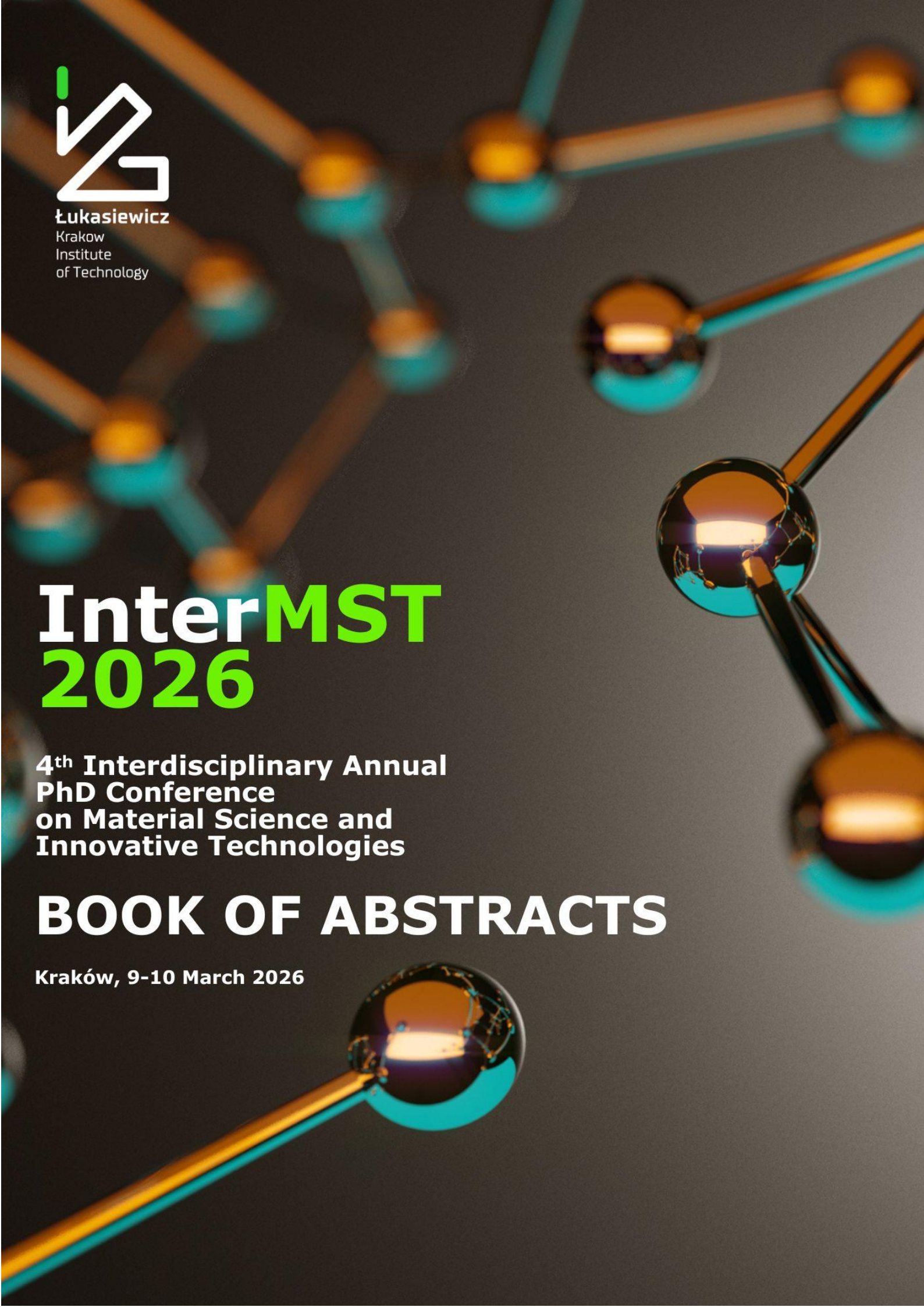

InterMST 2026

4th Interdisciplinary Annual PhD Conference on Material Science and Innovative Technologies

BOOK OF ABSTRACTS

Kraków, 9-10 March 2026

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Welcome to the 4th InterMST 2026

Dear PhD Conference Participants,

On behalf of the Scientific Committee and the Organizing Committee we are pleased to welcome you on the InterMST 2026 conference – Interdisciplinary Annual PhD Conference on Material Science and Innovative Technologies hosted on-line by the Łukasiewicz Research Network – Krakow Institute of Technology, 09-10 March.

