gel routes to obtain nanoparticles with controlled composition and morphology, with the long-term goal of developing multifunctional systems for hard and soft tissue applications. Four SiO_2-CaO formulations were prepared in batch by sol-gel synthesis followed by hydrothermal treatment, introducing P, Sr or Zn as bioactive dopants. Their in vitro bioactivity, cytocompatibility and antimicrobial potential were then assessed. In parallel, a PDMS microfluidic chip was developed as an in-flow sol-gel reactor for silica nanoparticle production. Particles obtained from both approaches were characterized by TEM, SEM and DLS. The batch route enabled the preparation of bioactive glass nanoparticles with reproducible morphology and composition across the investigated formulations, providing a suitable platform to compare the contribution of specific ionic additions to the expected biological response. The microfluidic system successfully generated silica nanoparticles under continuous flow, confirming the feasibility of the device as a confined environment for sol-gel nanoparticle formation. Overall, the results indicate that hydrothermal batch synthesis is a robust strategy for producing doped bioactive glass nanoparticles, whereas microfluidics offers a promising route toward improved control and reproducibility. Current work is focused on transferring the full SiO_2-CaO-based compositions to continuous flow, including the incorporation of calcium and zinc, to engineer nanoparticles with tailored therapeutic functions and stronger translational potential.

POSTER

P1

Influence of compatibilization strategies on structure–property relationships in fully bio-based polymer blends

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Melt blending is an economical and industrially viable strategy to improve the ductility and toughness of polylactic acid (PLA), avoiding chemical functionalization and the associated environmental impact. In this work, highly toughened PLA-based blends containing poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) (PHBHH), and in selected formulations polybutylene succinate (PBS), were developed by melt blending to overcome the intrinsic brittleness of PLA while preserving its biobased nature. Particular attention was devoted to the role of processing-induced elongational flow on blend microstructure and mechanical behavior. PLA 4042D (NatureWorks®Ingeo™), PHBH IamNATURE-B6A13 (MAIP) and PBS PBE003 (Natureplast) were used to formulate different bioblends through melt compounding in a Thermo Fisher Process 11 twin-screw extruder. Span TM 80-LQ-(RB) and Tween TM 80-LQ-(CQ) by CRODA were used as compatibilizers. PLA/PHBH blends were also processed through cast extrusion and film blowing. Fully bio-based blends were formulated, aiming at improving the intrinsic brittleness and low impact strength of PLA, while maintaining unaltered the sustainability characteristics of the matrix. In particular, three different approaches were followed: *(i)* utilization of natural compatibilizers for enhancing the miscibility between the polymeric phases; *(ii)* formulation of ternary blends, involving the incorporation of PHBH and PBS as minor phases; *(iii)* proper designing of the process technology and parameters for achieving refined morphologies. In all cases, the characterization of the phase behavior, morphology and mechanical behavior of the blends allowed disclosing fundamental processing-microstructure-properties relationships governing the behavior of such kind of complex systems. All the exploited strategies have proved effective in enhancing the mechanical characteristics of PLA, especially in terms of toughness and impact strength, without significantly compromising its typical high stiffness and tensile strength. Particularly impressive results were obtained for anisotropic PLA/PHBH films produced through cast extrusion and film blowing. In this case, the application of the elongational flow was effective in inducing relevant modifications of the blend microstructure, passing from a droplet-matrix morphology for the isotropic sample to practically indistinguishable polymer phases in the anisotropic films. These processing-induced morphological alterations induced a brittle-to-ductile transition for both cast-extruded and blown films, which reached an elongation at break of 40 and 74%, respectively.

P2

Development of multifunctional sandwich composites for improved thermal management and mechanical performance

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The increasing demand for lightweight structures with integrated thermal management capabilities has driven the development of multifunctional composite materials. In advanced engineering sectors such as aerospace, automotive, and refrigerated transport, components must simultaneously ensure structural reliability, weight efficiency and temperature regulation. Phase change materials (PCMs) offer high latent heat storage capacity, enabling efficient absorption and release of thermal energy within specific temperature ranges. This work aims to develop and evaluate multifunctional sandwich composites combining thermal energy storage capability with high mechanical efficiency. Multifunctional sandwich panels were fabricated using an epoxy (EP) foam core embedded with microencapsulated PCMs. The microencapsulation technique ensured uniform PCM dispersion within the foam matrix and prevented leakage during phase transitions. The thermally functionalized foam cores were combined with external skins made of epoxy/carbon fibre laminates to produce lightweight sandwich structures. Microstructural characterization was performed to assess PCM distribution and interfacial bonding between the core and the laminate skins. Mechanical performance was evaluated through flexural and compressive testing. Microstructural analysis confirmed a homogeneous distribution of microencapsulated PCMs within the EP foam and good interfacial adhesion between the foam core and the carbon fibre-reinforced epoxy skins. Mechanical testing demonstrated that the developed sandwich composites exhibited good flexural and compressive properties. Thermal characterization revealed enhanced energy storage capacity, with the PCM-filled foams showing a distinct phase transition enthalpy and effective heat absorption and release within the targeted temperature range. The results demonstrate a successful synergy between mechanical strength and thermal functionality in the developed composites. The integration of microencapsulated PCMs within EP foam cores enabled latent heat storage without significantly sacrificing the structural performance. The strong core/skin interfacial bonding ensured mechanical reliability under loading conditions, while the carbon fibre skins provided high stiffness and favourable strength-to-weight ratios.

P3

Effect of titanium addition on the processability of Al 6061 alloy processed by laser powder bed fusion

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Additive Manufacturing, and particularly Laser Powder Bed Fusion (L-PBF), enables the production of complex metallic components with high geometric freedom and material efficiency. Among lightweight alloys, Al 6061 is widely used due to its low density, good corrosion resistance, and mechanical performance. However, its processability by L-PBF is very challenging due to its large solidification range, poor melt flowability, and high cracking susceptibility. Grain refinement through inoculant addition represents a promising strategy to overcome these limitations. This work investigates the effect of titanium additions to Al 6061 as a grain refiner, aiming to evaluate their influence on printability and microstructural evolution during L-PBF. Commercial Al 6061 powder was mechanically mixed with CP-Ti powder, and the effect of different amounts of reinforcement phase was systematically investigated. The feedstock powders and their blends were preliminarily characterized to verify their suitability for L-PBF processing. Cubic samples were fabricated using a TRUMPF TruPrint 1000 L-PBF system equipped with an infrared fiber laser. Process parameter optimization was carried out by varying laser power, scan speed, and hatch distance, while maintaining a constant layer thickness. The fabricated specimens were subsequently subjected to detailed microstructural investigations and preliminary mechanical characterization to assess the influence of titanium addition on material performance. Powder characterization confirmed suitable morphology and phase composition for L-PBF processing. The densification behavior of the samples was strongly influenced by the applied volumetric energy density (VED), with an optimal processing window identified within the range of 95–150 J/mm^3. Within this energy input interval, improved melt pool stability and reduced defect formation were observed. Moreover, titanium addition contributed to enhanced process stability, and solidification cracks were no longer observed. SEM-EDS analyses revealed the presence of reaction zones surrounding Ti particles, indicating the in-situ formation of Al–Ti intermetallic phases. Moreover, a progressive transition was observed from a predominantly columnar microstructure in the base alloy to an equiaxed grain structure with increasing Ti content, accompanied by significant grain refinement. Titanium effectively promotes heterogeneous nucleation during solidification, refining the grain structure and enhancing microstructural homogeneity. The transition to a fully equiaxed microstructure demonstrates the strong inoculant effect, suggesting a viable approach to improve the L-PBF processability of Al 6061 alloys.

P4

Fused granular fabrication of PHBH and PLA: a comparative study of 3D printed biopolymers

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Additive manufacturing (AM) has significantly transformed modern production processes by enabling the fabrication of complex, lightweight, and highly customized components. The evolution of 3D printing technologies has driven research interest toward the development of materials that combine high performance with environmental sustainability, key requirements for expanding AM applicability across several industrial sectors. In this framework, bio-based polymers have emerged as promising and eco-friendly alternatives to conventional fossil-derived polymers. Poly(lactic acid) (PLA) is currently one of the most widely used polymers in AM. However, its intrinsic brittleness and limited thermal resistance motivate the investigation of alternative biopolymers with improved performances. This study represents a comparative investigation of two bio-based polymers, poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) (PHBH) and PLA, processed by an innovative AM technology known as Fused Granular Fabrication (FGF), which derives from the well-known Fused Filament Fabrication (FFF) but enables direct printing from polymer pellets, eliminating the need for filament production. This approach offers several advantages, including reduced material costs, flexibility in material selection, and the possibility of processing novel polymers. An extensive experimental campaign was carried out to evaluate the mechanical, thermal, and biological properties of the two biopolymers printed by FGF. Thermo-mechanical characterizations, including tensile and flexural tests, as well as dynamic mechanical analysis (DMA), were performed on specimens printed with three different deposition orientations (0°, 90°, and ±45°) to assess the influence of process-induced anisotropy on material performance. Thermal analyses were conducted using thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) to investigate the thermal stability, degradation behavior, and thermal transitions of the printed samples. To further address their suitability for biomedical applications, scaffold structures were fabricated and analyzed using both indirect and direct in vitro cytocompatibility tests, focusing on cells viability and biocompatibility. The results demonstrate that both PHBH and PLA exhibit promising properties for FGF-based AM. In particular, PHBH shows significant potential as sustainable bio-based material, supporting its use in 3D printing applications and highlighting its relevance for future developments within biomedical field.

P5

Structure–property relationships in isotropic and anisotropic PP/PET/GNP nanocomposites

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In this work the influence of a rubber compatibilizer and of the elongation flow on a GNP PP/PET nanocomposite was investigated. Specifically, our goal was to understand whether the presence of the compatibilizer affects the fibrillation efficiency of the dispersed PET phase. To this end, the mechanical and morphological properties of melt-spun fibers obtained with different hot drawing ratios were analysed and compared with isotropic samples. Polypropylene (PP), polyethylene terephthalate (PET) - obtained by grinding preforms for water bottles - a linear triblock copolymer based on styrene and ethylene/butylene with a polystyrene content of 30% (commercial name Kraton), and graphene nanoplatelets (GNPs) were used. All samples were prepared by melt mixing. Isotropic samples were obtained by compression molding, while anisotropic samples were produced using the drawing module of a capillary viscometer. Morphological, rheological, and mechanical tests were conducted. Both nanocomposites based on compatibilized and non-compatibilized blends did not obey the Cox–Merz law, with the nanocomposite based on the compatibilized blend exhibiting a higher viscosity than that based on the non-compatibilized blend. Furthermore, the melt strength of nanocomposites based on the compatibilized blend increased more than that of those based on the non-compatibilized blend, depending on the viscosity. The anisotropic samples exhibited better properties than the isotropic systems, with nanocomposites based on compatibilized blends showing overall better performance. The improved adhesion between the PP and PET phases, due to copolymer formation from reactions between the compatibilizer and PET macromolecules, enhances the nanocomposite properties. Moreover, elongational flow acts at two levels: it orients the PP chains and elongates the dispersed PET phase along the draw direction, increasing interfacial contact, and it fragments the nanoplatelets, enhancing polymer–nanofiller interactions. These effects lead to a more ordered and homogeneous morphology with enhanced interfacial properties, resulting in a transition from brittle to ductile behavior and improved elastic modulus, tensile strength, and elongation at break.

P6

Studio sulla miscibilità di componenti bio-based in compound elastomerici

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The increasing demand for sustainable materials in tire manufacturing drives the substitution of fossilbased ingredients with bio-based alternatives. However, integrating these bio-based components into the matrix is challenging the intricate physical and chemical interactions between the many constituents of a typical tire compound. A limited compatibility among the components can negatively affect processing, filler dispersion, and final mechanical properties. To move beyond empirical trial-and-error approaches, this work employs a combined predictive and experimental multiscale methodology to assess and optimize the interactions between bio-based resins and the rubber matrix. Model silica-filled tread compounds based on styrene-butadiene rubber and containing different resins were prepared and tested. Compatibility was first predicted using Hansen solubility parameters (HSP) theory, which quantify the affinity between additives and the rubber matrix. The solubility parameters of the materials under study were determined via their affinity with solvents of known HSP values, enabling the calculation of Hansen distances and prediction of component miscibility. Broadband dielectric spectroscopy (BDS) provided further insights into segmental relaxation phenomena and filler-elastomer interactions. HSP and BDS findings were then validated by experimental techniques, like differential scanning calorimetry (DSC), dynamic-mechanical analysis (DMA) and trasmission electron microscopy (TEM), which were employed to assess miscibility of additives and dispersion/distribution of silica within the rubber. HSP predictions established a clear miscibility ranking among the investigated bio-based and conventional resins, which was fully corroborated by experimental data. Specifically, highly compatible bio-based resins, such as polyterpenes, exhibited stronger matrix-resin interactions, evidenced by DSC, DMA and BDS. Morphologically, TEM analysis confirmed that this higher compatibility prevents large aggregates, promoting a finer and more uniform silica dispersion compared to less miscible alternatives. Compatible bio-based resins can successfully replace petroleum-derived ingredients, actually improving filler networking and dynamic-mechanical performance. Furthermore, the strong agreement between theoretical HSP predictions and multiscale experimental validations demonstrates that this combined methodology is a predictive tool to guide the rational design of next-generation sustainable tire compounds.

P7

Role of the multiphasic nature in the release of microplastics from PP-based blends and nanocomposites

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Microplastics and nanoplastics release into the environment is, currently, a very important issue in terms of impacts on environment and health. In this context, the behaviour of multiphase polymer systems, including polymer blends (with a dispersed phase in a continuous matrix phase) and nanocomposites (with nanosized filler particles dispersed into the matrix) is of particular interest, since generation and release of microplastics (and even nanoplastics) could follow different paths (for instance, generation from the dispersed phase; or, from the nanofiller itself and matrix) but, in spite of this, such issues have not been extensively investigated so far, especially with regard to polyolefin-based systems. In this work, therefore, we focused on two (i.e. without and with a suitable compatibilizer) polypropylene (PP)/polyethylene terephthalate (PET) blends, and also on a PP nanocomposite filled with an organically modified nanoclay. The blends based on PP and PET (75/25 wt/wt), without and with (5 wt%) a styrene-ethylene-butadiene-styrene (SEBS) copolymer functionalized with maleic anhydride (MA) compatibilizer, were prepared by melt mixing in a Brabender internal mixer; same equipment was used for the preparation of the PP based nanocomposites, filled with 5 wt% organically modified nanoclay. Samples for tensile characterization, photo-oxidation and microplastics generation were prepared by compression molding using a table-top lab press. The systems were subjected to mechanical fragmentation using a high-speed cutting mill, and photo-oxidation using a Q-UV Accelerated Weathering Tester, in order to evaluate the impact of both mechanisms of microplastics generation and release. Size distribution of the released particles was investigated, and the underlying mechanisms were deepened via FTIR-ATR and TGA analysis. The obtained results showed that the blends are significantly more prone to release microplastics, especially in presence of a specific photo-oxidation source; nevertheless, compatibilization provided a significant help in mitigating this tendency, despite the size reduction of the dispersed particles. In the case of the nanocomposites, the nanoclay presence proved to lower the microplastics generation and release, and this was attributed to the slowdown of the photo-oxidation process.

P8

Lead halide perovskite nanocrystals for heterostructured ultrafast scintillators

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The development of ultrafast scintillators for Time-of-Flight PET imaging requires materials combining high stopping power, efficient light conversion and sub-nanosecond decay times. Conventional LYSO crystals exhibit a 40 ns decay time, far from the 10 ps target enabling superior imaging resolution with reduced radioactive doses. Lead halide perovskite (LHP) nanocrystals (NCs), such as $CsPbBr_3$, have emerged as promising candidates owing to their high photoluminescence quantum yields, tunable optical properties and fast recombination dynamics. In this work, we report on the synthesis and optical characterization of $CsPbBr_3$ NCs and their incorporation into polymer nanocomposite films, for fabricating LHP/LYSO ultrafast scintillator heterostructures for TOF-PET applications. $CsPbBr_3$ NCs were synthesized via hot-injection (HI) and ligand-assisted reprecipitation (LARP) using $PbBr_2$ and Cs_2CO_3 precursors with different ligands (oleic acid, oleylamine, dodecyl ammonium bromide, octylphosphonic acid). Morphological and optical properties were characterized by TEM, UV-vis absorption and steady-state and time-resolved photoluminescence spectroscopy. Solid-state nanocomposite films were fabricated by dispersing NCs in polystyrene and polymethylmethacrylate solutions of varying molecular weight and concentration. Films were deposited by drop-casting on quartz substrates, modifying preparation parameters to optimize thickness, homogeneity and optical property retention. LARP-synthesized NCs outperformed HI counterparts, exhibiting narrower emission bandwidths (<100 meV), quantum yields exceeding 80% and faster decay times down to 5 ns. Generally, polymethylmethacrylate better preserved NCs optical properties with no significant spectral shifts, while polystyrene enabled larger film thicknesses (30–500 μm), depending on molecular weight and concentration. Increased NC loading yielded films of comparable thickness but significantly enhanced photoluminescence intensity. LHP NCs/LYSO heterostructures were successfully fabricated by drop-casting polystyrene-based nanocomposite films directly onto commercial LYSO crystals. HI and LARP comparison highlights the critical role of synthetic protocols in determining NC optical properties, guiding the selection of optimal candidates for scintillation applications. Polymethylmethacrylate-based nanocomposites showed excellent optical property retention, while faster recombination dynamics observed in thin films are advantageous for ultrafast scintillation. PS matrices, despite minor spectral broadening at low energy, attributed to weak NC aggregation preserved the main photophysical properties while providing thicker films suitable for sufficient X-ray stopping power. These results pave the way for upcoming scintillation tests on LHP/LYSO heterostructures, towards the development of ultrafast detectors for TOF-PET medical imaging.
Acknowledgements: the PRIN 2022 NRRP project “UPSTART” (code P2022YKS4M), Mission 4 Component 2 Investment 1.1, concession decree No. 1384 of 01.09.2023 of MUR by the European Union - Next Generation EU is gratefully acknowledged.

P9

Sustainable nanocoatings with enhanced mechanical and antimicrobial performance for high-traffic surfaces

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**On behalf of the MIRIA Consortium*

The global coatings market is increasingly driven by the demand for high-performance materials that align with sustainability goals. In this context, within the MIRIA project, sol-gel-derived hybrid coatings represent a promising alternative, combining mechanical strength, functional versatility, and a reduced environmental footprint. Six hybrid coatings were designed for high-traffic surfaces. These systems were developed using non-toxic solvents such as water and ethanol, and all synthesis, drying, and curing steps were carried out at room temperature under ambient conditions. This makes them particularly suitable for real-world applications, including operating rooms and public transport stations. The sol-gel process enables the integration of inorganic network-forming units (e.g., Si–O–Si linkages) with organic functional groups, allowing the incorporation of both antimicrobial agents and mechanical reinforcement within a single material architecture. Six hybrid coatings were synthesized via sol-gel dip-coating on glass substrates, using organically modified silanes combined with functional additives such as CuO nanoparticles. Formulations were tailored to modulate mechanical properties and biological activity. Mechanical and wear properties were evaluated through nanoindentation with CSM (ISO 14577) and nanoscratch tests. Nanoindentation tests were conducted using a KLA G200 system with Continuous Stiffness Measurement (CSM) to obtain elastic modulus and hardness as functions of depth. While scratch testing was performed using nanoscratch techniques with maximum loads up to 400 mN, identifying critical loads for cohesive and adhesive failures (Lc2 and Lc3). Abrasive and adhesive wear were assessed via ball-cratering and pin-on-disk tests, respectively. Surface analysis was carried out by optical profilometry (Leica DCM3D) and Atomic Force Microscopy (Bruker, tapping mode). Antimicrobial tests were adapted from standard methods to ensure reproducible results. Antibacterial efficacy was evaluated against three bacterial strains after exposure for 24 hours and 1 hour at both room temperature and 37 °C. Coatings with nanoparticles showed superior mechanical properties, including higher hardness, modulus, and better scratch resistance, due to enhanced crosslinking and reinforcement. Abrasive and adhesive wear tests confirmed improved durability and reduced friction. FIB-SEM analysis revealed uniform, dense coatings with low roughness, and maintaining transparency. Biologically, all coatings were antibacterial against *S. aureus*, with nanoparticle-doped versions acting faster. This study demonstrates that scalable, low-energy sol-gel processes can produce sustainable hybrid coatings combining enhanced mechanical performance with effective antimicrobial activity. Nanoparticle reinforcement plays a key role in improving durability while preserving surface quality, supporting the suitability of these coatings for high-use environments such as healthcare settings.

P10

Robocasting and DLP-enabled fabrication of proton ceramic electrolysis cells and integration

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Protonic ceramic electrolysis cells (PCECs) enable efficient hydrogen production at intermediate temperatures (400–650 °C), reducing energy demand compared to other high-temperature electrolyzers while producing dry, pure H_2. However, large-scale deployment remains limited by the complex processing of $Ba(Ce,Zr)_{1-y}Y_yO_{3-\delta}$ (BZCY) electrolytes and the associated material losses and costs. Moreover, the integration of dense electrolytes with sealing materials presents additional challenges. This work explores additive manufacturing (AM) approaches - robocasting and digital light processing (DLP) - to simplify BZCY shaping, minimize waste, and improve PCEC component integration through enhanced geometric flexibility. Robocasting was used to deposit thermocurable BZCY pastes optimized for extrusion stability, shape retention, and high green density. Photocurable BZCY slurries were also developed for DLP to enable the fabrication of thin and complex electrolyte geometries with high dimensional accuracy. Debinding and sintering cycles were defined using hot-stage microscopy (HSM) and TGA/DSC analyses to identify organic burnout, shrinkage onset, and optimal thermal ramps for defect-free densification. Electrochemical impedance spectroscopy (EIS) was performed to measure protonic conductivity, while SEM, EDS, and XRD characterized microstructure, phase stability, and interfacial behavior with commercial glass sealants after thermal cycling and humid ageing. Robocast BZCY layers exhibited homogeneous microstructures, controlled porosity, and surface features favourable for reliable sealing. EIS confirmed protonic conductivities comparable to conventionally processed electrolytes. SEM revealed improved mechanical interlocking and reduced interfacial gaps. The design freedom provided by 3D printing also enabled engineered surface textures that significantly enhanced mechanical interlocking at the electrolyte–sealant interface. DLP printing produced high-fidelity thin components with smooth surfaces, enabling designs not achievable through conventional methods. Ageing tests confirmed phase stability and limited interdiffusion at interfaces. Robocasting and DLP provide versatile AM routes for shaping and integrating BZCY electrolytes, reducing materials waste while enabling engineered geometries and interfaces that improve sealing and long-term reliability. The optimized thermal processing further supports consistent densification and microstructural stability. These results outline a scalable AM-based pathway for next-generation protonic ceramic electrolysis systems.

P11

Symmetrical reversible solid oxide cells with innovative structural design

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This research is carried out within the framework of the PROMETHEUS project and is funded by Next Generation EU. The project focuses on the development of an advanced Solid Oxide Electrolyzer Cell (SOEC) for sustainable hydrogen production from seawater, coupled with its integration into a methanol synthesis reactor. Following the fabrication and sintering of the electrolyte, particular attention was devoted to maintaining the hierarchical porosity of the electrode layers, that guarantees effective triple phase boundary accessibility, improved interaction between gaseous reactants and catalytic sites, and rapid evacuation of reaction products. Dense GDC10 ($Gd_{0.1}Ce_{0.9}O_{2-\delta}$) electrolytes were fabricated by optimizing slurry composition, tape casting, sintering conditions, using CuO as a sintering aid. Hierarchically structured electrodes (GDC10+LSCuF) were prepared by freeze tape casting. Processing parameters were tuned to obtain controlled hierarchical porosity, enhancing gas diffusion and electrochemical activity. Stable and homogeneous slurries were achieved using dispersant, lubricant, plasticizer and binders, without the use of harmful organic solvents. Sintering at 1050°C for 3 hours ensured the formation of a dense, highly uniform electrolyte layer with preserved porous electrode architecture. SEM micrographs confirm strong interlayer adhesion at the electrode-electrolyte interfaces. FTIR-ATR spectra of the GDC10+LSCuF composites indicates the compatibility of the components and the stability of the suspension. The achieved electrolyte layer density at a relatively low sintering temperature demonstrates the effectiveness of the chosen approach to material synthesis and formation. The preservation of electrode porosity after heat treatment indicates good thermal compatibility of the system components, which is critical for the long-term stability of the SOEC. The developed porous architecture of the electrodes ensures efficient gas mass transfer and an increase in the area of active reaction zones, which is a key factor in performance in both fuel cell and electrolysis modes.
Acknowledgements: authors acknowledge Italian projectPROMETH2eus (ID: RSH2B_000039-CUP: F37G22000080006) funded by the Next Generation EU (PNRR, Missione 2, Componente 2) coordinated by the department DICCA of the University of Genoa.

P12

High piezoelectric property in polyvinylidene fluoride films through ion–dipole interaction approach for flexible electronics

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Poly(vinylidene fluoride) (PVDF) is a semicrystalline fluoropolymer widely studied for flexible electronics, sensors, and energy harvesting due to its intrinsic ferroelectric properties. Its electromechanical behavior mainly arises from the formation of the polar β crystalline phase, in which the aligned C–F dipoles, in the *all-trans* configuration, generate a net polarization under mechanical or electrical stimuli. Ionic doping strategies have been proposed to enhance dipole ordering by means of the interaction between introduced ions and CF_2 dipoles. This work examines the influence of calcium chloride ($CaCl_2$) incorporation on the piezoelectric response of a commercial PVDF. To manufacture the films, calcium chloride ($CaCl_2$) was dissolved through magnetic stir in a solvent mixture of N,N-dimethylformamide/acetone (70/30 v/v%) at room temperature. Commercial PVDF granules were then added to the solution and stirred at 60 °C for 2 hours. The mixture was then degassed before being tape cast. The obtained films, after the removal of the solvent at 150 °C under vacuum conditions, were annealed at 130 °C to stabilize the amount of polar β-phase. Samples from 0.5 to 4.0 wt% of $CaCl_2$ in PVDF were developed and investigated. The samples were poled through a lab-made small-scale contact poling setup, imposing an electric field of 100 kV/mm at 100 °C for 30 minutes to induce dipole alignment in PVDF, followed by cooling under the applied field before its removal. Homogeneous PVDF films were successfully obtained with a nominal thickness of 50 µm. The utilized low molecular weight PVDF displays a higher β-phase fraction in the salt-doped samples with positive effect on the piezoelectric strain coefficient (d_{33}). The observed enhancement in piezoelectric performance is mainly ascribed to the strong coordination between Ca^{2+} ions and the CF_2 dipoles, which promotes their preferential alignment under the applied electric field. This study propose a scalable and cost-effective approach that considerably enhances the piezoelectric PVDF performance, thus demonstrating the potential of producing flexible and easily manufactured electroactive materials with tunable properties.

P13

3D-printed hybrid adsorbent composites for thermal energy recovery

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Environmental sustainability and energy efficiency are key priorities in addressing global challenges related to climate change, resource depletion, and environmental degradation. Consequently, significant efforts are being directed toward optimizing the use of thermal energy by improving the efficiency of existing technologies, minimizing energy losses, and promoting effective storage strategies. Thermal energy storage and recovery through water vapor adsorption/desorption on microporous solids is a well-established technology that has reached substantial scientific maturity. In this work, we present the synthesis and characterization of composite materials specifically engineered for 3D printing technology useful for the recovery of thermal energy from low-temperature heat sources. Adsorbent composite materials were fabricated using different types of liquid resins containing microporous phases, such as silica gel and zeolites, and optimized to enable 3D printing of a prototype heat exchanger while preserving the functional properties of the adsorbent phase. The prepared materials were systematically characterized to evaluate their structural, thermal, and functional properties. Morphological analysis was carried out by scanning electron microscopy (SEM), thermal stability was assessed by thermogravimetric analysis (TGA), adsorption capacity was determined through water vapor uptake measurements, and mechanical behaviour was investigated via strength testing. Several prototypes were fabricated using different heat exchanger geometries, employing resin formulations optimized both in terms of resin type and additive content. The influence of material composition on printability and final component performance was systematically evaluated. In parallel, the 3D printing parameters were carefully studied and optimized to maximize manufacturing efficiency and ensure high structural quality. Process variables such as layer thickness, exposure conditions, curing strategy, and printing speed were tuned to enhance dimensional accuracy, mechanical stability, and overall heat exchanger performance. The fabricated prototypes, produced according to the described formulations and processing strategies, exhibited promising characteristics based on the morphological and structural characterizations performed. Although further investigations are required to fully assess their long-term performance and operational efficiency under realistic working conditions, the present findings indicate that 3D printing of hybrid polymer-based materials represents a viable and innovative alternative to conventional manufacturing techniques for adsorption heat exchange systems.

P14

Biohydrogen production from microalgae

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In recent years, hydrogen has been identified as an alternative to fossil fuels for both industrial and domestic applications, serving as an efficient energy carrier. Because of the constant increase in energy demand, it is necessary to invest in green technologies for its production, so that carbon-free and renewable resources are implied. One of these technologies involves the production of hydrogen via microalgae, through the processes of biophotolysis, biophotosynthesis, or dark fermentation. The challenge is to enhance production so that quality and quantity requirements for a widespread utilization are met.The idea is to produce hydrogen by exploiting the interaction between the microalgae and the light, inside a photobioreactor. The reactor is built with UV-assisted 3D printing and is covered with a substrate of microalgae loaded in a hydrogel matrix. Two possible reactor configurations are being considered. The hydrogel is formulated so that the microalgae can be cultivated in a cellular medium and kept together by alginate. In this way, the microalgae are physically trapped in the 3D reticulate of the polymeric chains of the hydrogel. The experimental activity is then completed by performing computational fluid dynamics simulations of the hydrogen production process in Ansys Fluent 2024R2, to analyse the influence of both the distribution of the light and the fluid dynamics inside the reactor on the production. First attempts on the formulation of the hydrogel have given good results in terms of adhesion on the surface of the reactor. Once the experiments are performed, tests are of particular interest to check the adhesion of the matrix on the reactor and how much it gets degraded throughout the process, the level of swelling of the hydrogel, the number of coating layers suitable, and the quantity of hydrogen produced. The final step is the optimisation of the production to reach a high level of purity and the further scaleup of the process for industrial application.

P15

Structure–performance relationship and metal–support interaction effects in high-loading Ni/Al_2O_3 and Ni/TiO_2 catalysts for CO_2 methanation

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CO_2 methanation is a relevant strategy for valorising captured carbon and storing green hydrogen via the Sabatier reaction. Ni-based catalysts are widely studied due to their balance of activity, selectivity, and cost; however, the role of the support remains insufficiently clarified, particularly in systems with high metal loading. Metal–support interactions, textural properties, and the reducible or non-reducible nature of the support can significantly affect Ni dispersion, reducibility, and the electronic behaviour of the active phase. In this context, this work investigates the structure–performance relationship of 36 wt% Ni catalysts supported on various Al_2O_3 and TiO_2 materials, evaluating how these variables influence CO_2 conversion, CH_4 selectivity, and stability under reaction conditions close to industrial operation. Catalysts containing 36 wt% Ni were prepared by wet impregnation on three alumina supports (Grade E, Grade M, and CN synthesised by calcination of aluminium nitrate) and two TiO_2 supports (pure anatase and P25 anatase–rutile), followed by drying and calcination at 600-700°C. Structural and surface characterisation was performed by N_2 physisorption (BET), FT-IR, UV-Vis DRS, Raman spectroscopy, SEM-EDX, STEM, XRD, XPS, H_2-TPR, and CO_2-TPD. Catalytic tests were carried out in a continuous fixed-bed tubular reactor at atmospheric pressure, with an H_2/CO_2 molar ratio of 4 and a time factor (Qt/W) of 60,000 mL g^{-1} h^{-1}, in the temperature range 200–550°C, after in situ activation in H_2 at 500°C. Conversion and selectivities were determined by gas chromatography. The alumina supports exhibited high surface area and mesoporosity, whereas anatase TiO_2 had a very low surface area. Metal loading generally reduced the specific surface area, except for Al_2O_3 CN, where delayed nitrate decomposition increased pore volume. NiO crystallite size was smaller on alumina-supported catalysts (~10 nm) and larger on titania-supported ones. XPS and TPR analyses revealed strong metal– support interactions associated with partial formation of $NiAl_2O_4$ or $NiTiO_3$ phases. The 36% Ni/Al_2O_3 CN catalyst achieved 81% CO_2 conversion and 99% CH_4 selectivity at approximately 400°C, approaching thermodynamic equilibrium, while 36% Ni/TiO_2 P25 showed similar performance (80%, 97%), and the catalyst supported on anatase TiO_2 exhibited lower activity. Stability tests over 24 hours confirmed the absence of significant deactivation. Catalytic performance correlated primarily with the strength of the metal–support interaction, rather than with surface area or particle size. The presence of mixed phases and oxygen vacancies promoted CO_2 activation and stabilisation of metallic Ni. Catalysts with stronger interactions exhibited higher activity and selectivity, indicating that electronic control of the active phase is a determining factor for efficient methanation in high metal loading systems.

Acknowledgments: MASE ministry funding the project “RSH2A_000018 - Stoccaggio e distribuzione di idrogeno attraverso una strategia power-to-gas/gas-to-power con cattura ed utilizzo completi del carbonio - CUP: F57G25000180006” in the frame the European Union Next-GenerationEU, PNRR – M2 C2 I3.5 (bando A)

P16

Biochar as a functional additive for controlling gas transport in poly(butylene succinate) for packaging and membrane applications

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Sustainable polymer membranes with controlled gas permeability and selectivity values are essential for both active packaging and CO_2 capture. Poly(butylene succinate) (PBSu) offers flexibility but limited barrier performance, which can be enhanced by incorporating biochar as a functional additive. This study shows that biochar improves permeability, diffusivity, solubility, and selectivity, enabling PBSu membranes with tunable properties for efficient CO_2 separation and advanced packaging applications. Poly(butylene succinate) (PBSu) membranes and their biochar-modified composites fabricated via in-situ polymerisation containing 2.5wt% and 5wt% of biochar were tested for He, N_2, CH_4, CO_2 and O_2 permeability, diffusivity and solubility using a closed-volume manometric permeation apparatus according to ASTM D1434. The tests were carried out at 25°C to elucidate structure-property relationships among transport properties and filler content. Neat PBSu, characterised by medium crystallinity and high chain mobility, showed high flexibility but poor gas barrier performance. The introduction of biochar effectively overcomes this limitation by enhancing the complexity within the polymer matrix and promoting heterogeneous nucleation. However, while improving the barrier performance, it also leads to an increase in brittleness - this highlights the importance of the filling ratio to balance mechanical strength and gas barrier performance.The addition of biochar reduced permeability and diffusivity due to enhanced tortuosity and reduced free volume, while increasing solubility. In particular, CO_2 solubility rose by nearly 60%, attributed to hydrogen-bonding and dipolar interactions between CO_2 and oxygen-containing groups (–COOH, –OH, C=O) on the biochar surface, whereas non-polar gases such as CH_4 and He showed decreased sorption. This dual mechanism - diffusion obstruction coupled with selective adsorption - improved CO_2/CH_4 and O_2/N_2 selectivity and compensated for PBSu's intrinsic low-barrier performance. Overall, the results demonstrate that tuning the amount of biochar allows precise control of the permeability-selectivity-mechanical balance in PBSu membranes. These findings provide a quantitative basis for integrating structural design with predictive transport modelling, advancing the development of sustainable and high-performance PBSu membranes for CO_2 capture, natural-gas purification, and active-packaging applications.

P17

Effects of phosphonation on the morphological and proton-conducting properties of graphene oxide for PEMFC applications

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Proton exchange membrane fuel cells (PEMFCs) are promising technologies able to directly convert the chemical energy of hydrogen into electricity with virtually zero emissions. However, their large-scale deployment remains challenged by the high cost of the benchmark PEM, i.e., Nafion® ($0.24 cm^{-2}), its critical performance loss when used above 80 °C and at low relative humidity, and the environmental concerns associated with its classification as a per- and polyfluoroalkyl substance (PFAS). Therefore, this work conceived self-standing phosphonated graphene oxide (PGO) membranes as potential non-fluorinated alternatives. The effects of phosphonation of GO via phosphoric acid (PA) were inspected by producing and systematically characterizing a series of membranes with acid-to-GO molar ratios (n) equal to 1, 2.5, 5, 10, 15, and 20. The PGO-n membranes were fabricated via a lab-designed strategy comprising the stirring of controlled quantities of GO dispersion and PA under a two-stage thermal treatment (25 °C for 3 h, 100 °C for 3 h), the vacuum filtration of the mixture, and the conclusive oven-drying to complete the self-assembling of the functionalized samples. OM, SEM, and XRD were performed for the morphological and microstructural characterization. Compositional information was inferred through ATR-FTIR and EDX spectroscopies. Thermo-mechanical characterization was based on TGA-IR and tensile testing. The functional properties were preliminarily evaluated through measurements of static OCA, IEC, and proton conductivity via ex-situ EIS. The uniformity of the self-assembled membranes was checked by microscopy. XRD patterns disclosed a progressive interlayer expansion at higher acid loadings. ATR-FTIR indicated the successful incorporation of phosphorus-bearing functionalities, further verified by contents of P from EDX up to ≈12 wt.% for PGO-15 and PGO-20. All membranes displayed good thermal stability relevant to PEMFC range, retaining about 85–90% of their initial mass up to 100 °C. A slight decrease of tensile strength and Young's modulus was observed in favor of better elongations. Functional characterization clarified the positive effects of the insertion of multi-protic and amphoteric phosphonic acid groups ($–PO_3H_2$) within GO. IEC increased monotonically with phosphonation up to the best value of 7.19 meq g^{-1} for PGO-20, roughly a tenfold enhancement with respect to pristine GO. The key feature was the strongly improved in-plane proton conductivity up to 0.8–1.0 S cm^{-1} at 80–100 °C for the most highly functionalized samples (n ≥ 10), exceeding the values of benchmark GO and Nafion® under comparable conditions.

P18

Silica from industrial waste as solid sorbent/catalyst support in decarbonization strategies

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CO_2 capture, storage and utilization (CCSU) technologies have attracted significant attention over the last decade as decarbonization strategies. The materials developed for these technologies are typically supported systems functionalized with amine-based compounds for CO_2 adsorption or promoted with (earth-)alkaline species and transition metals for CO_2 capture and catalytic conversion (Dual Function Materials, DFM). In this context, the growing interest in cost-effective materials aligned with the circular economy principles has positioned silica as a promising alternative support, due to its favorable morphological, physical, and chemical properties. This contribution focuses on the synthesis, characterization, and application of silica derived from H_2SiF_6 (FSA), a hazardous by-product of the aluminum fluoride industry, as a support material for different decarbonization technologies. Porous silica supports were synthesized from FSA by controlled precipitation incorporating different organic structure-directing agents (SiO_2-X, X= PEG; CTAB; P123). Selected supports were functionalized through grafting method with amine-bearing silanes (APTES or TMPDETA) to be applied as solid CO_2 sorbent. DFMs were also prepared by sequential impregnation of the waste-derived silica with Ru (0.5wt%) and barium promoter (16wt%). Materials were characterized by N_2 physisorption, XRD, SEM-EDX, CO_2-TPD, H_2-TPR, and *in situ* FT-IR spectroscopy. CO_2 capture capacity and catalytic conversion were also evaluated in a quartz fixed-bed microreactor. Silica samples were effectively obtained, showing surface areas in the range 45-900 m^2/g depending on template employed. *In situ* FTIR spectroscopic studies of Amine-functionalized silica showed the successful grafting at the surface and the corresponding consumption of silanol groups. These materials are active in CO_2 capture via carbamate formation at R.T. Carbamate species remained stable up to 50ºC but underwent total decomposition at 100ºC, allowing for surface regeneration and recyclability. The Ru-Ba/SiO_2-X DFM systems exhibited complex carbonate species formation on Ba-centers as revealed by XRD and by CO_2-TPD spectroscopic tests. H_2-TPSR experiments in the same conditions confirmed that methanation process begins at ~250ºC, evolving from the reduction of weakly bonded monodentate species to more stable bidentate and bridging carbonates. Cyclic FTIR tests at 350ºC proved the ability of the materials to repeatedly store CO_2 and convert it to CH_4. These results suggest that industrial hazardous waste (FSA) can be successfully valorized into high-performance mesoporous silica. These materials, once functionalized with amines or Ru-Ba, act as effective candidates for reversible CO_2 capture and catalytic methanation (DFM), offering a sustainable solution for decarbonization technologies.

Acknowledgements: authors acknowledge financial support of PRIN2022 PNRR SILCO (n. P2022SZANL) Project from the Italian Ministry of University and Research (MUR).

P19

Understanding interactions between SiO_2 support and active sites in dual function materials (DFMS) for CO_2 capture and conversion

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Rising atmospheric CO_2 levels drive the need for efficient capture and conversion technologies. Dual-function materials (DFMs), enabling integrated CO_2 capture and methanation in a single reactor, offer a promising route to e-methane production employing green H_2. While DFMs have been mainly studied on Al_2O_3 supports, the role of alternative supports remains largely unexplored. In this contribution, SiO_2-supported Ru-Na_2CO_3 DFMs, with different Na-loadings, are developed and investigated for integrated CO_2 capture and methanation, evaluating CO_2 storage sites, methanation activity, and cyclic performance, to assess the feasibility of SiO_2-based DFMs. SiO_2-supported Ru–Na_2CO_3 DFMs with Na_2CO_3 loadings in the range 2.5-20 wt.% and a fixed Ru loading of 0.5 wt.% were prepared by incipient wetness impregnation. Reference materials, including Ru/SiO_2, 10%Na_2CO_3/Al_2O_3, and their physical mixture, were synthesized for comparison. Structural and morphological features were analyzed by XRD, SEM–EDX. CO_2 storage sites and surface chemistry were investigated by *in situ* FT-IR techniques. CO_2 adsorption capacity and reactivity were assessed by CO_2-TPD and H_2-TPSR tests. Catalytic performance was evaluated in a fixed-bed microreactor under both co-feed and cyclic CO_2 capture-methanation conditions. N_2 physisorption and SEM analyses reveal a progressive loss of surface area and pore volume with increasing Na_2CO_3 loading, exceeding ~50% at ≥5 wt.% due to pore blockage and the formation of large sodium carbonate agglomerates. CO_2-TPD and *in situ* FT-IR spectroscopy indicate that CO_2 is predominantly stored as bidentate carbonate species, which are thermally stable and only partially reversible under regeneration conditions, resulting in a maximum effective CO_2 uptake at low Na_2CO_3 contents (5 and 10 wt.%) and a sharp decline at higher loadings. Increasing Na_2CO_3 loadings inhibit Ru activity, as observed by H_2-TPSR tests, shifting the onset of CH_4 formation toward higher temperatures after CO_2 adsorption phase. One-pot SiO_2-supported DFMs exhibited a limited performance during cyclic capture–methanation experiments, whereas a physical mixture of Ru/SiO_2 and Na_2CO_3/Al_2O_3 showed higher CO_2 capture efficiency and higher CH_4 production. The utilization of SiO_2 as support for DFM resulted in low CO_2 uptakes, due to the weak protonic acidity nature of the support as well as its non-interacting nature. These properties cause the agglomeration of the Na sorbent, increasing its bulk basicity and lowering its effectively available active sites when high Na loadings. On the other hand, higher efficiency of integrated CO_2 capture and conversion were observed by physical mixtures of reducing/storage formulations, which emphasize the important role of support selection in the rational design of effective DFMs.
Acknowledgements: authors acknowledge financial support of PRIN2022 PNRR SILCO (n. P2022SZANL) Project from the Italian Ministry of University and Research (MUR).

P20

Sustainably engineered n-doped carbon dots: structure–property modulation for advanced photoredox applications and light–matter interactions

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Carbon dots (CDs) are hybrid carbon-based nanomaterials with mixed aromatic and aliphatic domains and versatile surface functionalities, providing water solubility, low toxicity, and suitability for sustainable, low-cost synthesis. Their tunable optical behavior makes them promising platforms for advanced light–matter interactions. Here, nitrogen-doped CDs (N-CDots) synthesized from citric acid and nitrogen precursors were evaluated for their optical response and multifunctional behavior in optoelectronic interfacial engineering, UV-blocking coatings, photocatalysis, and plant-related bio-interactions. N-CDots were produced from citric acid obtained via biofermentation of glycerol waste using solvothermal and microwave-assisted routes, varying Nitrogen source, solvent, temperature, and reaction time. Morphology was assessed by AFM/TEM, functional groups by FT-IR, and optical response by UV-Vis and photoluminescence spectroscopy. Their performance was tested in: i) UV-blocking coatings for pakaging; (ii) interfacial layers for charge and interface control in non-fullerene OPVs, OLEDs, and OFETs; (iii) modulation of tomato plant growth and water demand; (iv) photocatalysis, and preliminary hydrogen production tests by reducing methyl viologen (MV) under visible-light irradiation, in the presence of an electron donor. and using microalgae systems. N-CDots display tunable absorption in the green/red spectral region and excitation-dependent PL. Films produced with CDs act as efficient UV-blocking coatings, with adjustable transparency depending on deposition conditions. In OPVs, incorporation of NCDs into PDINN layers improved fill factor and power conversion efficiency by enhancing charge extraction. Agritech experiments showed CDs significantly promoted seed germination, radicle elongation, hydroponic growth, stomatal conductance, and recovery from water stress, monitored in real time using the bioristor. Photocatalytic tests revealed that CDs act as excellent photosensitizers, enabling rapid reduction of MV under visible-light irradiation, accompanied by the characteristic color transition of reduced viologen species. The sustainable synthesis of N--CDs enables fine control over surface chemistry and optical response, resulting in a versatile nanomaterial suitable for multiple technological sectors. Their high surface area and rich functionalization ensure strong compatibility with both organic and inorganic interfaces, supporting their role as interfacial modifiers in optoelectronics and as UV blocking additives. Their strong -visiblelight- activity underpins their efficiency as photosensitizers in photoredox processes, relevant to hydrogenrelated- photochemistry. The observed enhancement in plant growth and stress tolerance suggests promising agritech applications. Further optimization of nitrogen doping, surface functionalization, and controlled oxygen environments could expand their potential in scalable photocatalytic and solardriven -hydrogenproduction- system.