The conference is devoted to exploring the richness of approaches, methodologies, and themes of the discipline in order to showcase a wide range of studies and provide a picture of the current state of research in the field of material science and innovative technologies. The interdisciplinary approach of the conference highlight the trajectories of the various scientific disciplines which allow for a progress in material science and innovative technologies – from the engineering and exact sciences to the natural sciences and medical disciplines.

"Book of Abstracts" comprises 80 extended abstracts that have been carefully selected on the basis of a peer review process. It includes state of the art in scientific considerations related to innovative materials and material characterization, advances in casting technology, high temperature and high entropy materials, advances in coatings technologies and finally additive technologies and advances in biomedical and optical technologies.

On behalf of the conference hosts, we would like to express our gratitude to the members of the Scientific Committee, the members of the Organizing Committee, and all the Authors for their effort and willingness to take part in the InterMST 2026 conference – Interdisciplinary Annual PhD Conference on Material Science and Innovative Technologies.

Kraków, March 2026

General information

The conference will focus on advancing innovation, fostering collaboration, and disseminating knowledge within the realm of advanced technologies. It will emphasize interdisciplinary topics across emerging areas, aiming to present the latest discoveries and technological advancements. The conference is an interdisciplinary meeting that connect various scientific disciplines from the engineering and exact sciences to the natural sciences and medical disciplines. The conference is addressed to PhD students. It is a free and virtual scientific event. Each participant will have 15 minutes to present their research and results.

The conference topic include:

- Material Science and Engineering
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- Computer simulation
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registration number: 86

Reinterpreting traditional Iranian wall materials through modern insulation strategies: a simulation driven architectural approach

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Enhancing the thermal behaviour of architectural envelopes is essential in hot–dry climates where passive design remains a core strategy for reducing building energy demand. This study investigates how traditional Iranian wall materials—specifically fired brick, adobe, lime, and gypsum plaster—can be reinterpreted through the integration of expanded polystyrene (EPS) insulation to create more energy-responsive and culturally coherent building envelopes. From an architectural standpoint, the research focuses on how combining vernacular material logic with contemporary insulation can reinforce both environmental performance and spatial comfort.

Two-dimensional modelling and three-dimensional thermal simulations were conducted in AutoCAD and DesignBuilder (EnergyPlus engine) to assess multiple hybrid wall assemblies under consistent climatic conditions representative of Tehran's hot–dry climate. The analyses measured heat transfer rates, thermal resistance, and seasonal stability to determine how the addition of a lightweight EPS layer alters the thermal dynamics of traditional wall systems.

The findings indicate that although traditional materials offer valuable thermal mass and contribute to the distinctive character of Iranian architecture, their performance in isolation does not meet contemporary energy-efficiency requirements. The integration of an EPS insulation layer markedly reduces heat transfer, enhances indoor temperature regulation, and enhances passive cooling, whilst preserving the tactile, aesthetic, and cultural qualities inherent in vernacular construction. These conclusions underscore the efficacy of hybrid wall assemblies as a design-centric approach that harmonises heritage preservation, functional performance, and sustainability.

This research presents an architectural framework that positions material innovation and simulation-driven evaluation as essential tools for developing climate-responsive envelopes in contemporary Iranian architecture. The integrative approach highlights the potential of modern insulation strategies to enhance traditional material systems within sustainable design practice.

registration number: 61

Synthesis and Application of Gold Functionalized MXene for the Colorimetric Sensing of Mercury Ions in Water

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Colorimetric sensors are increasingly explored for environmental and biological sensing applications due to their low cost, simple, and fast nature. These types of sensors offer high sensitivity and selectivity. They can utilize to detect emerging pollutants like pharmaceuticals, cosmetics, biomolecules, and heavy metal ions for water quality testing[1]. The basic principle of colorimetric sensors is to record color changes in the system due to the presence of the target analyte, providing real-time detection and direct identification of the target analyte[2]. Heavy metal ions are one of the emerging water contaminants as well as are among the most difficult to detect and remove from water. However, current lab based optical technologies are limited due to low extinction coefficients and low accuracy [3]. Advanced nanomaterials, such as 2D nano materials, have significantly aided the development of advance colorimetric sensors [4].