P21

pH-drift–aware formulation windows for Al_2O_3 and TiO_2 water nanofluids in low-temperature cooling

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Oxide-water nanofluids are widely proposed to enhance heat management in industrial and mobility systems operating between ambient temperature and 100 °C. In practice, long-term performance is constrained more by colloidal stability than by nominal thermal conductivity gains. A critical yet underappreciated factor is spontaneous pH drift driven by amphoteric surface hydroxyl chemistry. Such drift can move formulations toward their isoelectric point (IEP), reducing electrostatic repulsion and accelerating aggregation. This study presents a lightweight, practice-oriented framework that translates simple pH-drift and stability measurements into formulation windows for Al_2O_3 and TiO_2 nanofluids, supporting safe and energy-efficient operation in low-temperature loops. Single-loading Al_2O_3 and TiO_2 nanofluids were prepared in deionized water via a standardized two-step dispersion process. For each oxide, three initial pH setpoints were selected relative to the material's IEP (below, near, and above). Ionic strength was adjusted between low and elevated salinity to emulate utility-water conditions. Experiments were conducted at 25 °C and 60 °C. Time-resolved pH(t) was recorded over 24 h, while zeta potential (ζ) or DLS particle size was measured at 0 h and 24 h. Visual sedimentation complemented instrumental data. Stability outcomes were classified as green/amber/red based on |ζ| magnitude, particle growth, and visible settling. Operating windows were mapped as a function of pH, ionic strength, and temperature. For both oxides, formulations near the IEP destabilized most rapidly, with instability amplified at higher ionic strength and 60 °C. Al_2O_3 showed stable windows predominantly at alkaline pH under low salinity, whereas TiO_2 exhibited stable regions shifted toward mildly acidic to neutral pH, consistent with its lower IEP. Even when short-term dispersion appeared acceptable, 24-h drift toward the IEP reduced |ζ| and increased aggregation, particularly under elevated salinity. The findings define material-specific stability windows governed jointly by IEP, ionic strength, and temperature. Converting simple bench tests into green/amber/red operating maps offers a low-cost screening tool for deployment in energy-transition applications. Practical guidance emerges: select pH setpoints sufficiently distant from the IEP, control ionic strength (or apply buffering strategically), and track pH drift as an early-warning indicator of instability. This methodology-focused framework can be extended to closed-loop validation, additional oxides and base fluids, and digital monitoring strategies for predictive maintenance.

P22

Bottom-up and top-down strategies for emissive silicates nanocrystals

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Alkaline-earth copper silicates, with the general formula $ACuSi_4O_{10}$ (where A = Ca^{2+}, Ba^{2+} and Sr^{2+}), represent a family of materials known since antiquity. In particular, $CaCuSi_4O_{10}$ and $BaCuSi_4O_{10}$ dating back to 2500 BC and 1200 BC respectively and known as Egyptian Blue and Han Blue are characterized by an intense blue color and high long-term stability. Beyond their historical interest, their peculiar layered crystal structure and emission in the near-infrared region make them interesting new materials for optoelectronic applications. Copper silicate nanocrystals were synthesized through a bottom-up approach based on a modified hydrothermal process. Metal nitrates were employed as precursors for the A^{2+} and Cu^{2+} sites, while SiO_2 served as the silicon source in a basic environment. The resulting bulk material was exfoliated under various conditions to promote the formation of nanoparticles starting from the desired crystalline phase. Phase purity and crystal structure were verified via XRD. The morphology and size distribution of the nanocrystals were investigated using TEM, while the optical properties and near-infrared emission efficiency were characterized by photoluminescence spectroscopy and cuvette-based absorption analysis. In this work, we present our recent findings on the preparation of colloidally stable 2D nanosheets based on the aforementioned copper silicate compounds. The synthesized nanoplates exhibit an average lateral diagonal of 34 nm and a thickness of 6 nm. Their photoluminescence properties are consistent with those of the bulk material, featuring an excitation maximum at 618 nm and an emission peak at 950 nm. Furthermore, absorbance measurements in cuvettes demonstrate a nearly complete absence of scattering from the suspensions, confirming the high quality and stability of the resulting colloidal dispersions. This innovative synthetic protocol paves the way for a new class of 2D nanomaterials with promising applications in the fields of biomedical imaging, photovoltaic energy conversion, and IR light-emitting devices. Furthermore, their unique optical properties and stability make them excellent candidates for integration into advanced telecommunication systems.

P23

Plasma electrolytic oxidation (PEO) of aluminum alloy AA6082 for corrosion resistance

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The aluminum alloy AA6082 (Al-Mg-Si) is widely used in the automotive and aerospace sectors where a high corrosion protection is required. Plasma electrolytic oxidation (PEO) of aluminum is a high-voltage anodizing treatment carried out in aqueous alkaline solution under plasma conditions, aimed at increasing its corrosion resistance through the growth of a passive coating. The use of alkaline electrolytes implies a greater environmental sustainability than conventional anodization, typically employing acidic baths. Large reached voltages cause the production of stable, crystalline alumina phases, more protective than amorphous alumina. The scope of this work is the optimization of PEO treatment by acting on the main electrical process parameters, to evaluate their effect on the coating quality. PEO is performed on AA6082 samples in an alkaline solution, containing sodium hydroxide, potassium hydroxide and sodium metasilicates. The treatment is carried out in AC conditions under potentiostatic control, exploiting a pulsed bipolar electrical regime. Selected process variables are the frequency, the voltage profile, the duty cycle, the applied waveform, varied to find the optimized PEO configuration. All obtained coatings are characterized using SEM-EDX and XRD analysis, with the aim of correlating the production method with the oxide structure, morphology, porosity and composition. The corrosion behavior is analyzed through electrochemical tests such as linear polarization resistance (LPR), electrochemical impedance spectroscopy (EIS), potentiodynamic polarization (PDP), conducted in solutions with chlorides. Results show an important dependence of the oxide structure on the applied electrical process parameters, namely voltage, frequency, waveform and duty cycle, affecting the coating thickness, compactness, level of defects, and corrosion resistance. Oxide coatings are ranked according to the main electrical features of their production method. A complete linear voltage ramp up to 500 V, together with a low working frequency, results in a high corrosion protection. The chosen waveform and duty cycle also play a significant role. Considering the broad existing literature about galvanostatic PEO (current-controlled), the optimization of the process in potentiostatic conditions (voltage-controlled) offers a new research perspective to extend the service life of aluminum alloys in corrosive environments.

P24

The rich crystal chemistry of 1,3-bisammoniummethyl-cyclohexane, a large organic cation used in the formation of low-D perovskites

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Large organic cations (LOCs), mostly based on protonated amino residuals, are very popular in the field of halide perovskite photovoltaics, being prone to the formation of low-dimensional systems when crystallized with metal halides exhibiting much higher environmental stability than 3D perovskites. In some cases, LOCs are commercially available as uncontrollable mixtures of isomeric molecules, being the separation of which an expensive and tedious task. This is the case of the *cis*/*trans* mixture of bis(aminomethyl)-cyclohexane (BAC). Aiming at understanding the role of reactants purity on the formation and stability of low-D perovskites, in this study we present an original and easy purification method of the *cis*/*trans* mixture of BAC, eventually reducing the "contamination" of the *trans* isomer by a factor of four, a level comparable to that of the more expensive literature method. Thus, we discuss the impact of the pristine and purified LOC on the formation of low-D perovskites. Starting from the commercially available *cis*/*trans* mixture of BAC (Sigma-Aldrich, ca: 3:1), we tackled its purification by sequential crystallization methods. The study here presented is based on ^{1}H-NMR characterization, simultaneous TG/DSC measurements and *ab-initio* structural X-Ray Powder Diffraction (XRPD) analyses, including extensive thermo-diffractometric characterization. The low-D perovskites are studied by XPRD and UV/Vis absorption and emission spectroscopy. We isolated three distinct polycrystalline phases, a mono-iodide (HBAC)I, and two di-iodides, $(H_2BAC)I_2$, in the a- and b-polymorphs. Their full crystal structures were determined by XRPD. More relevantly, their phase stability and the relative enrichment in the *cis*-$(H_2BAC)I_2$ isomer were evaluated in parallel, as crystallographic and chemical purity, in these cases, *do not coincide*. When $(H_2BAC)I_2$ is mixed with PbI_2 in hot water, or BAC and PbI_2 are heated in concentrated HI, elongated single crystals form, their XRPD pattern perfectly matching that of the crystal structure model of a known 2D perovskite (CSD Code: MOCGOE). Broadband emission properties of single crystals and films are currently under investigation. A special attention was put into the selective isolation of *cis*-$(H_2BAC)I_2$ crystal phases, to be used as starting materials for the preparation of 2D perovskites, explored either as passivating/stabilizing agents e.g. for $MAPbI_3$ (the workhorse of perovskite-based solar cells) or for their own optoelectronic properties. XRPD analyses clearly demonstrated the tolerance of di-iodides in accommodating a minimal quantity of the *trans*-$(H_2BAC)^{2+}$ di-cation in the crystal lattice, which we attribute to the isosteric nature of the two isomers, accompanied by the flexibility of the-CH_2-NH_3^+ branches.

P25

Ni exsolution on an A-site-deficient titanate fuel electrode for solid oxide fuel cells

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Solid oxide fuel cells (SOFCs) are a mature technology for energy conversion and storage; however, conventional Ni–YSZ fuel electrodes suffer from coking, nickel coarsening, and agglomeration. To address these limitations, nickel-doped fluorite and perovskite oxides are being investigated as alternative to Ni-based cermets. In this work, an A-site-deficient nickel-doped perovskite titanate, $La_{0.40}Ca_{0.40}Ti_{0.95}Ni_{0.05}O_3$ (LCTNi), is studied as SOFC fuel electrode. Titanates are attractive due to their structural stability under reducing atmospheres. A-site deficiency promotes oxygen-vacancy formation, enhancing ionic conductivity, while Ni doping improves electrocatalytic activity via the exsolution of metallic nanoparticles. The influence of Ni doping on the reaction mechanism was investigated by electrochemical impedance spectroscopy (EIS) on symmetric cells under different fuel atmospheres, combined with Distribution of Relaxation Times (DRT) analysis. Electrolyte-supported SOFC tests were also performed to assess the material's feasibility as a functional fuel electrode. LCTNi and the undoped perovskite $La_{0.40}Ca_{0.40}TiO_3$ (LCT) were synthesised by a modified solution combustion method, carried out under nitrogen flux using ethanol as solvent. Structural and morphological properties were analysed by X-ray diffraction (XRD) and scanning electron microscopy (SEM). Electrochemical behaviour was evaluated using symmetric button cells, with LCT or LCTNi deposited on both sides of a YSZ electrolyte pellet with GDC buffer layers. EIS measurements were performed varying temperature and fuel partial pressure. Impedance spectra were analysed using the DRT method. Both LCT and LCTNi show a single perovskite phase, with no secondary phases detected after 0.5 mol% Ti substitution with Ni. Both perovskite oxides display remarkable stability after high-temperature reduction treatment. SEM analysis of reduced LCTNi shows well-dispersed Ni nanoparticles on the perovskite surface. EIS measurements between 700 and 850 °C under hydrogen and ammonia atmospheres show consistently lower polarization resistance for LCTNi compared to LCT across the entire temperature range. DRT analysis reveals distinct relaxation processes whose relative contributions vary with temperature and fuel, evidencing a modified electrochemical response for the Ni-doped material. The enhanced performance of LCTNi is attributed to exsolved Ni nanoparticles acting as stable catalytic sites that promote fuel activation. DRT analysis indicates a significant reduction of medium-frequency contributions associated with surface chemical reactions, suggesting improved reaction kinetics. The coherent behaviour under both hydrogen and ammonia highlights increased fuel flexibility and the ability of Ni exsolution to mitigate kinetic limitations in titanate-based fuel electrodes, demonstrating the feasibility of Asite-deficient Ni-doped titanates as alternative SOFC fuel electrode materials.

P26

Chiral hybrid perovskites with lead-free composition: investigation of crystal structure and chiroptical properties

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Hybrid Organic-Inorganic Perovskites (HOIPs) are being studied in various application fields because they show the structural flexibility easily modifiable throught the chemical composition. Furthermore, the insertion of chiral organic cations allows the excellent optical properties to be integrated into the perovskites structure. The single crystals were synthesized throught the dissolution of the metal in excess acid, subsequent heating 363 K and addition of the amine in the end then cooled down to room temperature. For the thin film the perovskites were dissolved in the Dimetilsolfosside (DMSO) and produced by spin coating, followed by annealing process. A series of chiral hybrid perovskites was successfully synthesized. Single-crystal X-ray diffraction analysis enabled the determination of the crystal structures and key structural parameters, including the distortion of the BBr_6 octahedra. Density Functional Theory calculations were carried out for all compounds to evaluate the electronic density of states and band structures. The computed bandgaps were consistent with those obtained experimentally by UV–Vis absorption measurements. Thin films of the materials were also prepared and preliminary chiroptical characterization was performed using Circular Dichroism spectroscopy.The combined structural and theoretical analyses highlight the significant role of the central metal in determining the structural and electronic properties of these chiral layered perovskites. These structural variations are expected to influence the electronic structure and optical behavior of the materials, as suggested by the agreement between theoretical band structure calculations and experimental optical measurements. Future work will therefore explore halide substitution and variation in the size of the chiral organic cations to investigate how steric effects and electronic factors modify the hydrogen-bonding network, octahedral arrangement, and ultimately the chiroptical response of the materials.

P27

Synthesis and characterization of Li_2Se, Na_2Se AND K_2Se by experimental and theoretical methods

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Alkali elements are known to play a crucial role in improving the performance of CIGS ($Cu(In,Ga)Se_2$) solar cells, although the mechanisms behind their effects are not yet fully understood. This has stimulated interest in alternative alkali-containing compounds, such as alkali selenides, which may serve as precursors or doping agents in future photovoltaic applications. In this context, the present work focuses on Li_2Se, Na_2Se and K_2Se to achieve a deeper understanding of their structural, optical, and thermodynamic properties. Li_2Se, Na_2Se and K_2Se were synthesized using reactive flux synthesis, which unexpectedly produced shiny and colorful crystals (red for Li_2Se and blue for Na_2Se). Structural characterization was carried out by powder X-ray diffraction (PXRD), while morphology and composition were investigated using scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS). Optical properties were examined through Raman spectroscopy, photoluminescence (PL), and UV–Vis spectroscopy. Experimental results were supported by *ab initio* calculations and simulated Raman spectra. The synthesis method yielded well-defined crystalline products with distinctive optical appearances. Optical measurements were found to be consistent with the observed crystal colors. PXRD and SEM-EDS analyses confirmed the formation of the expected phases and enabled monitoring of their degradation upon exposure to air. The combined experimental and theoretical Raman analyses provided initial insight into vibrational properties. Despite the overall agreement between experimental observations and theoretical predictions, some discrepancies remain and are currently under investigation. Ongoing work is focused on clarifying the electronic band structure of these compounds and on achieving a more comprehensive understanding of their optical behavior and stability.

P28

Ru-oxide based catalysts for biogas reforming and ammonia cracking in SOFCs

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This study investigates the development of a novel ruthenium-based catalyst designed for indirect internal reforming (IIR) of biogas and for ammonia cracking for direct integration with solid oxide fuel cells (SOFCs). Coupling catalytic fuel processing to SOFCs is an effective strategy to improve system efficiency and expand fuel flexibility. Both dry reforming and ammonia decomposition are highly endothermic reactions thus the direct feeding of biogas or ammonia to the SOFC anode is detrimental. not rec. Their significant heat demand can locally reduce the operating temperature, causing thermal gradients, anode shrinkage, and potential mechanical damage to the electrolyte or anode. Nickel-based catalysts are widely used due to their activity in both ammonia cracking and biogas reforming, but they suffer from major drawbacks such as carbon deposition, sintering, and the formation of nickel nitride (Ni_3N). Ruthenium-based catalysts offer a promising alternative thanks to the high intrinsic reactivity, resistance to coking, absence of nitride formation, and superior thermal stability. In this work, Ru-oxide catalysts are developed exploiting the exsolution of metallic Ru nanoparticles from a perovskite support, enabling multifunctional activity for both biogas dry reforming and ammonia cracking under high-temperature SOFC operating conditions. The catalysts are synthesized using solution combustion synthesis (SCS), employing metal nitrates as precursors. Exsolution of Ru nanoparticles are induced in operando under reducing conditions, producing highly dispersed and strongly anchored metallic sites. Several perovskite supports are investigated. The crystalline structures are characterized by X-ray diffraction (XRD), surface morphology by scanning electron microscopy (SEM), and specific surface area by Brunauer–Emmett–Teller (BET) analysis. The catalyst is deposited onto NiCrAl foams and used as a structured catalyst upstream of a conventional SOFC based on YSZ electrolyte with a NiO/GDC anode and LSFC/GDC cathode. Cell performances are evaluated through polarization and power density curves and electrochemical impedance spectroscopy (EIS). Among the synthesized materials, those exhibiting monophase structure, high surface area, and favorable morphology were selected for the structured catalyst fabrication. When the system was fueled with ammonia or biogas, the resulting performance - polarization resistance, power density, and stability - are evaluated and compared to operation with pure hydrogen. Our results demonstrate the feasibility of using a Ru-based exsolved catalyst to enable SOFC operation with alternative fuels. The high surface area and stability of the exsolved Ru nanoparticles provide a robust platform for efficient ammonia cracking and biogas reforming, supporting flexible and reliable SOFC operation.

P29

Organic HOMO-LUMO alignment in 2D chiral perovskites

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In most 2D hybrid perovskites, the electronic and optical properties are largely dictated by the inorganic layers, while the organic cations play only a secondary structural role. To date, the use of chiral organic molecules has mainly introduced chiroptical effects such as the circularly polarized exciton (CISS-related responses), without substantially contributing to the electronic structure of the material. Introducing chiral cations whose frontier orbitals (HOMO/LUMO) are energetically aligned with the valence and conduction bands of the inorganic framework offers a promising opportunity to directly influence charge transfer processes and excitonic behaviour. Designing organic cations that are both chiral and electronically matched to the inorganic perovskite layers could therefore enable a new class of chiral 2D perovskites with enhanced and tunable optoelectronic functionality. To achieve the challenging goal of precise energy band alignment, a library of chiral organic cations was synthesized following preliminary DFT computational screenings of their HOMO and LUMO levels. For the inorganic framework, lead (Pb) was selected as the primary metal center, with future plans to explore tin (Sn) and germanium (Ge). Iodine (I) was employed as the starting halide to maximize electronic coupling, though subsequent studies will evaluate bromine (Br) substitution to further tune the material's optoelectronic response. The samples were prepared via acid-phase synthesis, and X-ray diffraction (XRD) was employed to evaluate the obtained structures. Initial structural analysis confirms the successful incorporation of the chiral organic amines into the 2D perovskite framework, maintaining the desired layered architecture. Comprehensive characterization is currently underway to map the electronic band alignment and evaluate the photoelectronic properties, specifically focusing on how the electronically active cations influence charge-transfer dynamics and chiroptical responses. The successful integration of electronically active chiral cations marks a significant shift from traditional 2D perovskites, where organic layers typically act as inert spacers. By matching the frontier orbitals of the chiral molecules with the inorganic bands, we create a pathway for direct charge-transfer and enhanced excitonic control. This synergy is expected to amplify chiroptical responses beyond simple structural distortion, potentially overcoming current efficiency limits in spin-dependent optoelectronic devices.

P30

Computational and experimental studies on Bi and Sb containing chiral metal halides for chiroptoelectronic applications

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Metal halide perovskites (MHPs) attract intense research for their exceptional optoelectronic properties and tunable bandgaps. The incorporation of chiral organic cations induces chiroptical activity and the Rashba–Edelstein effect, enabling spin-dependent phenomena such as chirality-induced spin selectivity (CISS). Since most chiral metal halides reported to date contain toxic lead, the development of efficient lead-free alternatives based on Bi(III) and Sb(III) is crucial for sustainable chirality-driven optoelectronics and spintronics. Lead-free chiral iodides Cl-$PEA_4M_2I_{10}$ (M = Bi, Sb) were synthesized using R/S-1-(4-chlorophenyl)ethylammonium as the chiral organic cation, yielding enantiopure and racemic single crystals. Mixed Sb/Bi compositions were prepared to investigate bandgap bowing. Structures were resolved by single-crystal XRD; phase purity and bowing trends were confirmed by powder XRD. Optical properties were characterized by UV–Vis absorption and circular dichroism (CD) spectroscopy. DFT calculations, starting from experimental geometries, optimized crystal structures, computed electronic band structures, quantified Rashba spin splitting, and analysed total and projected density of states (DOS/PDOS). High-quality single crystals of both enantiomers and the racemic form were obtained for Cl-$PEA_4Bi_2I_{10}$, Cl-$PEA_4Sb_2I_{10}$, and mixed Cl-PEA_4BiSbI_{10}. Single-crystal XRD confirmed the expected 0D vacancy-ordered structure with chiral organic layers. Powder XRD verified phase purity and revealed clear bandgap bowing in the mixed Sb/Bi system. UV–Vis spectra showed absorption onsets between 2.1–2.6 eV, while CD measurements displayed strong bisignate signals confirming macroscopic chirality. DFT results quantified Rashba spin splitting up to 85 meV at the band edges and identified dominant Bi-6p/Sb-5p and I-5p orbital contributions to the valence and conduction bands. The experimental and computational data demonstrate that Cl-$PEA_4M_2I_{10}$ (M = Bi, Sb) successfully combines pronounced chiroptical responses with significant Rashba splitting in a completely lead-free framework. The observed bandgap bowing in mixed compositions, rationalized by PDOS analysis, originates from the different s/p orbital contributions of Bi and Sb, extending the tunability previously reported in achiral vacancy-ordered perovskites. These results position the new materials as promising platforms for sustainable spin-optoelectronic devices exploiting CISS. Future work will focus on thin-film fabrication and device integration.