Herein, we demonstrate the Au nanocluster-decorated, functionalized MXene-based colorimetric sensor prepared at room temperature for the colorimetric detection of trace amounts of mercury ions in water. The detection mechanism depends on the adsorption of Hg^{2+} ions onto the gold-modified MXene surface, which alters its Localized Surface Plasmon Resonance (LSPR), hence resulting in a shift of the plasmonic hump observed by absorption spectroscopy. The colorimetric sensor developed in this study showed a linear response to a change in the Hg^{2+} ions concentration up to 1 ppm in water. The LSPR signal at 580 nm exhibited a progressive redshift in λ_{max} up to 20 nm. The MXene-based plasmonic sensors demonstrated high selectivity against competing metal ions in tap water. Overall, this work not only extends the application of MXene in colorimetric sensors but also provides a general sensing principle for constructing highly sensitive sensors.

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registration number: 8

Controlled Electroless Deposition of Copper for Polymer Surface Functionalization in Core-Shell Discrete Particle Synthesis

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The optical, photocatalytic, or mechanical properties of insulating materials can be controlled by addition of functional material through methods such as electroless deposition. This process entails the chemical addition of small, catalytic nanoparticles. These particles act as the site of the an autocatalytic deposition reaction by a sacrificial reducing agent, where metal ions are reduced and precipitate solid metal layers at the insulator surface. We aim to control these reactions towards the synthesis of complex, multimetal coatings on polymer particles for photocatalytic and optical applications. However, the heterogeneous surface electroless deposition reaction can also compete with nanoparticle formation that occurs spontaneously in the homogeneous bulk solution. These homogeneous reactions can impact the ability to control the deposition on the particle surfaces. Therefore, it is essential to improve the control of these reactions to favor heterogeneous processes and prevent the formation of undesired by-products. Here, we outline our recent efforts to use *in situ* analytical methods, including UV-Vis spectroscopy, gas chromatography, and high-speed optical microscopy, to characterize the relationship between the chemical environment and the control of intended (heterogeneous deposition) and unwanted (homogeneous nanoparticle synthesis) reactions. Our goal is to identify the reaction conditions that are sufficient to promote the heterogeneous reaction of Cu or other metals on the nanoparticle surfaces while preventing the homogeneous one. In this talk, we will discuss our recent efforts to utilize spectrochemical analysis of reactant concentration and gas chromatography to monitor the reaction kinetics of both the homogeneous and heterogeneous reactions. Additionally, we will describe a particle tracking method for measuring the electroless copper deposition directly on single microspheres via in situ optical microscopy. High-resolution *ex situ* characterization techniques such as scanning electron microscopy and energy-Dispersive x-ray spectroscopy help to calibrate the optical microscopy measurements for quantitative analyses of deposition. Using this new technique, we will develop novel strategies for controlling the electroless deposition reaction on individual particles.

Impact of End-Capped Acceptor Modification on the Photovoltaic Properties of Phenylsulfonyl Carbazole-Based Materials: A DFT Study

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Solar energy is a rich, renewable resource that could enhance environmental health that is associated with fossil fuels [1]. Through efficient binding, supported towards a sustainable energy future and efforts to moderate pollution and diminish greenhouse gas emissions [2]. Organic solar cells (OSCs) have emerged as a promising technology owing to their distinct abilities, such as flexibility, light mass, and compatibility with roll-to-roll manufacturing [3]. In this work, a series of phenylsulfonyl carbazole–based organic chromophores (PSCD1–PSCD6) were rationally designed by modifying the terminal groups of a reference PSCR molecule to enhance their optoelectronic characteristics for energy conversion applications. Density functional theory calculations were performed using the M06/6-311G(d,p) level of theory to investigate the electronic, structural, and optical properties of the designed chromophores. All derivatives exhibited reduced energy band gaps (2.742–3.025 *eV*), pronounced bathochromic shifts (λ_{max} = 496.891–545.009 *nm*), and enhanced intramolecular charge-transfer characteristics relative to PSCR. Density of states and transition density matrix analyses confirmed the pivotal role of the central acceptor unit in promoting efficient charge delocalization, while lower binding energies indicated improved exciton dissociation and photovoltaic potential. Among the systems studied, PSCD4 demonstrated the narrowest band gap and the most red-shifted absorption response.