P31

Balancing viscosity and thermal conductivity in TiO_2/SiO_2 nanofluids: rapid operating-window maps for efficient heat exchange

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While oxide nanofluids often raise thermal conductivity, the same particles can increase viscosity, eroding net heatexchange gains once pumping power is included. For energy-efficiency and circular-economy targets – cutting energy waste and extending equipment life – the practical question is when a nanofluid delivers a net thermo-hydraulic benefit. This contribution proposes a rapid, design-oriented workflow to map viscosity-conductivity tradeoffs for TiO_2 and SiO_2 nanofluids into actionable operating windows for low temperature service exchange gains once pumping power is included. At a single, modest loading, k(T) and μ(T) were measured for TiO_2 and SiO_2 nanofluids between ambient and ~90–100 °C under standardized dispersion (pH/ionic strength control, fixed sonication protocol). From these properties, we computed Reynolds number shifts, number shifts, pressure trends, and a compact figure of merit rewarding conductivity gains while penalizing viscosity increases. Stability checks (zeta/DLS, visual sedimentation) ensured that apparent drop trends, and a compact figure of merit rewarding conductivity gains while penalizing viscosity increases. Stability checks (zeta/DLS, visual sedimentation) ensured that apparent- advantages were not artifacts of transient dispersion. Both oxides provided modest k enhancements whose usefulness depended strongly on μ(T). SiO_2 tended to preserve lower viscosity at comparable loading, shifting operating windows toward higher Re at equal flow, while TiO_2 offered slightly stronger k gains but earlier viscosity penalties. Stability screening eliminated conditions where agglomeration likely biased properties. The resulting maps identify temperature/flow regions in which each nanofluid can provide a net efficiency benefit without an unjustified pumping burden. A screen-then-design approach allows stakeholders to select formulations and duty points that minimize energy consumption and wear-key levers for the circular economy (lower electricity use, fewer maintenance interventions, longer component lifetimes). Moreover, the workflow is straightforward to scale up in the near future, for example by adding convective heat-transfer measurements, loop-level Δp validation, and broader concentration sweeps. This positions nanofluid adoption as a decision-guided choice rather than a generic percentage-improvement claim in thermal conductivity.

P32

Surface stability of $LaNi_5$: a foundamental basis for understanding its reactivity

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Among the key technological routes for reducing the carbon footprint, CO_2 methanation plays a relevant role. From previous works with $LaNi_5$ as catalyst, we observed a complex decomposition mechanism of the material in the reaction environment. Clarifying this mechanism is essential for the rational improvement of reaction conversion and selectivity. To do this, the first step has been to investigate surface stability through combining ab-initio and experimental studies. Several terminations of the crystal structure were modelled with Density Functional Theory (DFT) at the PBEsol level of theory, using the Vienna Ab-initio Simulation Package (VASP), enabling to build the particle Wulff shape as implemented in the WulffPack code. For the synthesis of $LaNi_5$, the pure elements were melted by arc-melting into an Ar-filled atmosphere. Single crystals of $LaNi_5$ were obtained employing the self-flux growth technique in a Canfield-type crucible. The crystals were characterized with Scanning Electron Microscopy (SEM), X-Ray Powder (XRPD) and Single Crystal Diffraction (SCXRD). Micrometric, hexagonally shaped crystals of the target phase were obtained. SEM and XRPD analyses confirmed the formation of the desired material. Indexing of the exposed crystal facets, performed by SC-XRD, revealed a predominance of the (001) surface. Notably, the latter displays the lowest surface energy, and the calculated Wulff construction shows agreement with the morphology of the grown crystals. The combined theoretical and experimental results identified the (001) surface as the most stable termination of $LaNi_5$, with an average surface energy of 1.57 J/m^2. This facet is both the lowest-energy termination predicted by DFT and the predominant surface observed by SC-XRD, clearly indicating that the surface energetics drives the equilibrium morphology. The agreement between the Wulff construction and the experimental crystal shape further validates the computational approach. These findings provide a solid foundation for future investigations on the surface reactivity of $LaNi_5$, particularly regarding how surface energetics and potential defect formation may influence the decomposition pathways previously observed during catalysis.

P33

A simple method to distinguish light scattering from light absorption by nanoparticles

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Understanding the relative contributions of light absorption and scattering in nanoparticle (NP) suspensions is crucial for optimizing their performance in photothermal, imaging, and energy-conversion applications. Since conventional methods rely on specialized and less accessible instrumentation, a simple approach based on a standard spectrofluorometer with synchronous scanning was developed to quantitatively separate absorption and scattering contributions. This method was then applied to explain the different photothermal efficiencies of natural (Sepia) and biomimetic (polydopamine, PDA) melanin NP. Extinction spectra were measured by UV-Vis spectroscopy, while synchronous excitation-emission spectra (SEES) were recorded using a conventional spectrofluorometer and silica NP as a scattering reference. Photothermal performance was evaluated by irradiating suspensions and monitoring temperature changes. Ultrafast transient absorption and fluorescence measurements were used to evaluate excited-state deactivation.The method enabled simple estimation of scattering efficiencies for different NP systems. Sepia and PDA NP displayed different scattering contributions despite their similar compositions. Photothermal experiments revealed higher temperature increase for samples with lower scattering efficiencies, with sepia NP exhibiting superior heating efficiency compared to PDA NP. Ultrafast spectroscopy confirmed that all samples deactivate rapidly and non-radiatively with very low fluorescence quantum yields, indicating that absorbed energy is efficiently converted into heat. The results demonstrate that differences in photothermal efficiency among melanin-based NP arise mainly from variations in light scattering rather than intrinsic excited-state dynamics. The proposed method provides a rapid and widely accessible tool to separate absorption and scattering contributions using standard instrumentation. Overall, this method provides an effective and accessible strategy for distinguishing absorption from scattering in nanomaterials and offers a valuable design tool for engineering next-generation photothermal platforms.

P34

Pirolisi catalitica di una miscela di rifiuti polimerici commerciale in un impianto in scala di laboratorio

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The increasing generation of plastic waste and the limitations of mechanical recycling have intensified interest in chemical recycling routes such as pyrolysis. Thermal pyrolysis involves non-selective radical cracking at high temperatures, producing complex mixtures of gases, liquids, and solids. In contrast, catalytic pyrolysis employs active materials to improve selectivity and tailor product distribution. Catalytic processes can be conducted in-situ, with direct contact between polymer and catalyst, or exsitu, where pyrolysis vapors are upgraded over a separate catalyst bed; the latter is considered more attractive for industrial implementation. This work compares thermal and catalytic pyrolysis under identical conditions and reactor configuration. All experiments were conducted in a laboratory-scale batch setup using a vertical quartz reactor loaded with 5 g of feedstock per run. Catalytic tests were performed in an ex-situ configuration with a downstream fixed catalyst bed. Nitrogen (100 mL min^{-1}) was used as sweep gas to maintain inert conditions and transport volatile products. The reactor was heated at 15 °C min^{-1} up to 850 °C. Condensable products were collected and qualitatively analyzed by GC–MS, while permanent gases were analyzed by gas chromatography. Outlet gas flow rate was monitored, and product yields were determined gravimetrically for liquids and solids, with gas yield calculated by difference. Two commercial powdered catalysts were tested: Pt/γ-Al_2O_3 activated in $NaBH_4$ solution and a ZSM-5 zeolite activated by calcination at 550 °C. Gas flowrate profiles were comparable in thermal and catalytic runs, indicating similar devolatilization behavior. However, total gas yield was higher in catalytic pyrolysis and gas composition significantly improved, with hydrogen concentration nearly doubling compared to thermal tests. Although liquid yield decreased under catalytic conditions, product quality markedly increased. The oils appeared clearer and less viscous, with strongly reduced waxy residues. Compositional analysis showed a higher fraction of light and aromatic compounds and the absence of heavy hydrocarbons in the C17–C40 range. The results demonstrate a significant effect of catalyst presence on product distribution and quality. Operational limitations were observed, including pressure drop increase and partial clogging of the fixed bed due to residues and coke deposition, particularly with zeolite catalysts. Ongoing experiments aim to modify catalyst–vapor contact (e.g., pellets or monoliths) to mitigate these issues. Future work will investigate the influence of catalyst bed position, and thus temperature, on carbon deposition, and evaluate tailored catalysts for polyolefin cracking.

P35

Engineered $CuWO_4$/*a*-TiO_2 photocathodes for photoelectrochemical nitrate-to-ammonia conversion in neutral

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Ammonia is a key chemical and energy carrier, but its conventional production via the Haber–Bosch process is energy and CO_2 intensive. Solar-light photoelectrochemical (PEC) nitrate (NO_3^-) reduction, to produce ammonia (NH_3/NH_4^+) offers a milder and more sustainable alternative. Cu-based photoelectrodes show promising nitrate affinity and selectivity, however their implementation is often limited by insufficient chemical and photoelectrochemical stability. Herein we report the application of CuWO4/*a*-TiO_2 photoelectrode for NO_3^- reduction, with excellent stability, enhanced solar to current conversion as respect to dark conditions, and a Faradic Efficiency of 54%. $CuWO_4$/*a*-TiO_2 emerges as a promising photocathode that mitigates stability problems typical of Cu-based systems while retaining selectivity toward ammonia production. Sol-gel spin coated (over FTO substrates and annealed at XX °C) crystalline $CuWO_4$ thin films were overlayed with an amorphous TiO_2 (*a*-TiO_2) thin film to obtain $CuWO_4$/*a*-TiO_2 photocathodes. PEC measurements were performed in aqueous 0.1 M Na_2SO_4 containing 0.5 M $NaNO_3$, under solar light illumination. Linear sweep voltammetry (LSV) (0.8 to −0.6 V vs RHE) and chronoamperometry (CA) (0.40 V vs RHE for 2 h) were carried out. After cronoamperometric tests, NO_2^- and NH_4^+ were quantified. $CuWO_4$/a-TiO_2 exhibits a stronger photoresponse than $CuWO_4$, with a 57% higher current density at 0.20 V vs RHE under illumination compared to dark conditions. Compared with $CuWO_4$, the heterostructure also showed superior stability: during 2 h chronoamperometry at 0.40 V vs RHE under illumination, it maintained a more stable photocurrent, suggesting improved operational durability. Product analysis further confirmed the performance gain in nitrate reduction selectivity: $CuWO_4$/a-TiO_2 reached a Faradaic efficiency of 51% towards NH_3/NH_4^+, corresponding to a 38% increase in NH_3/NH_4^+ production compared with $CuWO_4$.The addition of an amorphous TiO_2 overlayer on nitrate selective $CuWO_4$ acts as a protective and functional interfacial layer, enhancing long-term stability and improving PEC activity toward nitrate to ammonia conversion. Overall, $CuWO_4$/a-TiO_2 engineering provides a practical strategy to boost efficiency and durability of $CuWO_4$ photocathodes for ammonia production.

P36

Studio e realizzazione di un sistema a membrana catalitica finalizzato alla produzione di idrogeno attraverso la reazione di water splitting

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In catalytic membrane reactors, the membrane separation process is integrated with catalytic reactions. The thermolysis of water molecules into hydrogen and oxygen is a highly endothermic process with a positive standard Gibbs free energy change (ΔG° = 237 kJ/mol) and a very low equilibrium constant (Kp = 2 x 10-8 at 950 °C). Therefore, the efficient production of hydrogen using WS is difficult to achieve. However, by using a membrane reactor (equipped with an Oxygen transport membranes OTM), it is possible to remove the oxygen which is one of the reaction products. This approach enables the equilibrium to be shifted towards higher H_2 yields. Furthermore, if the membrane were made catalytic, they can be potentially for controlled oxidation reactions. By coupling an oxidation reaction on one side of the membrane with WS on the opposite side, it is possible to transfer more oxygen, promoting a shift in the equilibrium and thus increasing the final hydrogen yield. The objective of this project was to perform the WS in a membrane reactor by coupling it with the partial oxidation of methane (POM). Some OTM membranes were produced by RSE using perovskite materials. These were used as membranes to transfer oxygen. Both sides of the membranes were modified in order to be catalytic. To do this, POM catalysts were chosen and tested using in a temperature range of 650-800°C to evaluate the best performing one. Subsequently, the catalyst powders were deposited on the membranes to create homogeneous porous layers. The membranes will then be tested within the WS+POM process. Ni/CSTF, Ni/CeO2 and Ni/Al2O3-U achieved the highest values of H2 at temperature higher than 750°C. The CSTNi#2 catalyst achieved hydrogen selectivity values of 85% already at 700°C. The carbon formation was observed in almost all tests at all temperatures, with the exception of CSTNi#2 and CSTF -based perovskites. Screen printing and drop casting techniques proved to be viable options for the production of the final catalytic membrane. In this study different Nickel catalysts were tested in POM. A particular attention was placed on obtaining the highest H_2 selectivity and the lowest carbon formation. To do that, different supports and deposition techniques were applied. The carbon formation occurred in all catalyst except for CSTNi#2 and CSTF -based perovskites. Screen printing emerged as the most effective deposition technique for achieving uniform and precise layers on the membrane.

P37

Double b-site substitued co-free perovskite oxides for reversible solid oxide cells (RSOCs)

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High-temperature CO_2 electrolysis in solid oxide electrochemical cells offers one of the most efficient routes for carbon dioxide conversion, enabling the production of highly pure carbon monoxide due to favourable thermodynamics and fast kinetics above 600 °C. The emergence of CO:CO_2 reversible solid oxide cells (RSOCs) further enhances system efficiency promoting integration with CO_2- and CO-rich industrial exhaust streams. However, reversible operation imposes stringent requirements on electrode materials, which must combine high catalytic activity, redox stability, and long-term durability under a wide range of oxygen partial pressures. We report a doubly B-site–substituted perovskite, $La_{0.6}Sr_{0.4}Fe_{0.6}Mn_{0.2}M_{0.2}O_{3-\delta}$ (M = Cu, Ni), as a multifunctional electrode platform for RSOCs. Both $La_{0.6}Sr_{0.4}Fe_{0.6}Mn_{0.2}Cu_{0.2}O_{3-\delta}$ (LSFMC) and $La_{0.6}Sr_{0.4}Fe_{0.6}Mn_{0.2}Ni_{0.2}O_{3-\delta}$ (LSFMN) are synthesized as single-phase perovskites, with rhombohedral symmetry (R-3c). When evaluated as oxygen electrodes in symmetric cell configurations, LSFMC and LSFMN exhibit significantly enhanced oxygen electrocatalysis, achieving an area-specific resistance decrease by 51% and 38%, respectively, compared to the unsubstituted material. Under reducing conditions, LSFMN undergoes controlled and homogeneous exsolution of Fe–Ni nanoparticles, generating catalytically active metallic domains while preserving structural integrity. This exsolution process is key to the enhanced catalytic activity and redox stability of the fuel electrode, enabling efficient CO oxidation and CO_2 electrolysis under large oxygen partial pressure fluctuations. In contrast, LSFMC exhibits superior oxygen surface exchange and transport properties, making it particularly effective as an air electrode for ORR/OER. A quasi-symmetric electrolyte-supported cell based on $La_{0.8}Sr_{0.2}Ga_{0.8}Mg_{0.2}O_{3-\delta}$ (LSGM) electrolyte, employing LSFMN as fuel electrode and LSFMC as air electrode, demonstrates excellent performance and durability in both CO-fuelled solid oxide fuel cell mode and CO_2 electrolysis mode. Stable and reversible operation is maintained for over 150 h in a 50:50 CO:CO_2 mixture. Overall, exsolution-engineered Mn-stabilized ferrites are established as a robust, cobalt-free electrode platform for RSOCs, highlighting metal exsolution as a powerful tool to simultaneously achieve high catalytic activity, redox resilience, and long-term durability in reversible CO:CO_2 electrochemical conversion.

P38

STEROPE EU Project: Synergistic Advanced Carbon Capture Technologies for ConvERsion of Industrially Emitted CO_2 to sustainable Production of biofuels and chEmicals)

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The decarbonization of "hard-to-abate" sectors, as for example aviation, shipping, and heavy industry, is one most significant challenges to achieve climate neutrality. While electrification is a viable option for some industries, sectors like maritime and aviation need high-energy-density liquid fuels. The EU-funded Horizon Europe project STEROPE (Synergistic Advanced Carbon Capture Technologies for ConvERsion of Industrially Emitted CO_2 to sustainable Production of biofuels and chEmicals, ID 101235659, https://sterope-project.eu/) addresses this by turning industrial CO_2 emissions into a valuable feedstock for renewable e-fuels, such as e-methanol, e-DME, and sustainable aviation fuel (e-jet) by three Cabon Capture and Utilization (CCU) technologies. The project aims to demonstrate a first-of-a-kind TRL 7 system integrated into a real industrial environment to foster a circular economy and industrial symbiosis. The STEROPE approach is based on the integration of both membrane materials and systems capable of operating under real refinery conditions for CO_2 capture and of new catalytic systems for its conversion into fuels. The project has a multi-scale approach: from the selection of innovative materials and catalysts to the configuration of membrane modules and reactors. The initiative develops and integrates three CCU units, which will be installed and tested at the Eleusis refinery (Greece) as part of a demonstration plant. The demo including the three prototypes will be integrated into the regular operation activities of the refinery. The digital twin approach will enhance operational efficiency and optimise renewable e-fuel production. The STEROPE project is currently in its initial phase. The demonstration plant is designed to prove the technical feasibility and safety of producing e-methanol, e-DME, and e-jet fuels that comply with shipping and aviation requirements. Preliminary designs indicate that the membrane-based capture unit will significantly reduce the energy footprint compared to traditional amine scrubbing. The capture system is expected to provide a high-purity CO_2 feedstock (ready for catalytic conversion) while maintaining stability under industrial flue gas contaminants. STEROPE advances the principles of industrial symbiosis by enabling resource sharing and reuse within an active refinery. The deployment of advanced membrane systems and catalysts within the STEROPE project represents a significant advancement in Materials Science applied to industrial symbiosis. By shifting from lab-scale prototypes to a TRL 7 demonstration in a refinery, the project addresses the technical barriers of scalability and durability. By converting CO_2 into high-value renewable fuels, the project provides a scalable defossilization pathway that reduces exposure to carbon costs and unlocks new revenue streams.

P39

Understanding the effect of solvent and pretreatment on Ru-based catalyst for CO_2 hydrogenation reaction

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CO_2 hydrogenation via the Sabatier reaction using green hydrogen is a promising way to meet carbon neutrality, producing methane that can be injected into the natural gas grid. This reaction is performed with Ni- or Ru-based catalysts, which may deactivate due to particle sintering or coke deposition. For low-temperature applications, Ru-based catalysts are considered the best option. However, the cost of Ru has a significant impact, as does the selection of the solvent used in the preparation step and the subsequent pretreatment, since RuO_4 is volatile. This work aims to highlight the effects of both the solvent and the pretreatment on Ru-catalysts, and to investigate the reaction mechanism under transient *operando* conditions. Ru/Al_2O_3 catalysts were prepared by incipient wetness impregnation using ethanol and water as solvents. Different pretreatments were investigated: calcination in static air followed by reduction, direct prereduction, and heat treatment in nitrogen followed by reduction. Catalytic performance was evaluated in a laboratory-scale plant using a quartz reactor over the 523-773 K temperature range. An online FT-IR spectrophotometer analyzed reaction products. *Operando* transmission experiments on transient $CO_x/CO/CO_2$ streams were performed using an FT-IR spectrophotometer and a homemade "Sandwich" IR reactor cell. Solvent choice had a significant impact on the catalytic performance of Ru-based catalysts. The catalyst prepared with ethanol and pretreated in a N_2 environment, followed by H_2 reduction, exhibited the best performance in terms of CO_2 conversion, CH_4 selectivity, and catalyst stability. These results are supported by characterization, which revealed different Ru nanoparticle sizes depending on solvent choice and pretreatment, and particle sintering observed in pre-calcined catalysts. *Operando* studies on transient $CO_x/CO/CO_2$ streams revealed that the pathway for CO_x hydrogenation to methane follows the monohydrogen carbonate–formate–carbonyl route. This study revealed the importance of selecting the appropriate solvent and pretreatment for Ru-based catalysts for the CO_2 hydrogenation reaction, and it also highlighted the need to understand the reaction mechanism through *operando* studies of transient CO_x streams.

P40

Phase stability and competing crystal structures in the formation of the intermetallic compounds Cu_5As_2 and $Cu_5(As,Sb)_2$

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The new intermetallic phase $Cu_5(As,Sb)_2$ has been identified. Like the known parent binary Cu_5As_2 forming with a small Cu understoichiometry (*i.e.*: as $Cu_{5-x}As_2$), this new ternary compound was also found to form understoichiometric in Cu: therefore, with a composition $Cu_{5-x}(As,Sb)_2$. Cu-As and Cu-As-Sb samples were analysed using: light-optical microscopy (LOM); field-emission scanning electron microscopy (FE-SEM) coupled with energy-dispersive X-ray spectroscopy (EDS) and Electron Backscatter Diffraction (EBSD); powder and single crystal X-ray diffraction (XRD); Rietveld refinement; Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC); Physical Properties Measurement System (PPMS, Quantum Design). Solid solubility has been found for $Cu_{5-x}(As,Sb)_2$, with compositional ranges of 68.9–71.5 at.% for Cu (against a Cu content of 71.4 at.% for the stoichiometric ratio of 5:2), of 23.2–28.6 at.% for As and of 1.9–5.1 at.% for Sb. There appears to be no continuous solid solubility between the two phases. Similar to its parent compound, $Cu_{5-x}(As,Sb)_2$ crystallizes in the same crystal structure: the orthorhombic Mg_5Ga_2 structure type (*oI*28, *Ibam*, N. 72). Its lattice parameters have been detected within the range of a = 5.968–5.977(1) Å, b = 11.55–11.565(3) Å, c = 5.530–5.573(3) Å. Similar to the parent binary compound, forming peritectically and existing in between 709-300 °C, it also forms peritectically at 650–635°C and is a high-temperature phase. On lowering the temperature $Cu_{5-x}(As,Sb)_2$ starts to decompose at about 380–360°C and at about 320–300 °C is fully decomposed into the hexagonal $Cu_{3-x}As$ (Cu_3P-type; *hP*24–*P*6$_3$*cm,* N. 185) and As–Sb [As-type; *hR*6–*R*-3*m*, No. 166]. The kinetics of the decomposition mostly depending on the overall composition of the alloy and on the cooling rate. No proof of HT or LT phases of both the binary $Cu_{5-x}As_2$ and the ternary $Cu_{5-x}(As,Sb)_2$ compound was found. Electrical resistivity has been measured on polycrystalline bulk samples of the $Cu_5(As,Sb)_2$ compound. We have found that it is a good metal, with electrical resistivity decreasing monotonically with decreasing the temperature.