Beyond photovoltaic applications, the computational insights obtained in this study establish a transferable framework for the rational design and screening of materials for solid oxide fuel cell (SOFC) technologies. SOFCs are high-efficiency electrochemical energy conversion devices that directly convert chemical energy of fuels into electrical energy with low emissions and fuel flexibility, operating at elevated temperatures. Their performance strongly depends on the electronic structure, ionic conductivity, and thermodynamic stability of electrode and electrolyte materials [4]. Key electronic structure descriptors including density of states, band structure characteristics, formation energies, phase stability, and Gibbs free energy trends are highlighted as critical parameters for assessing electronic conductivity, thermodynamic stability, and charge transport behavior relevant to SOFC electrode and electrolyte materials. The methodologies employed to correlate molecular structure with electronic and energetic properties provide a foundation for evaluating defect chemistry, interfacial charge transfer, and electrochemical activity in solid oxide cells. Overall, this work presents a unified DFT-based perspective for advancing functional materials across both solar energy harvesting and solid oxide fuel cell systems.

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DFT- guided design of pH-responsive ^{19}F mri contrast agents

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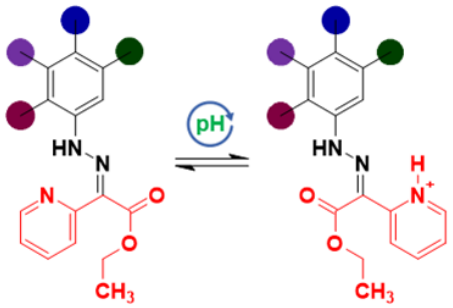
pH is a key physiological parameter that changes in many disease-associated microenvironments, including inflammation, ischemia, and solid tumors. These variations motivate the development of molecular probes that can report local acidity noninvasively [1]. ^{19}F MRI is well suited for this goal because biological tissues contain negligible endogenous fluorine, enabling background-free detection and, in principle, quantitative readouts. The remaining challenge is to design small fluorinated agents that combine high ^{19}F sensitivity with a robust, tunable pH-triggered response that can be translated into MRI contrast [2-3].

This work presents a DFT-guided design approach to develop pH-responsive ^{19}F MRI contrast agents based on fluorinated hydrazone molecular switches. The central concept is to exploit protonation-dependent electronic redistribution and, where relevant, E/Z isomerization in hydrazones to induce predictable ^{19}F chemical-shift changes. We built a focused set of fluorinated hydrazone scaffolds and used density functional theory to compute ^{19}F NMR shielding values for the dominant acid/base states, allowing rapid estimation of the expected shift separation and the likelihood of spectrally resolvable states under physiological pH ranges.

Based on the computational screening, candidates were prioritized using practical criteria: large predicted $\Delta\delta(^{19}F)$ between acidic and neutral forms, minimal overlap with other resonances, and synthetic accessibility with clear handles for tuning pK_a and switching sharpness. The top-ranked compounds were synthesized and evaluated experimentally by ^{19}F NMR titrations to map chemical-shift trajectories versus pH, assess reversibility and stability, and benchmark the agreement between DFT predictions and measured responses. This combined workflow links molecular structure directly to MR-relevant observables, reducing trial-and-error in probe discovery.

The most promising switches were tested in ^{19}F MRI phantom experiments to verify that the pH-dependent shift separation enables offset-selective imaging and controllable signal modulation. Clear differences in signal intensity at defined frequency offsets confirmed that chemical-shift switching can be leveraged as an MRI contrast mechanism, supporting selective "on/off" detection across pH conditions. Overall, fluorinated hydrazones emerge as a modular platform for responsive ^{19}F MRI, and the DFT-first strategy provides an efficient route to accelerate the development of next-generation pH-sensitive fluorinated imaging agents.



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registration number: 35

Medical silicone in implantology: clinical applications and material challenges

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Among various biomaterials, polymers play an important role. For instance, medical silicone is used in breast implants, ophthalmic devices, catheters, endotracheal tubes, and respiratory implants, where its mechanical properties, resistance to degradation, and the possibility of long-term tissue contact are crucial. Their high flexibility, chemical and thermal stability, and good biocompatibility have led to their widespread use in implantology [1-2]. Despite these advantages, medical silicone presents inherent material limitations that may affect its clinical performance. Regardless of its low surface energy and highly hydrophobic nature, medical silicone promotes protein adsorption and microbial adhesion, which can lead to biofilm formation on the implant surface. Because of its tendency to mechanical deformation and difficulties in permanent surface functionalization, there are some challenges for long-term applications. In response to these limitations, surface modification strategies are being developed based on physical activation (plasma, UV/ozone), chemical introduction of functional groups (silanization), and the deposition of thin functional layers with hydrophilic, antibacterial, or controlled-release properties [3-4]. This study focuses on a complex description of medical silicones applied in medicine and its modification outcomes in tissue environments.

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Effect of silica grade and loading on mechanical response of epoxy matrices

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Particulate modification is a widely used route to increase stiffness of epoxy matrices, yet it often introduces a stiffness-ductility trade-off that is strongly resin- and filler-dependent and may narrow the practical formulation window. This study reports preliminary screening results for two bisphenol-A-based epoxy systems that differ in baseline rheology: (i) a relatively thixotropic laminating epoxy based on bisphenol-A type resins (from bisphenol A and epichlorohydrin) containing a reactive solvent, and (ii) a standard low-viscosity epoxy resin described as bisphenol-A-based. Both systems were cured at room temperature for ≥72 h with a slow amine hardener at manufacturer-specified mixing ratios. Fumed silica (AEROSIL 200) and precipitated silica (Arsil) were incorporated at 1–5 wt.%, while TiO_2 was evaluated at 2 wt.% (in one matrix) using a standardized processing route: high-shear mixing followed by staged vacuum degassing prior to casting specimens without fibers. Mechanical response was evaluated by tensile testing (ISO 527, n=5), three-point bending (n=3) and unnotched Charpy impact testing (n=3) to identify formulations maximizing Young's modulus while retaining at least 3% strain at break ($\varepsilon \geq 3\%$) - a pragmatic constraint for subsequent fiber-reinforced composite development. In the thixotropic system, fumed silica provided the most favorable stiffness–ductility window across the investigated loadings. Specifically, 5 wt.% fumed silica increased tensile modulus by 14.8% while maintaining elongation above the target limit, and increased flexural modulus by 20.6%. In contrast, precipitated silica in the same system increased stiffness only moderately but reduced elongation below 3% already at low loadings. For the low-viscosity bisphenol-A-based system, the maximum tensile stiffness gain reached 14.9%, yet all investigated silica variants reduced elongation below the 3% criterion, indicating a substantially narrower formulation window under the current dispersion/degassing protocol. Overall, the results demonstrate strong resin-specific sensitivity to silica grade and loading and provide a data-driven basis for down-selecting candidate matrices for the next stage (fiber-reinforced and hybrid composites), including expanded screening of further silica grades (e.g. Sipernat 22 LS, AEROSIL OX 50).

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Deterministic laser direct writing and Raman-based screening of quantum emitters in hexagonal boron nitride

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Laser direct writing (LDW) enables the spatially defined creation of room-temperature single-photon emitters (SPEs) in hexagonal boron nitride (hBN). However, the rapid characterization of written sites remains a bottleneck, and the available toolset for efficient screening is limited. Here, we demonstrate a streamlined LDW workflow utilizing single-shot pulses combined with a confocal screening technique that exploits the hBN E_{2g} Stokes line to rapidly localize and map laser-modified regions without relying *a priori* on defect photoluminescence (PL). This approach enables the direct correlation of site morphology with PL hotspots, revealing that the emergence of single-photon emitters coincides with a threshold regime of minimal lattice modification. Micro-Raman spectral mapping further uncovers localized compressive strain surrounding these emission sites. We classify the generated defects into two families: narrowband "red" emitters (650–750 nm) with weak phonon sidebands (PSB), and 600–650 nm emitters with stronger vibronic coupling, both exhibiting linear polarization and high single-photon purity. These results establish a practical protocol for rapid prototyping, offering a valuable addition to the characterization toolkit for scalable quantum nanophotonic.

registration number: 22

Polycations for plant protection applications: model membrane studies and biological assessment

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The development of innovative and sustainable strategies for controlling fungal pathogens remains a major challenge in agriculture. With chemical pesticides gradually being reduced because of environmental and health concerns, the search for new, safer antifungal agents is becoming increasingly important. [1] One promising strategy is the use of polycations - positively charged macromolecules that can interact with components of microbial cell membranes. Cationic polymers, including Poly(2-(dimethylamino)ethyl methacrylate) (PDMAEMA), have demonstrated confirmed antimicrobial effects, especially against bacteria, whereas their antifungal potential remains to be further explored. [2]

The aim of this study was to investigate how differences in the molecular weight of PDMAEMA polymers influence their interactions with biological systems, using a combination of physicochemical and cellular approaches, in order to better understand how polymer characteristics affect antifungal activity and potential cytotoxicity.