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Mössbauer spectroscopy: opportunities and perspectives for materials science

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Mössbauer Spectroscopy (MS) has established itself as a very powerful technique, being able to provide chemical, structural and magnetic information on a wide variety of materials. In such perspective, this technique is used in a broad range of research areas, (e.g. Chemistry, Physics, Biology, Geology, Materials Science) for both fundamental and industrial applications. The present communication, by shortly discussing several examples, will show how MS on condensed matter opens interesting opportunities and perspectives in the research area of Materials Physical Chemistry, with particular attention to the nanostructured magnetic materials. MS probes the effects of hyperfine interactions between the nucleus and the surrounding environment. In fact, even if the energy contribution due to hyperfine effects is very low, this technique allows to detect them thanks to its very high energy resolution (e.g. $\Delta E \sim 10^{-9}$ eV for the ^{57}Fe I= 1/2 → 3/2 14.4 keV nuclear transition). In this regard MS allows a quantitative evaluation of Iron Fe^{3+} an Fe^{2+}, which often represents a tricky issue in several systems. Taking as a case study nanostructured spinel iron oxide, the longstanding distinction among magnetite (Fe_3O_4) and maghemite (γ-Fe_2O_3) will be discussed, showing how MS can give a resolutive contribution in this scientific debate. The extraordinary sensitivity in investigating hyperfine interactions also allows the study of interface between different materials, as demonstrated in the $SrFe_{12}O_{19}/CoFe_2O_4$ system, where MS makes it possible to identify the crystallographic sites at which the interface iron atoms are located. In studying nanostructured magnetic materials, the very short experimental time windows (tw = 5×10^{-9} s) of MS allows a careful investigation of the magnetization dynamics revealing interesting features, such as super spin-glass regime. Moreover, Mössbauer spectroscopy under intense magnetic field (MSHF) allows even to investigate magnetic structure of such class of materials: using nanostructured spinel ferrites as a model system it is possible to evaluate how the interplay among inversion degree and surface magnetic disorder (i.e. spin canting) affects the magnetic properties. Finally, the perspectives related to the use of ^{57}Fe-enriched nano-heterostructures in order to increase Mössbauer sensitivity will be discussed.

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Surface functionalization of biodegradable films by cold plasma treatment for sustainable packaging applications

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Biodegradable polymers such as poly(butylene succinate) (PBS), poly(butylene adipate-co-succinate) (PBSA), and poly(lactic acid) (PLA) are promising candidates for sustainable packaging applications. However, their low surface energy and poor wettability limit their performance in processes such as coating, printing, and lamination. Surface functionalization is therefore required to enhance interfacial properties. In this context, cold plasma treatment represents an environmentally friendly and solvent-free technique capable of modifying surface properties. However, process optimization is crucial to enhance surface wettability while avoiding polymer degradation and preserving the thermal and mechanical stability of the material. Blown biodegradable films based on PBS, PBSA and their blends with PLA were treated using a lowpressure capacitively coupled plasma (CCP) reactor with oxygen as the ionizing gas. In a first stage, process parameters (treatment time, applied power, and gas flow rate) were optimized using a Design of Experiments (DoE) approach based on Response Surface Methodology (RSM), combined with a Random Forest regression model, enabling the identification of conditions that maximize surface wettability. In a second stage, films treated under optimized plasma conditions were subjected to an extensive characterization of chemical, thermal, mechanical, barrier and adhesion properties to investigate the effect of plasma treatment. The influence of biopolymer type and film composition on plasma effectiveness and hydrophobic recovery was also systematically assessed. The optimized plasma conditions led to a significant improvement in surface wettability, with a reduction in water contact angle observed for all films, reaching a maximum decrease of up to 40%. Oxygen plasma treatment promoted the formation of polar oxygen-containing functional groups on the film surface, as confirmed by FTIR analyses, resulting in increased surface free energy (up to 57 mN/m). The extent of modification depended on both processing conditions and material composition, with different responses observed for PBS-, PBSA-, and PLA-based systems and their blends. Plasma-treated films also exhibited improved adhesion and enhanced printability with water-based inks. Surface morphological changes induced by plasma treatment also showed a slight effect on the functional properties of the films. The results highlight the effectiveness of cold plasma treatment as a surface modification strategy for biodegradable polymers, enabling improved interfacial properties. The combined use of DoE and machine learning tools provides a promising framework for process optimization, supporting the development of high-performance, sustainable packaging materials with enhanced functionality and industrial applicability. The observed dependence on polymer type and composition suggests that plasma effectiveness is strongly influenced by material-specific characteristics. In particular, molecular mobility plays a key role in governing surface reorganization phenomena, affecting both the incorporation of polar functional groups and the hydrophobic recovery over time.

P43

Electrospun fibers based on furanic copolymers for air filtration

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Current research focuses on sustainable materials for air filtration with intrinsic antimicrobial and antifouling properties. Poly(alkylene furanoates) (PAFs) represent a promising alternative to polyethylene terephthalate (PET). Here, electrospun fibrous filters based on different PAFs were developed and characterized to improve hydrophobicity and filtration performance. A copolymer of poly(hexamethylene 2,5-furanoate) (PHF) containing Pripol moiety and two different copolyesters of poly(butylene 2,5-furanoate) (PBF) containing different amounts of Priamine were synthesized and used to produce electrospun fibers using exafluoro isopropanol (HFIP) as the main solvent and chloroform and dichloromethane as co-solvents. The obtained fibrous meshes were characterized by Scanning Electron Microscopy (SEM), surface porosity using ImageJ software on SEM micrographs, bulk porosity measured by pycnometry, and water contact angle (WCA) measurements. Selected samples were incubated with *E. coli*, and the evaluation of adhesion/growth after 24 h was performed by SEM imaging. Staphylococcus epidermidis (*S. epidermidis*) was selected as a representative bacterial species commonly detected in automotive air filters for antibacterial evaluation. The addition of co-solvents to HFIP enabled the formation of fibers with improved morphology and lower fiber size, leading to diameters approaching the 200 - 300 nm range and WCA in the range of 103°- 122°. No marked differences were observed in the surface porosity of fibrous meshes prepared with different co-solvents, with values ranging in 19.5 - 21.5 %. The bulk porosity of all fibrous meshes ranged in 60 - 90 %, meeting the expected porosity requirements for cabin air filters. SEM observations revealed the presence of highly damaged bacteria on PHF based copolymer fiber surfaces after contact, suggesting a potential bactericidal effect. The different content of Priamine in PBF-based copolymers copolymers affected the bacterial adhesion.The combination of bio-based PAFs chemistry and hydrophobicity, together with the fibrous structure, may contribute to reduce bacterial adhesion and viability. These results indicate that hydrophobic PAF-based electrospun fibers, combined with tailored surface textures, represent a promising strategy for the development of sustainable antibacterial air filtration materials.
Acknowledgments: This project has received funding from the Circular Bio-based Europe Joint Undertaking under grant agreement “GA101112541” project FURIOUS (Call: HORIZON-JU-CBE-2022).

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Valorization of polyolefin blends from marine litter via additive manufacturing: a study on thermo-mechanical and rheological stability

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The increasing dispersion of plastic waste in marine environments represents a pressing environmental challenge of our time. In this context, this research aims to transform marine plastic waste into a valuable resource for additive manufacturing. The variability of recovered mixed polyolefins (MPO), sourced from heterogeneous items, requires careful formulation optimization to ensure adequate processability and performance. This study investigated the thermal, rheological, and mechanical properties of MPO, with the goal of producing functional artifacts through pellet-based 3D printing. The formulation consisted of an MPO (PE/PP from marine recovery) with added Irganox B215, Epolene E43, and a $CaCO_3$-based biofiller (10wt%). Characterization included TGA, DSC, and SEM microscopy. Oscillatory rheology was performed on the ready-to-print formulation and after 12 extrusion cycles. Dogbone specimens were produced using a Delta Wasp 4070 High-Definition Pellet (HDP) 3D printer. Mechanical properties were evaluated through tensile and three-point bending tests. TGA analysis confirmed that the use of Irganox leads to greater thermo-oxidative stability, while DSC determined 70/30 PE/PP composition (from crystalline phase), essential for setting the HDP printing parameters. Rheological tests showed optimal shear-thinning behavior and stable viscosity over time. Mechanical characterization revealed that the biofiller and compatibilizer (Epolene) addition significantly increased Young's and Flexural Moduli, as well as Flexural Strength compared to neat MPO. Tensile Strength values confirmed the effectiveness of the stabilization and compatibilization strategy. SEM micrographs validated the efficacy of Epolene in ensuring excellent interfacial cohesion, eliminating structural voids in the printed specimens. Integrated characterization allowed the definition of an optimal processing window for HDP technology. The bio-filler enhanced tensile and flexural performance which combined with the rheological stability, ensured structural integrity and dimensional accuracy. Despite the degradation of marine plastics, the effect of the additives enabled the regeneration of MPO into a high-performance material for large-scale circular manufacturing.
Funded by the Interreg Maritime FR-IT programme https://interreg-marittimo.eu/fr/web/plastron.

P45

Aesthetic transparent wood from underexploited mediterranean species

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Transparent wood composites have recently attracted growing interest due to their renewable origin, low density, and cost-effective processing. Aesthetic transparent wood is particularly appealing because it combines optical transparency with mechanical performance while preserving the natural warm tone and characteristic wood veining. The idea is to develop aesthetic transparent wood composites derived from underexploited Mediterranean wood species, targeting potential applications in emerging engineering fields where lightweight, and optically functional materials are required. A time-efficient delignification process is adopted, followed by a vacuum impregnation with a partially bio-based epoxy resin, as a step toward reducing dependance on typical fossil-based polymer matrices. Delignification was performed on three Mediterranean wood species, both native and cultivated, considering different cut orientations (parallel and orthogonal to the wood grain) through a short-duration acid chlorite treatment. The resulting cellulose-rich templates were subsequently vacuum impregnated with a partially bio-based epoxy resin. Both the delignified templates and the final aesthetic composites were characterized by optical and SEM microscopy, IR spectroscopy, thermogravimetric analysis (TGA), X-ray diffraction (XRD), UV–Vis spectroscopy, dynamic mechanical analysis (DMA), and mechanical testing. The selective acid chlorite treatment produced cellulose-rich templates with preserved morphology and mesostructure, accompanied by a reduction of lignin signatures and partial hemicellulose removal depending on species and cut orientation. Compared to native wood, the delignified templates showed reduced thermal stability and increased crystallinity due to the removal of amorphous components.Optical analysis showed an increase of the total transmittance, particularly at longer wavelengths, attributed mostly to chromophore removal, but also to refractive index matching in the final aesthetic composites. DMA and tensile tests revealed a decrease in stiffness and strength after delignification, while the epoxy impregnation recovered, and in some cases improved, the tensile performance. The process also preserved the characteristic warm hue and veining of wood, yielding mechanically resistant composites with potential for engineering applications.
Acknowledgements: progetto di Dottorato di Ricerca sviluppato nell'ambito del PNRR, "Rivoluzione Verde e Transizione Ecologica" (D.M. 351/2022).

P46

Circular carbon economy applied to cement manufacturing using natural and synthetic CO_2 adsorbents

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Annually, cement manufacturing accounts for almost 7% of global CO_2 emissions. This study aims at creating a circular economy around CO_2 emitted in cement industry, studying carbon dioxide adsorption properties of some materials, and the possibility of using them as supplementary cementitious materials (SCM) in mortar production, which implies replacing part of the cement required for mortar production with the CO_2 loaded materials allowing the reintroduction of the carbon dioxide generated during the cement production process, into the final cementitious product. The materials chosen for the study are natural and synthetic zeolites, since zeolites exhibit good characteristics in terms of adsorption capacity and affinity towards CO_2 compared to other materials. Natural zeolites are used as extracted from the quarry without further modifications other than grinding, synthetic materials instead, are obtained through hydrothermal processes from waste materials such as ashes. First, CO_2 adsorption capacity and moisture content of materials are determined through thermogravimetric analysis; the tests are then performed on a larger scale; finally, mortar samples with zeolites as SCM are produced and tested through compressive strength test. Both thermogravimetric and lab-scale experiments showed that synthetic materials have better CO_2 adsorption performance compared to natural materials, due to the functionalization process performed on those materials that contributes to the formation of extra-frameworks channels resulting in an increased specific surface area. The use of the CO_2 loaded materials as SCM instead has not proved a clear increase in mortar compressive strength, but neither a decrease compared to mortar samples produced without zeolites, meaning that it is possible to replace part of the cement with the zeolites. Future tests will focus mainly on studying the interaction of CO_2 loaded materials with cement phases during mortar hydration, using different materials and proportions between mortar components, to promote the formation of calcium carbonate into the mortar paste, which should improve mortar strength through a pore filling effect and increase in mortar matrix density.

P47

Polybutylenesuccinate-co-adipate (PBSA), a versatile, highly biodegradable polymer for composites and mulch films

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Biodegradable plastics 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 nanoplasticas in the agriculture sector. This work presents an overview of preparation, properties and biodegradability in different environments, from industrial compost to marine water, of composites and films 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 mulch films. Bio-composites were prepared with filler derived from different biomasses such as insect exoskeleton powder (IEP), a by-product obtained from grinding the insect's post-protein extraction dry biomass. Pots were produced by injection moulding with PBSA-PHBV based polymeric matrix with 15%-wt IEP as filler and positively tested for mineralization in compost, soil and water. For mulch films PBSA, was compounded with wax-coated biochar at 2-8 wt.% and processed via twin-step extrusion followed by blown film extrusion, producing films with thicknesses of 40-100 µm. Biochar or IEP filler incorporation don't compromise thermal stability and mechanical properties, maintaining values meeting the requirements for application in respectively mulch films or pots. The presence of filler either biochar or IEP fasten the disintegration and consequently promotes the mineralization of PBSA polymeric matrix.A proper combination of natural polymers, by products of biorefinery (insect exoskeleton powder, biochar), allows tuning properties on bioplastic substrates production of biobased, highly biodegradable and sustainable materials for single use applications such as those in agricultures.
Acknowledgements: this work has received funding from Plastic Free Vineyards project has received funding from the Ministero dell'agricoltura, della sovranità alimentare e delle foreste, project Prot. n. N.0546217 of 25/10/2022 ID 20220546217. the Bio Based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme grant agreement "GA887648" project RECOVER "Development of innovative biotic symbiosis for plastic biodegradation and synthesis to solve their end of life challenges in the agriculture and food industries".

P48

Sandwich-structured bimodal polymeric fiber/waste wool fiber bio-composite membrane for high-performance and eco-friendly air filtration

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Air pollution due to fine dust particles remains a pressing environmental challenge. To reduce the environmental footprint of air filtration technologies, it is crucial to develop solutions based on biodegradable polymers blended with natural fillers, ideally sourced from waste materials, to create efficient, durable, and reusable air filters. Sandwich-structured membranes based on waste wool fibers (WWF) were produced by combining a central layer of hot-pressed wool fibers with two layers of composite fibrous membrane based on polylactic acid (PLA) and waste wool powder (WWP) obtained by solution blow spinning (SBS) technique. Air filtration performance of the PLA/WWP, WW-BCM (a bilayer membrane composed of hot-pressed WWF and only one layer of PLA/WWP) and WW-SCM membranes was evaluated on a homemade filtration test system. Aiming to simulate a polluted air environment, incense was burned in the first chamber generating the particles (PMs) with particles size ranging from 1 μm to 3 μm. The PMs were drive from the first to the second chamber, through the membranes, by inject air at different flow rate (10, 32, 65, 85 L/min). Air filtration performances of the membranes were also monitored at different environmental condition. Moreover, the potential reusability of the bi-layer membrane was assessed by testing them for five cycles of filtration. The addition of WWP improved the viscosity of the spinning solution, leading to thinner and more uniform fibers, which in turn enhanced the capture efficiency of fine particles. The S-WWM, due to its unique multilayer architecture, exhibited the highest filtration performance, achieving filtration efficiencies of 99.5 % at 32 L/min, with a pressure drop of 70 Pa. Moreover, the filtration performance remained almost stable across a wide range of flow rates, temperatures, and relative humidity levels. The membranes also demonstrated excellent mechanical properties and good reusability over five filtration and washing cycles, maintaining high efficiency with only a moderate increase in pressure drop. These findings confirm the potential of wool-based sandwich membranes as durable, reusable, and highperformance air filtration materials, offering a promising route for the valorization of natural and wastederived resources in sustainable environmental applications.

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Enzymatic degradation optimization in natural fiber reinforced PLA/PBSA composites

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The global rise in plastic pollution has intensified the need for effective end-of-life strategies. Biodegradable polymers such as poly(butylene succinate-co-butylene adipate) (PBSA) and poly(lactic acid) (PLA) represent environmentally friendly alternatives to conventional plastics. In this study, a biocomposite constituted by a polymer blend (60 wt.% PLA - 40 wt.% PBSA) as matrix and hemp fabric as reinforcement was developed. However, to ensure efficient disposal and minimize environmental impact, the degradation performances of this system must be optimized. In this context, enzyme-based degradation approach offer a promising route to accelerate the degradation. A range of lipase and cutinase enzymes was evaluated to determine their ability to degrade the polymeric substrates. Weight loss measurements were performed to quantify polymer mass reduction over time. High-performance liquid chromatography (HPLC) was used to identify soluble degradation products and confirm the progression of enzymatic hydrolysis. Additionally, gel permeation chromatography (GPC) was conducted to assess molecular weight distribution before and after enzymatic treatment. The enzymatic screening revealed distinct substrate specificities. Lipase Pseudomonas sp., Lipase B from Candida antarctica (CalB), and Lipase from Alcaligenes sp. exhibited high efficiency in degrading PBSA, demonstrating strong activity toward this aliphatic polyester. However, none of these enzymes showed significant degradation capability toward pure PLA. In contrast, Proteinase K proved to be highly effective in degrading PLA, confirming its specificity for this polymer. Based on the observed enzyme specificities, the development of a sequential or combined enzymatic system is essential to achieve efficient degradation of PLA-PBSA based composites. PBSA-selective lipases can initiate degradation by targeting the PBSA fraction, while Proteinase K can subsequently act on the PLA component. The complementary use of weight loss measurements, HPLC, and GPC ensured accurate monitoring of the degradation process, confirming both mass reduction and molecular-level depolymerization. Overall, the results demonstrate that a multi-enzyme approach is necessary to optimize the biodegradation of PLA/PBSA composites recovering the fabric after the degradation process.

P50

Design and development of recovery and valorization processes for flexible polyurethane foams from the bedding sector

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The end-of-life management of polyurethane (PU) materials, widely used in automotive, construction, furniture and bedding sectors, is a critical technological and environmental challenge for the chemical industry. Their thermoset nature prevents remelting and reprocessing, making conventional recycling routes considerably more complex than those applicable to thermoplastic matrices. Currently, PU recovery relies on chemical or mechanical recycling. While chemical recycling can recover original monomers, its implementation is often limited by high energy requirements, complex purification steps, and significant operational costs. Instead, mechanical recycling is the most accessible route, utilizing shredding or cryogenic grinding to produce functional powders or granulates that can be reincorporated into new polymer matrices as inert fillers or reinforcing agents, or used in the manufacture of new products. The objective of this work is to develop a mechanical recycling process of post-consumer flexible PU foams from mattresses capable of producing value-added solutions for sectors beyond the bedding industry. In particular, the study focuses on how composition and processing conditions influence the structure and performance of the resulting materials. Three commercially flexible polyurethane foams, characterized by different viscoelastic properties and currently used in the bedding sector, were selected for this study. Polyurethane foam panels were produced by cryogenically grinding the material in a liquid nitrogen-cooled mill and subsequently compression molding the resulting powder. Key processing variables, such as particle size, temperature, and pressure, were strictly controlled using a hydraulic press. The resulting panels were subsequently characterized in terms of morphology, structural features, thermal stability, dynamic-mechanical behavior, and mechanical performance through tensile and puncture resistance tests. Following the optimization of the compression molding process, panel prototypes were fabricated from individual foams and their blends at different composition (densities 1.05-1.2 gr/cm^3). The panels exhibited good particle adhesion driven by a chemical reaction, as confirmed by FTIR analysis, which showed the consumption of residual isocyanate groups in the original foams and the formation of new urethane/urea linkages in the panels. The tensile elastic modulus varied across a broad range (approximately 2.5-18 MPa) depending on the nature of the precursor foams, with the blended panels displaying values closely aligned with the rule of mixtures for blends, while the puncture strength (470-1220 J/m^2) reached values typical of thermoplastic polyurethane films. These findings demonstrate the potential for recycled PU foams to be repurposed into new value-added solutions e.g., as mats for domestic, sports, or industrial applications.

P51

How size and composition shape local structure inducing persistent luminescence in Mn-doped halide double perovskites

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Persistent luminescence materials (PeLMs) are interesting due to their ability to store excitation energy and release it gradually as light over extended periods (from minutes to several weeks) after the removal of the excitation source. This unique property makes them suitable for applications including emergency signage, road safety markings, bioimaging, photocatalysis, optical data storage, and anti-counterfeiting technologies. For most of these applications, the use of PeLMs nanocrystals is preferable. However, the downscaling of PeLMs often has a detrimental effect on the persistent luminescence (PeL) observable at room temperature. In this work, we investigated Mn-doped halide double perovskites, specifically we synthesized various compositions of $Cs_2(Ag_xNa_{1-x})InCl_6:Mn^{2+}$ single crystals (SCs) and nanocubes (NCs) and nanoplates (NPs). We performed optical analyses, including photoluminescence excitation, photoluminescence, PeL, and thermally stimulated luminescence measurements (across 10 K–450 K). Since PeL is related to the presence of trapping sites, which may originate from local structural defects, we further investigated these defects using X-ray Powder Diffraction, Pair Distribution Function (PDF) analysis, and X-ray Absorption Near Edge Structure (XANES) spectroscopy at the K-edge of Mn (the emissive center). Our results indicate a strong size-and-composition-dependent behavior. By varying samples composition and size, via PDF analysis we identified local structural changes. In addition, from the XANES analysis, the pre-edge peak is broader for the bulk sample, suggesting Mn coexists in the 2+ and 3+ oxidation states. We hypothesize that the PeL disappearance from bulk to nanocrystals is ascribed to differences in the position of the traps in the bandgap between bulk and nanostructured samples. Further, the local structural changes may explain the observed differences in PeL. The coexistence of Mn^{2+} and Mn^{3+} species for PeL SCs highlights a mixed-valence scenario commonly reported in PeLMs, like $SrAl_2O_4$: Eu^{2+}, Dy^{3+}. These results improve the understanding of how compositional and size tuning can optimize PeL performance in emerging perovskite-based materials.

P52

Advanced composites based on thermoplastics and halogen-free flame-retardant additives for sustainable industrial solutions

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Emerging polymer-based materials containing flame/fire retardants (FRs) are widely used in various applications due to their fire resistance, flame retardance and smoke suppression properties. Common types of polymers, such as polyolefins, polycarbonate, polyamides, polyester, polyurethanes and epoxy resins often incorporate Flame Retardants (FRs) to formulate safe Flame/Fire-Retardant Polymer Composites (FRPCs) for numerous application sectors [8–10]: (i) electric and electronics, e.g. cable insulation and circuit boards; (ii) construction, e.g. insulation materials, sheathing application and coatings; (iii) transportation, e.g. automotive interiors and aircraft and train components; and (iv) textiles, e.g. flame-retardant clothing and upholstery.
FRPCs are often designed to have high strength, stiffness, and a low weight-to-strength ratio. It is worth noting that the demand for fire-safe materials in various industries has driven research into fire-retardant composites and, more recently, into halogen-free FRs. Three different metal hydroxides: finely precipitated aluminium hydroxide (p-ATH), high-purity, finely precipitated magnesium double hydroxide (p-MDH) and naturally milled magnesium double hydroxide (nm-MDH) as sustainable halogen-free flame-retardants (FRs) for polyolefin-based formulations were considered. The p-ATH and p-MDH exhibit high purity and lamellar, hexagonal structures, which do not promote adhesion between polymer macromolecules and inorganic particles. The nm-MDH, being naturally milled particles, exhibits an irregular and rough surface, promoting the adhesion of polymer macromolecules. The p-ATH and p-MDH exhibit gibbsite and brucite structures, respectively, while the nm-MDH predominantly exhibits a brucite structure containing small amounts of dolomite (magnesium and calcium carbonates), which have a beneficial effect on fire resistance due to their high decomposition temperatures and the formation of inert carbon dioxide during combustion. Rheological analysis shows that the polyolefin-based composite containing p-ATH exhibits liquid-like behaviour similar to the neat matrix. In contrast, the p-MDH and nm-MDH composites exhibit solid-like behaviour. Therefore, all investigated FRPCs show good processability and optimised morphology, although the p-ATH promotes the formation of voids between the matrix and inorganic particles. Therefore, all FRPCs containing approximately 60 wt.% of p-ATH, p-MDH and nm-MDH exhibit excellent flame/fire and thermal (static heat) resistance, highlighting the effectiveness of these three hydroxides as halogen-free flame-retardant additives. Furthermore, while the effect is only slight, it appears that the three metal hydroxides offer some protection against photooxidation weathering of the polyolefin matrix.

P53

Advanced biocomposites based on biopolyester and halogen-free flame-retardant additives for sustainable applications

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In recent years, polymer-based materials have been used extensively in a wide range of applications, including transportation, construction, textiles, and packaging, due to their excellent versatility and ease of processing. Replacing these polymers with bio-derived and biodegradable polymers is another sustainable approach that aligns with the principles of sustainability. In addition, the demand for emerging biopolymer-based materials containing halogen-free flame/fire retardants (HFFRs) is a valuable step towards sustainable, safe industrial solutions. Biopolyester-based biocomposites, considering polybutylene succinate (PBS) as matrix, were prepared by melt mixing incorporating three different metal hydroxides: finely precipitated aluminium hydroxide (p-ATH), high-purity, finely precipitated magnesium double hydroxide (p-MDH) and naturally milled magnesium double hydroxide (nm-MDH) as sustainable halogen-free flame-retardants (FRs). The ATH demonstrated high purity and lamellar structures, exhibiting excellent dispersion within the PBS matrix. The MDH dispersion proved more challenging due to its rough surface. Consequently, the ATH exhibited a gibbsite structure, while MDH predominantly showed a brucite structure containing beneficial traces of dolomite (calcium and magnesium carbonates). The enhanced fire resistance of these carbonates is attributable to two principal factors. Firstly, their high decomposition temperatures and, secondly, the formation of inert carbon dioxide during the process of combustion. The investigation of all PBS-based biocomposites has demonstrated that they exhibit adequate processability and acceptable mechanical properties. Furthermore, enhanced photo-oxidative stability was observed in the presence of MDH and ATH, in comparison to the pure matrix. This phenomenon can be attributed to the contrasting alkaline properties of MDH and ATH, which are distinct from the process of succinic acid molecule formation resulting from PBS degradation. It was established that both MDH and ATH were capable of reducing the peak heat release rate with effectiveness. This reduction in heat release rate resulted in enhanced ignition resistance and a significant reduction in smoke release. Furthermore, the combined MDH/ATH hybrid compositions exhibited clear synergistic effects, balancing two degradation steps to produce stable, ceramic-like char layers. This mechanism resulted in a drastic heat reduction and almost complete suppression of smoke, thereby demonstrating the high efficacy of this sustainable approach to producing flame-retardant materials. Finally, the presence of both MDH and ATH simultaneously offers the advantage of providing acceptable processability and a wide range of fire protection effects that are not offered by individual components.

P54

Aqueous carbonation process to produce supplementary cementitious materials from steel slag

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Cement industry is responsible of about 8% of global CO_2 emissions. It is imperative that urgent action is taken to achieve the European target of zero net emissions by 2050. Among the various possible strategies, the use of supplementary cementitious materials to reduce clinker use, and the implementation of carbon capture and utilisation processes, are identified as highly promising. The utilisation of industrial waste and by-products represents an added value that further contributes to the principles of the circular economy. Basic Oxygen Furnace steel slag, the by-product of a European steel production plant, is adopted as raw material. The product has been milled in powder before the use. Cement of the type CEM I 52.5 N is utilised. The aqueous carbonation process is carried out with the following operational parameters: liquid-to-solid ratio of 5, CO_2 flow of 50 l/h, ambient pressure and temperature conditions, time of carbonation of 1 h. The powder is characterised by means of granulometry (Malvern Mastersizer 3000E), thermogravimetry (TG-DTA, LabSys evo machine, Setaram), XRD (Malvern Panalytical Empyrean), XRF (Rigaku Supermini 200), microscopy (FE-SEM Hitachi S4000). The reactivity is investigated by means of pozzolanicity tests. The strength is assessed by means of compressive tests (BS EN 196–1) carried out on mortar samples. The mineralisation process strongly affects the mineral composition and the microstructure of the steel slag particles. The presence of silicates is reduced in favour of stable calcium carbonate precipitates that confer roughness to the particle surface. The process promotes the leaching of calcium from silicates increasing the reactivity of the particles that show a higher pozzolanicity compared to the raw material. The findings of the study demonstrated that the 28 days compressive strength of mortar samples with 20% wt. cement replacement with steel slag increased by up to 14% when carbonated powder was used in place of the raw material. The results emphasise the potential of the mineralisation process as a valuable strategy to decarbonise cement industry. Firstly, by promoting the formation of stable calcium carbonate, it results in direct carbon capture. Secondly, the treatments demonstrated the potential for valorising steel slag, thereby enabling its utilisation as a cement replacement with performance comparable to that of standardised cements. Further analysis is required to investigate the applicability and scalability of the technology, with a view to integrating it into the cement industry.

P55

MOFs in catalysis: challenges, limitations and strategies

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In the extremely wide panorama of Material Science and Technology, one class of materials has undoubtedly stolen the scene in recent years: metal-organic frameworks (MOFs). Over the years, the scientific interest in MOFs applications have enormously increased, indeed leading to their award for the Nobel Prize in Chemistry in 2025. Despite this, these versatile and innovative materials might present some challenges that scientists sometimes face concerning both their syntheses and their catalytic applications, among all. These issues could involve: i) thermal, mechanical and chemical stability of the MOFs structure to the reaction conditions; ii) products analysis; iii) leaching of catalytically active centres. In this context, a multi-technique approach is fundamental to deepen our understanding on this topic. MOFs of the UiO-6X family were synthesised and physico-chemically characterized in a multi-technique fashion, including powder X-ray diffraction (PXRD), textural properties and thermogravimetric analysis (TGA). Several spectroscopic techniques were applied for their advanced spectroscopic characterization, as diffuse reflectance ultraviolet-visible (UV-Vis) spectroscopy and infrared (IR) spectroscopy. These MOFs were applied for catalytic light hydrocarbons conversion, having products detection by gas-chromatography (GC-FID) and, if applicable, monitoring by mass spectrometry (MS). In this contribution, difficulties encountered in the synthesis of such MOFs will be reported. Additionally, challenges and limitations related to the catalytic applications of MOFs will be highlighted, as a part of the investigation of the conversion of several light hydrocarbons as substrates for both gas- and liquid-phase catalysis. According to our experience, in these activities the main issues we have faced and tried to overcome are related to the effective stability of MOFs to the chemical and pressure conditions used for the testing protocols. This aspect has consequences of the effective applicability of MOFs for the targeted reaction and the practical recyclability of the spent MOFs. For sure, a complicating factor is the intrinsic nature of this hybrid inorganic-organic materials. Our contribution aims at sharing possible common difficulties encountered within the scientific community and spreading awareness for supporting scientific research.

P56

Furan based polyesters for paper coating: barrier properties and sealing performance

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In this communication, we present the sealing, barrier, and grease-resistance properties of a thin poly(pentamethylene furanoate) (PPeF) coating on paper. Among furan-based polyesters, PPeF was selected for creating a thin coated-paper packaging structure due to its well-known characteristics. In particular, PPeF has been reported to show low crystallization capability, high elongation at break, and excellent barrier properties, which suggest its suitability for flexible packaging applications. PPeF was prepared by two-stage melt-phase polycondensation according to a procedure developed by our group and published in the literature. Solutions of PPeF in chloroform at three different concentrations - 5, 10, and 20% (by wt) - were prepared, and three coating techniques were tested: dip coating (DC), bar coating (BC), and solvent casting (SC). Mechanical properties of uncoated and PPeF-coated paper were determined using a 5966 Instron Universal Testing Machine under tensile mode. Weldability of PPeF-coated paper was tested using ultrasonic and thermal welding laboratory machines. Joint strength was measured with the same Instron machine in tension mode. Barrier properties to oxygen and carbon dioxide were determined using a custom-made apparatus at the LABIC laboratory of DICAM. Coating of paper using PPeF solutions was carried out to identify the best combination of PPeF concentration and coating method that would allow deposition of a continuous polymer film with the appropriate thickness to keep the paper/polymer ratio compliant with ATICELCA recyclability guidelines. The bar-coating method proved to be the best option in terms of both PPeF film properties and grammage. All subsequent tests were performed on paper coated using this method. Good sealing strengths were obtained using both thermal and ultrasonic techniques. In particular, forces required to open a 15-mm joint (a common test widely used in the packaging industry) between 14 and 16 N/15 mm were achieved by optimizing parameters such as pressure applied to coated paper specimens and temperature (for thermal welding), as well as amplitude and pressure (for ultrasonic welding). Barrier properties of 20–40-μm PPeF films deposited on paper were comparable to those of pure PPeF films of similar thickness. The results of this work show that PPeF is a very promising drop-in solution to replace polyethylene coatings on paper. This combination represents a more sustainable flexible-packaging option than fossil-based alternatives.

P57

Piezoresistive behavior of construction and demolition waste based smart alkali-activated foams

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In recent years, the development of smart building materials with piezoresistivity properties has gained increasing attention, which allows them to function as stress/strain sensors. Alkali-activated materials (AAMs), identified as a sustainable alternative to cement, serve as fundamental components for self-sensing materials. AAMs are commonly prepared with aluminosilicate powders with alkali-activator. Recently, the promising piezoresistive properties of AAMs have gained increasing attention from researchers. Despite the inherent multifunctionality of alkali-activated foams (AAFs), their potential applications in these areas have received limited attention. Therefore, this study aims to explore the potential of waste-based AAFs as strain sensor. Specifically, the self-sensing properties with and without functional fillers, such as graphene oxide and reduced graphene oxide, were investigated. Two types of Construction and Demolition Wastes were selected: brick waste (BW) and glass waste (GW). Their reactivity in an alkaline medium was demonstrated through chemical-mineralogical characterisation. Organic–inorganic hybrid foams were prepared by using diatomite, selected CDWs as a partial and/or total replacement of diatomite, as matrix, silicon and whipped surfactants as pore forming. The highest compressive strength foams were selected to be transformed into smart foams. Two carbon-based filler were selected: graphene oxide (GO) and reduced graphene oxide (rGO). The percentage of each filler used was 0.01%wt relative to the precursor, and it was introduced into the surfactant before whipping. The results demonstrated the feasibility of using selected CDWs as foam precursor using the selected organic-inorganic hybrid foam production process. This waste can be used both as a co-binder and, above all, as a binder, i.e., 100% of the precursor system. The highest compressive strenght foam –100%wt diatomite-based, 100wt.% GW-based and 100wt.% BW-based foams – were subject to the piezoresistivity test. This foams are already sensitive to strain, even without filler. However, the resistivity is very high (>1MΩm). Using rGO fillers rather than GO fillers results in a more significant reduction in resistivity. This work contributes to the broader goals of reducing non-renewable raw materials, energy consumption, and greenhouse gas emissions in the construction sector, in line with global efforts to promote sustainable development. Specifically, it involves the development of sustainable lightweight insulating panels made from waste with additional sensor functionality.

P58

Effect of starch and zeolite microfillers on waterborne pva thin films: structure-property and soil-burial behaviour

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Waterborne coatings of fully hydrolysed poly(vinyl alcohol) (PVA) are considered as attractive polymer layers for more sustainable packaging applications, but their performance and environmental fate strongly depend on formulation. Starch and synthetic zeolite microfillers are assessed in this study as parameters to tune processing, structure and soil-burial behaviour of PVA thin films. Glycerol-plasticised PVA and PVA/starch (10 wt% starch) aqueous formulations were filled with up to 4 wt% zeolite 4A or 13X (2–3 µm particle size) and rod-coated on PTFE to obtain transparent ~20 µm films after peeling. An ATR-FTIR "up–down" check (evaluating zeolite bands) screened conditions preventing filler sedimentation. Microscopy, thermogravimetric analysis, X-ray diffractometry, water uptake/water vapor transmission rates and 16-week soil-burial tests (30 °C, wet peat soil) were performed on the films; soil bacterial activity was measured with AlamarBlue® assays. Uniform micro-zeolite distribution was achieved (ATR protocol); 13X caused fewer drying defects than 4A. Starch and zeolites increased thermal stability (T_{max} ≈280-290 °C for PVA to ≈340 °C with starch and up to ≈360 °C with starch + 13X), while crystallinity remained low (~10%). Moisture response stayed high (water uptake >130% after 1 h; WVTR ~1000 g m^{-2} d^{-1}). After 16 weeks of soil burial, plasticized PVA lost ~10-12% mass, whereas starch blends reached ~19% with pitting; zeolites (4 wt%) slightly increased mass loss without inhibiting microbial activity. The combined dataset on soil-burial tests highlights that PVA is the most recalcitrant organic component, so starch acts as a biodegradable sacrificial phase enabling controlled film degradation, whereas micro-zeolites provide additional thermal robustness and do not hinder biodegradation, consistent with local water retention and micro-erosion at interfaces. The FTIR check supports scalable processing for coated layers. However, at the tested loadings, zeolites do not provide major moisture-barrier improvements, so these films are best positioned as thin functional coatings coupled with hydrophobic substrates.

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Temperature driven structural evolution of Mn-LTA zeolite

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While transition-metal-exchanged zeolites are promising for high-temperature gas combustion and exhaust treatment, their thermal structural evolution remains poorly explored. Here, fully Mn-exchanged LTA was studied from 25-700 °C by synchrotron X-Ray Diffraction, revealing dehydration-driven lattice contraction, cation mobility, and Mn^{2+} occupation of non-conventional sites, with implications for high-temperature adsorption and catalytic behavior. A commercial Na-LTA zeolite was fully exchanged with Mn^{2+} through ion exchange in 0.2 M $Mn(NO_3)_2$ solution. The sample was studied by collecting synchrotron XRD patterns from 25 to 700 °C in 100 °C steps under fixed instrumental conditions (wavelength = 1.549 Å (8 keV); angular range = 2-50° 2θ; angular step = 0.009° 2θ; exposure time per step = 1s). Diffraction patterns were refined using GSAS-II. The Mn-exchanged LTA zeolite structure at 25 °C was refined in the cubic space group Pm-3m. Extra-framework Mn^{2+} cations occupy two sites along the threefold axes: Mn1, near the six-membered rings, and Mn2, closer to the center of the sodalite cage. Most water molecules coordinate the Mn^{2+} cations, whereas a smaller fraction persists near the four- and eight-membered rings. Heating triggers progressive dehydration and continuous contraction of the cubic lattice parameter. Structural refinements reveal the shrinkage of the six-membered rings and the expansion of the four-membered rings. Notably, the Mn1-O distance decreases linearly with temperature, whereas the Mn1-Mn2 distance follows a non-monotonic trend. The observed structural evolution reflects the different bonding strengths of the two Mn^{2+} sites. Cations in Mn1 remain strongly anchored to the framework, tightening their coordination and contracting the six-membered rings upon dehydration. Conversely, cations in Mn2 are weakly bound, and their position is strongly influenced by the presence of water molecules. Complete dehydration enables Mn2 migration into the sodalite cage, increasing its separation from Mn1. The apparent Mn site occupancies increase with temperature suggests a redistribution of initially disordered Mn^{2+} cations into well-defined crystallographic positions during dehydration, leading to a more ordered cation arrangement. These structural modifications are believed to significantly influence the zeolite adsorption and catalytic properties, emphasizing the need for characterization under real operating conditions.

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Titanium dioxide and nitride nanotubes for photochemical conversion of green energy

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Titanium dioxide and more recently titanium nitride metasurfaces have attracted high attention in photochemical catalysis. Both nanostrutured, are active as catalytic material for alcohol reforming and carbon dioxide reduction. The presence of cocatalysts in form of nanoparticles let to achieve very high activity, making the overall process promising for future industrial applications. This work has been carried out within the PRIN PNRR RESOLCAT project. Electrochemical anodization was used to obtain titanium dioxide nanotubes, then conveniently convertible into titanium nitride in furnace. Using magnetron sputtering physical vapour deposition (MS-PVD) the catalyst is deposited on the surface. Samples are then evaluated on their photocatalytic activity using dedicated setups secondly to the reaction. Compositional and morphological characterization is performed using X-rays photoelectron spectroscopy (XPS), scanning electron microscope (SEM) and trasmission electron microscope (TEM). The adopted synthetic route enables the formation of highly active catalytic materials. Using TiO_2 nanotubes, very high hydrogen production values were achieved per gram of cocatalyst employed. Additionally, decorated TiN nanotubes showed promising in product selectivity and stability for CO_2 reduction. The good results obtained can be rationalised basing upon the onset of plasmonic effects that, coupled with the easy formation of electron and holes in the titanium dioxide based material makes the two metasurfaces of paramount interest in such applications. These effects arise from the adopted synthetic route, which enabled the formation of small, homogeneously distributed metallic nanoparticles over a catalytically active, heavily nanostructured, but easily accessible surface, optimizing the photons flux and the reactants, the electrons and the holes motion, thereby strengthening the plasmonic resonance of the nanoparticles.

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Development of a new processing method for unprecedented electrospinning of collagen in water from waste animal biomass

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Electrospinning of collagen-rich feedstocks is typically constrained by poor solubility, jet instability and the frequent need for fluorinated solvents or carrier polymers. Animal glue (AG), a denatured collagen byproduct from slaughterhouse and tanning streams, offers a minimally processed, water-soluble alternative that could enable circular nanomanufacturing. AG solutions were prepared in water and benchmarked against hydroalcoholic and HFIP formulations. Solubility and oscillatory rheology were used to define processability windows, while fiber morphology was assessed as a function of concentration and evaporation conditions. A temperature-regulated far-field electrospinning setup (independently controlling chamber temperature T1 and dope temperature T2) was developed to accelerate solvent removal and stabilize the Taylor cone in aqueous spinning. At room temperature, aqueous and hydroalcoholic systems yielded bead-dominated deposits despite viscosities within the conventional electrospinning range, indicating that evaporation kinetics not only rheology governed jet solidification. Increasing T1 promoted a clear beads-to-fibers transition in water. Controlling T2 further enabled continuous spinning at high protein loadings (up to 30 wt%), mitigating premature gelation and producing uniform nanofibrous membranes with good mechanical integrity. FTIR-ATR and TGA confirmed the absence of detectable chemical degradation under the employed thermal conditions. The membranes were highly hydrophilic yet oleophilic and showed rapid uptake of oils from water, reaching ~26 g g−1 for motor oil. These results demonstrate, to our knowledge, the first all-aqueous electrospinning route to fully collagen-derived nanofibrous membranes from waste-grade AG, without blending or chemical crosslinking. The thermally assisted strategy provides a scalable pathway for converting collagenous wastes into functional membranes for oil/water remediation and, potentially, other separation and bio-based applications.

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First-principles insights into nitrogen mustard cwas and their simulant on zinc oxide surfaces

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Although banned worldwide, chemical warfare agents (CWA) still pose significant health risks, driving the need for effective detection methods such as chemiresistive metal-oxide sensors. Due to safety concerns, low-toxicity simulants are commonly used, with DPGME proposed as a stand-in for nitrogen mustards despite structural differences. This study uses first-principles calculations to examine the physicochemical similarities between DPGME and nitrogen mustards and their interactions with ZnO $(10\bar{1}0)$ surfaces. First-principles DFT, TD-DFT and MP2 calculations were used to analyze DPGME and nitrogen mustards (HN1–HN3) in the gas phase, determining optimized structures and excited-state properties. The adsorption of DPGME and HN2 on ZnO $(10\bar{1}0)$ surfaces was then studied using periodic DFT, with plane wave basis set with electronic properties assessed within a DFT+U approach. After optimizing the molecules in vacuum, nitrogen mustard (HN2) and its simulant DPGME were contacted with stoichiometric and O enriched ZnO$(10\bar{1}0)$ surface. For all surface models considered, the two molecules exhibited similar adsorption energies, with the closest agreement on O-enriched ZnO surfaces. In addition, the study demonstrates that the ZnO$(10\bar{1}0)$ surface undergoes a change from n-type to p-type conductivity in passing from a stoichiometric to an oxygen-rich slab. This n-to-p transition is subsequently reversed, restoring n-type behavior, following the adsorption of either HN2 or DPGME. In all cases studied, electron transfer from the adsorbed molecules to the oxide surface was also observed. Interestingly, both HN2 and its surrogate DPGME produce comparable changes in the electronic structure of the ZnO surface, irrespective of defects presence. The resemblance in both energy and electronic characteristics between DPGME and HN2 when adsorbed on ZnO$(10\bar{1}0)$ offers a microscopic, first-principles explanation for why DPGME, despite not being structurally similar to nitrogen mustard chemical warfare agents, can serve as an effective simulant for azoyprites.

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Circular recovery of PPE: sanitization methods, degradation mechanisms and recycling strategies

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The way the world's economy works, where things are made and then used up and thrown away, is causing big problems for the environment. The EU's Green Deal and Italy's National Recovery and Resilience Plan outline the necessary shift towards circularity. Transitioning to a circular economy is urgent because the planet has limited resources and waste absorption capacity. This signifies the imperative of perceiving end-of-life products as opportunities for the reclamation of resources, a matter of particular pertinence for plastics in order to address the accumulation of waste and meet the escalating global demand. Even though polypropylene (PP) is the most commonly used polymer in the EU, it is only recycled about 5% of the time. This is much less than polyethylene terephthalate (21%) and polyethylene (9%). This low rate is due to various factors. It is challenging to separate PP from other polyolefins. PP products contain various additives. PP degrades rapidly during reprocessing and use. This is due to its thermo- and photo-degradation. Polypropylene was recycled through melt blending. The material used was 3-ply facemasks, each weighing 4.41 ± 0.05 grams, with the polypropylene filter layers accounting for 3.41 ± 0.02 grams (77% of the total weight). The facemasks underwent simulated sanitization processes using steam, aqueous sodium hypochlorite, and ultrasound treatments. The resulting pellets after extrusion were subjected to thermal, rheological, and mechanical characterization. Additionally, spectrometric and calorimetric analyses were conducted to assess degradation phenomena and pathways resulting from the sanitization and melt blending processes. The objective of this study is to convert waste into secondary raw materials by implementing a circular economy and a waste-to-materials strategy. Following processing with and without sanitisation, the resulting pellets were characterised in terms of their thermal, rheological and mechanical properties. The conducting of spectrometric and calorimetric analyses was for the purpose of assessment of the degradation phenomena and pathways induced by the sanitization and melt blending processes. It was revealed by the analyses that varying degrees of polymer chain degradation were caused by different sanitization methods. We can see this because we've got different types of polypropylene crystals in the calorimetry curves and the spectroscopic analyses show bigger peaks when it's degrading. The mechanical recycling processes are associated with degradation. However, the use of masks as a secondary raw material remains viable. This is especially the case when mixed with virgin materials.
AcknowledgmentS: Finanziato dall'Unione europea – "Next Generation EU" - PNRR M4 - C2 -investimento 1.1: Fondo per il Programma Nazionale di Ricerca e Progetti di Rilevante Interesse Nazionale (PRIN) - PRIN 2022 cod. 20229BHA75 dal titolo "FUnctional Technology Unlocking Recycling and VALorization of Personal Protective Equipment production scrap and waste" (FUTUREVAL-PPE). CUP B53D23005690006.

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From lab-scale design to industrial-scale validation: PCL–hemp biocomposites for sustainable packaging and potential 3D printing applications

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The research project aims to valorize plant waste derived from hemp processing as a renewable industrial resource by integrating stem by-products into low environmental impact and easily biodegradable polymeric composites, promoting carbon storage within the final product. The work evolved from the concept of a symbolic "green" product toward a material-oriented strategy, positioning the composite as a technological platform for high value-added applications. The cosmetic sector was identified as a promising target due to its sensitivity to sustainability, aesthetics, and sensory quality. Polycaprolactone (PCL) was selected as matrix for its biodegradability, biocompatibility, and low softening temperature, which facilitates processing and mainly limits thermal degradation of the natural reinforcement. On this basis, a PCL–hemp composite system was developed to integrate sustainability, mechanical performance, and industrial transferability. Hemp fibers were mechanically milled using different technologies to obtain controlled particle size distributions. Powders were characterized through laser granulometry to quantify granulometric and morphological distribution and correlate dimensional parameters with composite properties. Biocomposites were designed considering three variables: reinforcement granulometry, hemp weight fraction, and matrix type, using two different PCL grades (CAPA 6500 and CAPA 6800) characterized by distinct mechanical behavior. The neat matrices were preliminarily mechanically characterized. Composites were produced via solvent casting at laboratory scale and subsequently processed through industrial injection molding to assess scalability and transferability. Mechanical testing, water absorption tests, and scanning electron microscopy (SEM) analyses were performed to define process–structure–property relationships. The two PCL grades exhibited distinct intrinsic behavior: one showed higher strength but lower elongation at break, while the other displayed greater ductility. The combined analysis of granulometry and weight fraction demonstrated that mechanical response depends on the interaction between matrix type, particle size, and filler content. Finer particle size distributions improved dispersion and load transfer at low reinforcement percentages, whereas at higher contents granulometry significantly affected stress distribution and system stability. Matrix mechanical nature further modulated composite behavior. Laboratory trends were subsequently verified and confirmed in injection-molded specimens, allowing identification of an optimal compositional window balancing stiffness, strength, ductility, and processability. The study highlights that designing PCL–hemp biocomposites requires integrated control of morphological, compositional, and matrix-related parameters. The multi-parametric approach enabled the definition of a process–structure–property map transferable to industrial scale. The optimized formulation was further subjected to preliminary filament extrusion trials for additive manufacturing, confirming compatibility with 3D printing processes and extending application potential within a circular economy framework.

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Active coagulation-wet electrospinning for rapid multiscale design of sustainable materials

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Polymer-based materials with well-orchestrated architectures and engineered surfaces are emerging as key systems for sustainable technologies, including water treatment/monitoring and drug delivery. However, their preparation often relies on multi-step protocols, limiting scalability and sustainability. Active coagulation-wet electrospinning (AC-WE) may represent a rapid route to simultaneously fabricate and functionalize 3D porous monoliths with *ad hoc*-designed structure and properties. Nevertheless, many aspects of this emerging processing technique are still far from elucidated due to the large number of process variables involved and their possible interactions. A series of biodegradable polymers, dissolved in the dope solution, was selected as a constituent of the porous substrate. Liquid and/or solid additives (0D, 1D, and 2D) were introduced into either the dope solution or the coagulation bath. Three groups of variables, namely the characteristics of the two media (dope solution, coagulation bath) and the operating parameters were individuated and systematically varied to independently control both the polymer microstructure and the polymer-additive assembly. The resulting materials were fully characterized to elucidate the processing-structure-property relationships. This technique allowed the rapid construction of materials with multiscale architecture, where the polymer was the main component of the porous framework, while additive localization and nanohybrid assembly depended on the loading strategy and physicochemical interactions between components. Polymeric substrates with fibrous or bead-on-string morphologies could be obtained by controlling the characteristics of dope solution and electrospinning parameters, while the features of coagulation bath allowed the formation of either dense or spongy internal architectures. Furthermore, the possibility to load liquid and/or solid additives into either dope solution or coagulation bath allowed to govern not only the additive content but also its/their localization inside the bulk or onto the surface of polymer substrates. Nanohybrid assembly depended on the features and mutual interactions between polymer and additives, with co-dispersion of multiple additives further increasing morphological and functional complexity of the resulting materials. Consequently, systems with a broad array of bulk and surface properties can be designed, aiming to meet the requirements of specific target applications. This independent control over polymer microstructure, additive localization, and nanohybrid assembly makes AC-WE a versatile strategy for rapidly preparing sustainable materials with designable architecture and functionality, suitable for applications in water treatment, sensing, and drug delivery.

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Mixed titania silica thin films for selective photodegradation of cationic pollutants

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Persistent cationic compounds pose significant challenges in water remediation due their high solubility and stability in environment. Heterogeneous photocatalysis stands out as a promising route to address water purification but conventional powdered catalysts still suffer from critical drawbacks in real applications, including difficult recovery and strong light scattering. To overcome these limitations while preserving strong photocatalytic performance, this work introduces mixed TiO_2–SiO_2 thin films fabricated via a facile one-step sol–gel method. These nanostructured coatings synergistically combine TiO_2's well-established photocatalytic activity with SiO_2's high porosity and negative surface charge, enabling selective adsorption of cationic species such as dyes and herbicides. Precursor sols of TiO_2 and SiO_2 were mixed at varying volume fractions (ϕ_{TiO_2}) and spun-cast onto glass substrates, followed by simple hot-plate calcination. Films optical and electrical properties were characterized prior to testing the new catalysts. Sorption and photodegradation were assessed using methylene blue (MB) and Diquat under simulated sunlight (AM1.5), monitoring absorbance changes. Optimal sorption and degradation performance occurred at $\phi_{TiO_2} \sim 0.46$ due to enhanced porosity, reduced reflectance, and negative surface charge with respect to other samples. Testing selective sorption and degradation over cationic and anionic dyes confirmed the lack of interaction with negatively charged species. The system can efficiently degrade cationic ones, including the herbicide Diquat, under simulated sunlight and show remarkable stability. Intermixing photoactive TiO_2 and porous SiO_2 allows films with boosted sorption and low refractive index, improving light harvesting without compromising TiO_2's redox potential. Compared to literature TiO_2-SiO_2 systems, these films achieve competitive rates (0.06-0.08 min^{-1} for MB/diquat at 5 ppm under solar simulation) using a simpler process, ideal for scalable wastewater treatment.

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PBAT/grape pomace biocomposite for film blowing applications

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The valorization of agricultural by-product in biodegradable polymer systems represents a strategic pathway toward more sustainable materials and circular economy models. Grape pomace (GP), a major residue of the wine industry, is rich in lognocellulosic components and natural antioxidant compounds, making it a promising biofiller for polymeric matrices. While several studies have explored GP in bulk biocomposites, its use in thin films produced by film blowing remains largely unexplored. Firstly, a masterbatch of GP into poly(butylene adipate-co-terephthalate) (PBAT) was produced using a co-rotating twin-screw extruder (OMC; screw diameter = 19 mm; length/diameter ratio = 35; temperature profile: 145–150–155–160–165–170–180 °C. The masterbatch was then mixed with virgin polymer to produce 5% and 10% biocomposites films evaluating their processability and melt stability. The materials were characterized through rheology, tensile mechanical testing, accelerated photo-oxidation aging, and biodegradation analysis under controlled conditions. Rheological characterization and measurement of melt strength (MS) and breaking stretching ratio (BSR) highlighted the filmability of the biocomposite. Mechanical tests showed that the addition of filler does not cause embrittlement of the material, which therefore maintains adequate elongation at break values. The addition of filler also showed a different response in the kinetics of photo-oxidation and biodegradation. The results highlight the potential of grape pomace as a biofiller in PBAT films produced by film blowing. These findings support the development of sustainable packaging films derived from agro-industrial waste.

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Data analysis and predictive modeling of vineyard soil properties using machine learning

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The digital transformation of agriculture represents a strategic pillar of European policies aimed at enhancing productivity and sustainability through advanced technologies. In this context, the AGRARIAN project, funded by the Emilia-Romagna Region under the PR-FESR 2021–2027 program, focuses on developing an integrated precision agriculture system for vineyard monitoring. In this context the aim of this study is to develop machine learning models to predict soil chemical properties from spectral analysis. The study was conducted in two main phases. In the first phase, soil samples were collected from vineyards in Fabbrico and Mandrio, Reggio Emilia, during three distinct time periods. Data included reflectance measurements in the visible (Specim) and near-infrared (NIR) spectra, alongside laboratory-determined chemical properties. Central tendency, dispersion, significant correlations among chemical properties and between chemical properties and reflectance values were examined, and potential outliers were identified and corrected to ensure data consistency using exploratory data analysis (EDA) in Python. In the second phase, different machine learning models were trained on the filtered European LUCAS 2015 dataset and tested on the cleaned Fabbrico and Mandrio datasets. Predictive algorithms compared included Partial Least Squares Regression (PLSR), Feed Forward Neural Network (FNN), Support Vector Machine (SVM), and Random Forest (RF). Model performance was evaluated using Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and coefficient of determination (R^2) metrics. Exploratory analysis revealed significant correlations between soil chemical properties and spectral reflectance, confirming the relevance of selected wavelengths. Outlier correction improved the distribution of variables, enhancing model reliability. Among the machine learning approaches, Random Forests and Feed Forward Neural Networks outperformed linear methods, such as PLSR, in predicting soil chemical properties. Model evaluation metrics indicated higher accuracy and stability for ensemble and non-linear models compared to traditional regression, particularly for properties with complex spatial variability such as pH or nutrients content. The results demonstrate that integrating UAV-based remote sensing, ground measurements, and machine learning provides an effective framework for precision viticulture. Non-linear and ensemble algorithms are particularly suited to capture complex relationships between soil spectral characteristics and chemical properties. These findings suggest that data-driven approaches can support more accurate soil monitoring, inform management decisions, and optimize vineyard productivity. The AGRARIAN project illustrates how digital technologies, combined with predictive modeling, contribute to sustainable agricultural practices and align with European objectives for productivity enhancement and environmental stewardship.

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Food waste processing for rotomolding applications

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Food wastes along the supply chain reached tonnes in Italy in 2024, having an impact on production sustainability. With this in mind, an application of food wastes as fillers for rotational moulding was envisaged to reduce the use of plastics and reciclying wastes, in accordance with objective 12 and 13 of the United Nations sustainable development goals, namely: “responsible consumption and production” and “climate action”. Different polymeric materials (*i.e.* PBS, PHA, and low density polyethylene) were tested, integrating different percentages of ground coffee wastes up to 30%. Materials were chosen according to their possible bio-degradable nature, where polyethylene performs as a benchmark solution. Polymer and filler were treated with melt compounding before being grinded to a powder of around 100 µm. The material presented a scattered porous area on the external surface, as well as wall thickenings according to the set processing parameters. Additionally, the surface darkened considerably after the moulding, leaving a larger set of defects on the After regulating process temperature and time, the new rotomolded piece had a better material spreading and did not present a surface darkening. Pores number were reduced as well as the roughness of the surface. Rotational moulding is a process were little or no pressure is applied when fabricating a product. As such, the main concerns lyes in the formation of air bubbles inside the molten polymer. When adding a filler, its limited compatibility with the polymer leads to the formation of voids inside the structure, that can have deleterious effects on the mechanical properties of the moulded part. With this in mind, the process was optimized to limit bubble insurgence in the material and to permit the desorption of the one which eventually formed to the internal surface, thus to the external air. Temperature optimization was also necessary to avoid filler degradation and darkening of the surface. The material was envisaged to remain sustainable and bio-degradable, according with the type of polymer selected.

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Multifunctional catalysts for the continuous-flow valorization of butanol toward high-value chemicals and jet-fuel precursors

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The design of advanced heterogeneous catalysts is central to the development of sustainable energy and chemical processes. Multifunctional materials combining redox and acid-base properties enable cascade reaction to occur in a single reactor, enhancing carbon efficiency and process intensification. Understanding structure and property relationships in oxide-supported metal systems is therefore essential to control carbon-carbon bond formation and tune product selectivity. Recently we reported on an innovative upgrading pathway for renewable ethanol over Cu-based multifunctional catalysts through a complex cascade sequence of reactions leading to C6-C14 compounds. Extending this strategy, biobutanol represents a promising substrate due to its longer carbon backbone, facilitating direct access to C7+ compounds through cascade reactions including dehydrogenation, aldol condensation, dehydrogenative coupling (DHC) and ketonization, enabling selective production of high-value chemicals and heavier blends for energy applications. Catalysts containing 5 wt% Cu were prepared by incipient wetness impregnation on monoclinic ZrO_2, TiO_2 (anatase) and γ-Al_2O_3, followed by calcination at 450 °C. Physicochemical properties were investigated by BET, XRD, NH_3-TPD, CO_2-TPD and H_2-TPR. Catalytic tests were performed in a gas-phase fixed-bed reactor at 300 °C and atmospheric pressure, feeding 10 mol% butanol in He. The influence of contact time (1-3 s) was evaluated over 5Cu/*m*-ZrO_2. Products were analyzed by on-line GC-TCD and off-line GC-MS. 5Cu/*m*-ZrO_2 showed high butanol conversion (>90%) and tunable product distribution. Short contact times favored selective dehydrogenation to butyraldehyde, a key intermediate. Increasing residence time promoted DHC of butanol, leading to the formation of butyl butyrate, followed by ketonization to 4-heptanone. These products are valuable fine chemicals widely used as solvents and intermediates. The balanced acid-base properties of monoclinic ZrO_2 sustained efficient C-C bond formation, leading to a significant C7+ fraction (~50%). In contrast, TiO_2 and γ-Al_2O_3 displayed less effective carbon growth due to unbalanced surface functionality and different metal and support interactions. The cooperative interplay between Cu redox sites and oxide acid-base properties governs the reaction cascade. Cu/*m*-ZrO_2 emerges as an efficient multifunctional material for butanol valorization into high-value chemicals, while simultaneously generating heavier compounds potentially integrable into alcohol-to-jet energy pathways.

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Assessing the accuracy of cathodic protection potential probe measurements via finite element analysis

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The use of potential probes to monitor the effectiveness of cathodic protection systems for buried metallic structures, such as pipelines, is becoming increasingly widespread. A potential probe typically consists of a reference electrode, commonly a copper rod or coil immersed in a saturated copper sulphate electrolyte ($Cu/CuSO_4$, CSE), and one or more metallic coupons electrically connected to the structure under cathodic protection. This configuration should allow the measurement of the structure's IR-free potential reducing the contribution of ohmic drops in the surrounding soil. Depending on the geometry of the probe (distance between the porous septum and the coupon), the soil resistivity, and the intensity of the circulating currents, the potential measurement remains affected by a residual ohmic drop. In this study, a finite element method analysis is performed to investigate the influence of probe geometry, cathodic current density, coupon size and soil resistivity on the reliability of ON and IR-free potential measurements. The simulations are performed using a secondary current distribution interface, accounting for the ohmic losses in the electrolyte and overpotentials on the coupon surface, modelled through Tafel kinetic equations paired with oxygen limit current density. The results highight the importance of appropriate probe design and, for the geometries considered, identify combined threshold values of soil resistivity and cathodic current density required to ensure accurate potential readings. Overall, the analysis highlights that residual ohmic drops can still bias ON potential measurements under certain combinations of probe geometry, soil resistivity, and circulating current intensity. Defining coupled design/operating thresholds provides guidance to improve measurement reliability and supports the selection of probe configurations suited to specific soil and cathodic protection conditions.

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Photoactive stained glass for visible-light degradation of emerging pollutants

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Over the past two decades, plasmonic metal nanoparticles (NPs) have attracted great interest due to their easy synthesis, tunable size and shape, and consequent control of light absorbance. Indeed, they have been increasingly studied in combination with wide bandgap semiconductor photocatalyst to extend the spectral range of photocatalytic activity. In fact, upon plasmon excitation, metal particles can relax via multiple pathways, and generate plasmon-induced charge carriers, or "hot" electrons and holes that can be transferred to a semiconductor and be exploited for the photocatalytic process. However, these carriers can also be transferred to different surrounding medium, including water, thereby generating solvated charges or reactive oxygen species, or directly to pollutant molecules, leading to their oxidation or reduction. Here, we present a fully plasmonic photocatalyst based on Au NPs immobilized into inert porous glass coatings. Reminiscent of the ancient Lycurgus Cup, whose colour derives from embedded metal particles, this system combines high optical quality with strong visible-light absorption and intrinsic porosity, making them perfect materials for solar driven plasmonic photocatalysis targeting water remediation. The coatings were prepared by hydrolysing an alcoholic solution of tetraethyl orthosilicate and poly(acrylic acid) in the presence of a catalytic amount of HCl at 100 °C for 3 h. The resulting sol was then either supplemented with gold chloride or with previously synthesized gold nanoparticles obtained via standard wet-chemical methods. The mixture was subsequently spin-cast onto a glass substrate and calcined on a hot plate to yield a silica film decorated with Au nanoparticles. Thin film sorption and photocatalytic capability were then assessed using model pollutants. Samples synthesized by the one-pot method were prepared under different conditions to modify and tune the structural and optical properties of the resulting films. In particular, the synthesis conditions affected the porosity of the silica matrix and their absorbance spectrum, which is directly related to the size, distribution, and localized surface plasmon resonance of the embedded gold nanoparticles. Inert silicon oxide thin films decorated with photoactive Au NPs, featuring tunable absorption spectra and photocatalytic activity in the visible spectral range, were efficiently synthesized via a simple one-pot process. Sorption and photodegradation tests under simulated sunlight demonstrated the films photoactivity toward organic pollutants. These results highlight the potential of such nanostructured films for practical applications in solar-driven water remediation.

P73

Valorization of post-consumer recycled polypropylene blends

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The fashion industry is one of the world's most influential sectors in terms of waste production and resource use. It is currently facing the challenge of meeting the more demanding targets set out in the European Green Deal, making it a key sector in the transition to sustainability and circular economy. This study aims to investigate different types of recycled polyolefins to improve the sustainability of everyday items, such as clothes hangers and simple technical parts, which are ideal for experimental laboratory analysis. The study has two objectives: to add value to end-of-life materials and to reduce CO_2 emissions. Several types of recycled polyolefin blends were considered as starting materials for producing low- impact clothes hangers. The first part of the study involved a preliminary modelling step using MATLAB to calculate pressure drops and analyze viscosity as a function of temperature, to select suitable recycled polyolefins as raw materials. The best commercial polyolefin blend is then used to produce prototypes of clothes hangers using an injection molding machine from Travin (UK) with a custom-made V-shaped mold (total width 80 mm, 25° angle and 3 mm thickness). The analysis of nozzle geometry highlighted a high-pressure drop sensitivity to the nozzle radius, with stability achieved only by increasing the radius to reduce backpressure. Under fixed-nozzle conditions, the pressure drop increases linearly with flow rate. In this configuration, a specific polypropylene-based polyolefin blend with high melt-flow rate proved to be the most processable material, maintaining pressure drops consistently within the machine's safety limits. This performance is validated by the Arrhenius model of the viscosity, which shows a significant viscosity reduction in the optimal temperature range (220-250°C). The results obtained show that the selected commercial polyolefin blend has good stiffness and impact resistance properties, making it suitable for secondary processing. Laboratory tests using steel molds shaped like clothes hangers to confirm the MATLAB results are still ongoing. This step is crucial for confirming the stress-strain and thermal properties of the recycled material and for successfully reproducing the dimensional tolerances and mechanical properties required for an industrial production process.

P74

Passive indoor CO_2 capture by zeolite-enhanced plasters

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Increasing anthropogenic CO_2 emissions are associated with environmental impacts that can translate into measurable adverse outcomes for human health. Within the built environment, indoor air quality is a critical exposure pathway, typically mitigated through optimized ventilation and complementary passive strategies. In this framework, material-based solutions applied at the building-envelope level are attractive because they can provide passive, spatially distributed adsorbents of CO_2. This study proposes two novel zeolite-based composite plasters to enable cement-free, low-cost, passive CO_2 adsorption on interior walls at room scale. Two plasters were prepared using zeolite-X combined either with a conventional hydraulic-lime binder (NZ) or with recycled alkali-activated precursors (LZ). Both materials were characterized by XRD, DTA–TG, density measurements, SEM, and flexural/compressive strength testing (EN 196-1). CO_2 adsorption was assessed by applying each plaster as an internal coating inside a polystyrene box and continuously monitoring CO_2 with an Aranet4 sensor, using both a long sealed test and cyclic opening/closing to mimic intermittent fresh-air exchanges. Both plasters undergo progressive dehydration and consolidation during curing, while simultaneously developing carbonate-related signals consistent with carbonation of the binder phase. XRD confirms that zeolite-X remains structurally intact in both matrices. Physical characterization indicates a strong trade-off: NZ has high water-accessible porosity (48%) while LZ remains below 16% but is notably more compact, suggesting NZ is more permeable/accessible for gas–solid contact whereas LZ is more mechanically robust. SEM observations align with this interpretation. Room-scale box tests for both NZ and LZ showed a significant reduction and stabilization of CO_2 in sealed conditions; NZ exhibits a slightly lower steady CO_2 range (420–450 ppm) than LZ (440–470 ppm), and cyclic opening/closing confirms that both systems recover toward stable levels overnight. Finally, an inverse correlation between relative humidity and CO_2 is highlighted, due to competitive adsorption between H_2O and CO_2, providing a simple capacity-based estimate suggesting an order-of-magnitude service life of roughly two years (≈840 days) under daily "recharging" cycles in the laboratory scenario.

P75

Understanding Structure–Process–Property Relationships in Biodegradable Blends with Ludovic®

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In this study, two biodegradable polymers commonly used in packaging - polylactic acid (PLA) and poly(butylene adipate-co-terephthalate) (PBAT) - were blended, and their morphological, rheological, and structural evolution during extrusion was investigated. An experimental prototype extruder allowed in-line monitoring of the blends throughout the process. Following the experiments, Ludovic®, a simulation software for extrusion processes, was employed to gain deeper insights into the effects of processing parameters on the blend behavior. Polylactic acid (PLA) and poly(butylene adipate-co-terephthalate) (PBAT) were used. A prototype co-rotating twin-screw extruder was employed. Morphological, mechanical, thermal, and rheological tests were performed both on extruded samples and in-line during processing. Ludovic® was used to evaluate the processing conditions. Morphological analysis showed an evolution in droplet size across processing conditions. Rheological tests indicated that some conditions led to decreased viscosity due to degradation, with PBAT exhibiting shear-thinning at low frequencies, likely from branching or cross-linking. Mechanical tests revealed that adding PBAT improved flexibility and elongation at break, particularly at higher PBAT content. However, degradation led to stiffer systems with lower elongation. Ludovic® simulations showed stable processing temperatures, but higher residence times. Model predictions initially overestimated viscosity, especially under conditions favoring degradation. These results highlight the critical role of processing parameters on polymer stability and blend behavior. Incorporating residence time into Ludovic® simulations improved agreement with experiments, demonstrating its importance in predicting material behavior. The study emphasizes the balance between mixing efficiency and degradation in achieving optimal polymer properties. Simulation tools like Ludovic® can therefore guide process optimization and performance prediction for biodegradable blends.

P76

Indium-gallium oxide thin films functionalized with gold nanoparticles for solar powered photocatalysis

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Photocatalytic treatments aimed at the degradation of emerging contaminants, such as pharmaceuticals, personal care products, endocrine-disrupting chemicals, pesticides, and perfluorinated species, are commonly based on powdered wide bandgap semiconductors, including TiO_2. However, these materials often suffer from limited harvesting of the solar spectrum, difficulties in post-process recovery, and strong light scattering phenomena that ultimately hinder efficient photon absorption. In this work, a one-step synthetic approach was employed to produce monolithic indium-gallium oxide (IGO) thin films functionalized with plasmonic gold nanoparticles. The films were prepared via a sol-gel route, where a gold chloride precursor was added to a solution containing indium and gallium salts. The resulting sol was deposited via spin coating onto a suitable substrate and then subjected to flame annealing to yield the final Au@IGO monolithic structure. Adjusting the gallium-to-indium ratio allows modulation of the optical and electrochemical properties of the films. The monolithic configuration overcomes issues related to catalyst recovery and minimizes light scattering losses. Gallium oxide contributes a wide bandgap and high reduction potential, while the presence of indium enables precise control over the electronic properties, enhancing compatibility with the UV portion of the solar spectrum. Furthermore, the integration of plasmonic Au nanoparticles promotes absorption in the visible range through localized surface plasmon resonance effects. With the aim of evaluating their catalytic capabilities, these materials were tested for the adsorption of emerging and perfluorinated pollutants in water solutions, then catalytic degradations were carried on under solar simulator illumination, allowing the study of these catalytic processes under realistic illumination conditions. The possibility to employ Au decorated mixed IGO allows extensive absorption of the solar spectrum thanks to tunable optical and electrochemical properties, which make these materials attractive candidates for both reductive and oxidative photocatalytic reactions driven by solar irradiation.

P77

Synthesis and self-assembly of amphiphilic chelating polymers for radionuclide sequestration in water

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Amphiphilic random copolymers offer a powerful strategy for obtaining nano-objects (< 20 nm) via intramolecular single-chain folding that lead to the formation of unimer micelles. The ability to create a confined hydrophobic environment, combined with their stability, makes them ideal for hosting hydrophobic molecules, while their LCST-like thermoresponsiveness enables easy recovery of the material. Decorating the copolymers with hydrophobic, selective chelating agents, either through physical encapsulation or covalent attachment, yields highly effective systems for the efficient sequestration of metals ion that can find application in the sequestration and recovery of radionuclides. PEGMA-*co*-FA random copolymers were synthesized through RAFT and ARGET-ATRP. Different hydrophobic metal chelators were either physically encapsulated within the nano-micelles or functionalized with polymerizable moieties. Copolymer solutions were evaluated through turbidimetry and dynamic light scattering (DLS) while the sequestration of radionuclides was investigated through radio-TLC. DLS measurement confirmed that PEGMA-*co*-FA copolymers, while dispersed in water, self-assembled in nanostructure of size between 7 and 10 nm. All the solutions displayed a cloud temperature T_{Cp}, tuned acting on PEGMA side chain length. The unimer micelle above T_{Cp} collapsed in larger aggregate (100-1000 nm), that can be removed from the solutions by filtration. The complexation experiments demonstrated an exceptional ability of the chelating polymers on sequestrating radionuclides. This study demonstrates two approaches to obtain self-folding amphiphilic copolymers combined with chelating agents. On one hand, highly hydrophobic chelating agents were encapsulated within unimer micelles that are emerging versatile nanocarriers. On the other hand, chelating agents with lower encapsulation efficiencies were covalently linked to unimer micelles after functionalization with polymerizable moieties. Both approaches provide thermo-responsive nanoparticles with promising applications in radionuclide sequestration and recovery.
Acknowledgments: Italian MUR, project PRIN 2022 PNRR AquaGreen, P20222ALWS, CUP I53D23005960001. Multidetector GPC/SEC were performed at CISUP (Centro per la Integrazione della Strumentazione della Università di Pisa).

P78

Microwave-cured acrylated epoxidized soybean oil foams: processing, rheology, and properties

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Vegetable oils represent ideally renewable, abundant, and low-cost feedstocks for the synthesis of sustainable polymers exhibiting diverse structures, properties, and applications. Their inherent molecular complexity, stemming from their carbon backbones, unsaturations, and array of functional groups, offers a significant opportunity for the development of novel materials. Furthermore, the utilization of waste cooking oil as a precursor for bio-based materials presents a compelling alternative to the consumption of virgin vegetable oils, offering substantial cost reductions while aligning with principles of waste valorization and sustainability. In the present study, acrylated epoxydized soybean oil (AESO) was used in the preparation of thermosetting foams cured via a free-radical polymerization mechanism initiated by tert-butyl peroxybenzoate (Luperox® P) and sodium bicarbonate, as blowing agent, under microwave (MW) irradiation at 800 W for 2 minutes. Unlike conventional heating, MW energy directly couples with polar molecules, enabling rapid and volumetric heating of the resin. Therefore, MW irradiation offers a precise and efficient method for temperature control during the crosslinking of foams. The influence of rheological properties during the pre-curing and the MW processing parameters on the resulting cellular morphology of AESO foams was investigated. In detail, cellular growth was observed to be promoted under conditions where the viscosity of the liquid phase was sufficiently elevated to reduce coalescence and coarsening, and where the crosslink density was adequately low to permit foam expansion. Moreover, the thermal stability and mechanical properties of AESO-based foams were studied by thermogravimetric analysis and compression tests. The optimal cellular morphology of foam, characterized by a density of 0.37 g/cm^3, an average cell size of 190 µm and an elastic modulus of 1.8 MPa, was achieved by arresting the pre-curing phase immediately prior to the gel point of resin. Such findings demonstrate the potential of microwave-assisted production of bio-based AESO foams with tailored performance.

This study was conducted within the MICS (Made in Italy - Circular and Sustainable) Extended Partnership and received funding from the European Union Next-Generation EU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR)-MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.3-D.D. 1551.11-10-2022, PE00000004).

P79

Effect of microalgal biomass incorporation on the physical and biodegradation properties of PBSA-based composites

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The incorporation of bio-derived fillers into biodegradable polymers represents a promising strategy to tailor material performance while promoting circular material approaches. Microalgal biomass obtained from wastewater treatment is an abundant and low-cost resource whose potential as reinforcement in biodegradable matrices remains largely unexplored. Understanding how biomass incorporation affects the structure–property relationships of poly(butylene succinate-co-adipate) (PBSA) is essential for designing high-performance and environmentally sustainable biocomposites. An autochthonous microalga belonging to the genus *Chlorella* was cultivated in synthetic wastewater rich in organic contaminants, with the dual objective of evaluating effluent treatment efficiency and valorizing the resulting biomass. The harvested biomass was recovered by centrifugation, freeze-dried, and mechanically milled to obtain a fine powder suitable for melt processing. The resulting microalgal biomass was incorporated into PBSA at 10 and 20 wt% via melt compounding. The obtained materials were compression-molded into specimens and characterized by rotational rheology, tensile mechanical testing, differential scanning calorimetry, contact angle measurements, FTIR-ATR spectroscopy, and controlled composting biodegradation tests. Rheological analysis showed a progressive increase in complex viscosity and storage modulus with increasing biomass content. Thermal analysis revealed a reduction in crystallinity and a slight decrease in melting temperature upon filler incorporation. Mechanical testing demonstrated a significant increase in elastic modulus accompanied by an improvement in elongation at break, while tensile strength remained comparable to neat PBSA. Composting tests evidenced accelerated degradation kinetics in the biocomposites relative to the neat polymer. The combined rheological, mechanical, and biodegradation results suggest favorable interfacial compatibility between PBSA and microalgal biomass. Biomass incorporation modifies both the structural organization and the degradation pathway of the matrix, enabling the development of sustainable biocomposites with enhanced stiffness and improved biodegradability.

P80

Green biocomposites based on biodegradable polymers and vegetal biomasses of the mediterranean area: processability, characterization and degradation

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Upcycling Mediterranean plant biomasses into biopolymers is attractive for reducing fossil content and creating materials with controlled end-of-life. However, lignocellulosic fillers may play a dual role, stabilising the polymer during service while promoting biodegradation in soil. In this work, we compare three local resources with distinct morphologies, *Posidonia oceanica* residues (bioplatelets), *Chamaerops humilis* fibres, and *Ailanthus altissima* particulate as reinforcements for PLA, PBAT, and a commercial starch-based blend (Mater-Bi). Biocomposites containing 10-20 wt% filler were prepared by melt compounding and shaped into specimens. SEM was used to connect filler architecture with interfacial features, including matrix infiltration into lumen structures and the formation of a polymer–biomass interphase ("intrafase"). Durability was assessed via accelerated photo-oxidation (monitoring E/E0, mass loss and crystallinity changes) and chemical ageing in aqueous media at pH 5 and pH 9 for up to 120 days. Thermo-degradation/flammability trends were screened by thermal analysis and residue/char observations. Biodegradation in soil/compost was evaluated through mass loss and surface inspection for microbial attack. All formulations were readily processable by melt routes and exhibited markedly different microstructures. Lumen impregnation was frequently observed, suggesting enhanced mechanical interlocking and a non-negligible interphase contribution. During photo-oxidation, biocomposites showed a slight decrease of E/E0 than neat matrices; *Ailanthus* provided the most controlled evolution of modulus and mass loss, while crystallinity generally increased during ageing, consistent with chain scission and structural reorganisation. Chemical degradation was strongly pH-dependent (pH 9 to pH 5) and sensitive to filler type/loading; *Ailanthus*-filled samples displayed lower mass loss and less severe surface damage. Thermal behaviour was matrix-dependent, yet porous fillers, especially *Posidonia,* suggested barrier/char effects influencing residue and degradation kinetics. In soil/compost, fillers accelerated biodegradation, consistent with increased wettability, microcavities and microbial colonisation. Mediterranean biomass fillers impart an environment-dependent response: they can be protective under photo/chemical ageing and activating in soil, enabling tunable design of green composites by balancing service durability with targeted biodegradability.

P81

Impact of –OH defects on NiO(100) surfaces

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NiO nanomaterials are relevant for applications such as gas sensing or heterogeneous catalysis. This modeling study is aimed at exploring the effect of –OH surface defects, almost ubiquitous on oxide material surfaces, both on NiO(100) electronic structure and on the local environment of top-layer Ni atoms. All computational models featured two magnetic sub-lattices (spin-up and spin-down Ni), consistent with NiO antiferromagnetic (AF) character. Slab models of NiO(100) surfaces with increasing –OH surface density were built, by introducing defects in pairs to maintain NiO AF ordering. Two kinds of OH defects were modeled, by adding: i) H atoms on top layer oxygen atoms (Type I); ii) OH groups on top-layer Ni atoms (Type II). A Density Functional Theory (DFT)-based approach was employed for structural optimization of the models, with Hubbard correction (DFT+U) for the electronic structure treatment. Self consistent magnetization calculations indicated that NiO model surfaces present AF ordering, like bulk NiO. For all slab models, the computed E_{gap} are lower than the bulk value, in line with experiment. Defected slabs show lower E_{gap} with respect to regular NiO(100). Type I and Type II –OH surface defects induce different modifications in NiO electronic structure. High coverages of either Type I or Type II defects induce surface reconstructions with top-layer three-coordinated Ni sites. The co-presence of both Type I and Type II defects at high concentration leads to formation of physisorbed water. Overall, computational results suggest that: i) the type of -OH defects, as well as their concentration, play a key role in affecting the electronic properties of NiO(100) surfaces; ii) a high concentration of a single type of –OH defects favor the formation of highly undercoordinated sites, which may be relevant for catalysis; iii) by tuning the defect chemical structure and surface density, the energy gap of –OH bearing NiO(100) systems could be engineered, modulating the behaviour from p-type to n-type.

P82

Consorzi biostampati di chlorella-saccharomyces per il trattamento delle acque reflue

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Water pollution from heavy metals, dyes, and organic compounds threatens ecosystems and human health. Conventional treatments are costly, energy-intensive, and inefficient at low contaminant levels. Microalgae–yeast consortia exploit symbiotic nutrient exchange, with microalgae producing oxygen and assimilating inorganic nutrients, while yeasts metabolize organics. Immobilization in chitosan hydrogels and 3D bioprinting enhances stability and mass transfer. Dynamic systems better simulate industrial wastewater. This study develops a bioprinted Chlorella–Saccharomyces consortium for continuous-flow wastewater treatment. A thermosensitive chitosan-based bioink was developed and characterized for rheological and mechanical properties. *Saccharomyces cerevisiae* and *Chlorella vulgaris* were encapsulated, and 3D bioprinting was performed using pneumatic extrusion to fabricate the consortium scaffolds. A MIX medium was optimized to support both species' growth. Methylene blue (MB) solutions at varying concentrations were used to assess biosorption, with dye removal monitored by UV–Vis spectrophotometry. A continuous-flow bioreactor with different flow rates simulated dynamic wastewater conditions, maximizing contact between hydrogel scaffolds and contaminated solutions for efficient removal evaluation. Rheological tests indicated a gelation time compatible with maintaining high viability of the microbial consortium, while mechanical characterization showed that the bioink supports cell stability, closely mimicking physiological conditions favorable for both yeast and microalgae. Bioprinted scaffolds demonstrated high print fidelity and uniformity. Encapsulation enhanced yeast metabolic activity versus free cells. MB exposure revealed dose-dependent toxicity in microalgae; batch tests showed the highest removal by free consortia (~49.5%), with printed consortia achieving lower yet reproducible removal. Continuous flow experiments indicated that dynamic wastewater conditions strongly influenced removal kinetics, with slower flow promoting sustained adsorption and biodegradation. 3D bioprinting enabled stable compartmentalization and synergistic interactions between yeast and microalgae, improving MB removal efficiency. MTT assays confirmed cell viability and proliferation within scaffolds. Flow optimization influenced kinetics, accelerated initial removal, and extended sustained adsorption. These findings highlight the potential of engineered microbial consortia as scalable, sustainable solutions for water bioremediation.

P83

A generalized toolbox for design of equilibrium modified atmosphere packaging

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Optimizing packaging design is key to reducing food loss and waste by maintaining product quality and safety. Modified Atmosphere Packaging (MAP) is widely used, but its effectiveness is limited when product respiration and packaging properties alter headspace gas composition. Fresh produce respiration drives O_2 depletion and CO_2 accumulation, while material permeability governs gas exchange with the environment. Equilibrium MAP (EMAP) addresses these interactions by balancing respiration kinetics and gas fluxes, though its design typically requires complex modeling. Here, we propose a generalized toolbox for the a priori design and optimization of EMAP systems. Headspace gas evolution in packaging can be described by mass conservation. In Equilibrium Modified Atmosphere Packaging (EMAP), steady state is achieved when produce respiration balances gas exchange, yielding constant gas composition, volume, and pressure. Under these conditions, the mass balance reduces to $J_i^{eq} + R_i^{eq} W_0 = 0$, where J_i is the net flux of species *i*, R_i its mass-specific production rate, and W_0 the food mass. Reformulation of the gas flux term led to the identification of two design parameters, Π and Δ, which integrate material permeability, thickness, package geometry, respiration kinetics, and micro-perforations. Combined with gas production rates, these parameters enable graphical determination of packaging requirements for targeted O_2 and CO_2 headspace compositions. The approach was validated using literature data and new experiments on blueberries packaged under eight different conditions. We present a graphical method based on the rationalized governing equations of packaging dynamics, enabling straightforward determination of EMAP design parameters without solving differential equations. The approach accounts for variable permselectivity and provides insight into the time required to reach equilibrium from arbitrary initial conditions. Validation against literature data and new experimental results shows excellent agreement between model predictions and observed behavior. This work introduces a unified graphical framework that links optimal storage conditions - defined by headspace O_2 and CO_2 levels - to all key packaging design parameters, including gas permeability, material thickness, package geometry, respiration kinetics, and micro-perforations, within a single plot, thereby simplifying EMAP design for practitioners.

P84

Innovative functional platforms for sustainable energy generation based on ultra-dispersed copper oxides and amorphous carbon nitride

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The urgent need to decarbonize the current energy portfolio is progressively triggering the transition to a hydrogen-based economy. Over the last decade, water splitting activated by solar light has emerged as a strategically appealing route for a large-scale hydrogen production. In this regard, a key challenge is the development of green, cost-effective, efficient and durable electrocatalysts sustaining the oxygen evolution reaction (OER), the kinetic bottleneck of the overall process. Among the possible candidates, carbon nitride (CN) is a rising star due to its favorable combination of chemico-physical properties. In this study, we focus on the less explored carbon-rich amorphous carbon nitride (a-CN_x), featuring various attractive characteristics, but never investigated for similar applications up to date. The target films, fabricated at room temperature on conducting glasses by a magnetron sputtering process, are functionalized with low amounts of nanostructured Cu_xO (x = 1,2) as complementary catalyst by radio frequency (RF)-sputtering under mild conditions, and finally subjected to ex-situ annealing under an inert atmosphere. A comprehensive multi-technique characterization by forefront analytical tools demonstrated the successful formation of a-CN_x-based composite systems, featuring an intimate contact with Cu_xO nanoaggregates. The sole variation of RF-sputtering duration enabled to modulate not only Cu_xO content, but also its dispersion in and on a-CN_x. OER tests revealed that the best electrocatalytic activity enhancement compared to the pristine carbon nitride required a balance between an increased Cu_xO content and a suitable dispersion of the functionalizing agent. These results, interpreted basing on the formation of heterojunctions between the system components, were accompanied by appreciable long-term stability, and hold a significant promise for a variety of energy-related applications.

P85

One-step synthesis of polymer-coated superparamagnetic iron oxides nanoparticles: morphological and magnetic characterization for biomedical applications

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Superparamagnetic iron oxide nanoparticles (SPIONs) are commonly produced through wet-chemical methods that require high temperature and pressure and involve multiple synthesis steps, especially when a surface coating is required for biomedical applications. Our research group has developed an innovative, sustainable, and patented one-step aqueous synthesis operating at ambient temperature and pressure, enabling the direct production of SPIONs in aqueous suspension. We have investigated the extension of this method to obtain polymer-coated SPIONs by adding a hydro-soluble polymer directly in synthesis, obtaining promising results that led to a preliminary evaluation of relaxivity parameters for magnetic resonance imaging (MRI). The innovative process is based on ionic exchange in water between an anionic resin and a solution of ferrous chlorides (2:1 ratio of FeCl3-FeCl2) with a hydro-soluble polymer added in solution, either polyethylene glycol (PEG) or polyvinyl alcohol (PVA). Six samples for each polymer (with varying concentrations of polymer and iron chlorides) were produced, analysed and characterised using X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FT-IR), transmission electron microscopy (TEM), and alternating gradient magnetometry (AGM). From these results, a sample of PVA-coated SPION was chosen for a preliminary evaluation in MRI. The polymer-coated SPIONs obtained have a cubic spinel magnetite core, showing a definite surface bond with the polymer. PEG produced spherical, monodisperse particles (10–30 nm) that are superparamagnetic but have lower magnetization values (1–5 emu/g) than bare SPIONs. In contrast, PVA-coated nanoparticles showed morphology dependent on polymer concentration and reagent molarity, while maintaining an average size of ~10 nm and superparamagnetic behaviour with magnetization values comparable to bare SPIONs (25–50 emu/g). A preliminary MRI evaluation of a selected PVA-coated sample revealed relaxivity values of r_1 = 0.12 mM^{-1} s^{-1} and r_2 = 6.44 mM^{-1} s^{-1}. Our results show that PEG and PVA-coated SPIONs can be produced with an innovative one-step process, which is easily scalable compared to the more used wet-chemical routes. These coated nanoparticles show promising characteristics for biomedical applications; in particular, PVA-coated SPIONs obtained with this method could be a good prospect for possible T_2 contrast agents for MRI.