The analyses included studies on model Langmuir monolayers representing *Candida albicans* membranes, along with preliminary tests on keratinocyte and fibroblast membrane models and cell cultures. The *Candida albicans* monolayers were composed of POPC and POPE phospholipids in a 1:1 molar ratio, with varying ergosterol content (10, 25, and 50 mol%). [3] Surface pressure-area isotherms were recorded to evaluate monolayer properties, and the incorporation of the polycation into the monolayers was assessed depending on its molecular weight. To verify toxicity of presented polymer, studies for keratinocyte and fibroblast models were conducted using single-component monolayers composed of cholesterol, SOPC, sphingomyelin, and ceramides (C17 and C22), representing key components of these membranes. The experiments allowed to observe of which membrane components were most affected by polymers of different molecular weights. These studies were complemented by cell-based assays using the crystal violet staining method to assess cellular response.

This approach provides an important framework for evaluating how polymer molecular weight affects antifungal activity, as well as their effects on keratinocyte and fibroblast cells, helping to verify whether these polymers could be safe agents for plant protection.

Acknowledgement:
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registration number: 85

The influence of long-term exposure to elevated temperature on the microstructure and mechanical properties of austempered ductile iron (ADI) castings

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Austempered Ductile Iron (ADI) is a group of cast iron alloys characterized by very advantageous combination of high strength and toughness. The unique microstructure of ADI matrix called ausferrite is a mixture of a bainitic ferrite plates surrounded by high carbon austenite. High carbon austenite is a metastable phase and under harmful conditions it might become thermomechanically unstable. For example, at elevated temperature high carbon austenite can transform into bainite-like product – a mixture of ferrite and cementite. This transformation may be detrimental to the mechanical properties of an alloy which can lead to a reduction in safety indicators and an increase in the risk of damage during operation of a casting.

The aim of this study was to investigate the influence of long-term exposure to elevated temperature on the microstructure and mechanical properties of ADI castings. Four alloys of ductile iron – one without alloying elements and three alloys with the addition of Ni and Cu at different levels – were cast and heat treated. After heat treatment one batch of castings was cut into samples and another batch was heated up to 250 °C and soaked in this temperature for 1000 hours than cut into samples. The metallographic examination using light microscope and SEM was carried out. Also, mechanical properties were determined in tensile, Charpy impact and hardness tests. It was found that long-term exposure to elevated temperature leads to high carbon austenite decomposition in all of four ADI alloys but at different degree depending on the alloying elements used in the alloys composition. Tensile strength of all alloys showed up to be stable but there was a slight increase in hardness. Plastic properties of the alloys changed in a different manner but all of the requirements of the standard for ADI grade remained satisfied.

registration number: 71

A Novel Small-Molecule Inhibitor Targeting Biofilm-Associated Resistant Pathogens in Diabetic Foot Infections

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Diabetic foot infections (DFIs) are a serious health and economic burden globally. Diabetes affects about 537 million people worldwide, and it is estimated that about 19-34% of patients are expected to develop DFIs, which, through an untreatable bacterial infection lead to foot amputation and even death [1].

DFIs are characterized by the invasion and multiplication of microorganisms in diabetic non-healing wounds and are associated with tissue destruction and/or alterations in the host's inflammatory response. They are commonly polymicrobial and involve antibiotic-resistant strains of microorganisms. DFIs can be particularly insidious because wounds can become infected by bacteria that form protective biofilms over time or when the body's natural defense mechanisms are impaired by diabetes [2]. These infections can be difficult to treat, and despite the administration of multiple rounds of antibiotics, the prospects of clinical resolution of infection can still be poor, and repeated courses of antibiotics risk selecting for antimicrobial resistance. Given these challenges, there is an urgent need for novel therapeutic strategies targeting DFIs.

Here, we demonstrate a novel compound with selective activity against Gram-positive biofilm-forming bacteria. Importantly, the compound demonstrates pronounced antibiofilm activity, disrupting established biofilm structures and reducing bacterial viability within microbial communities. In combination with a clinically used antibiotic, the compound exhibits synergistic antibacterial activity, supporting its potential role as an adjuvant that potentiates antibiotic efficacy. By targeting biofilm-mediated tolerance and enhancing antibiotic susceptibility, this strategy may improve therapeutic outcomes in chronic DFIs.

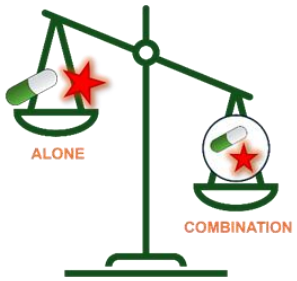

Fig. *Synergistic effect of adjuvant (star) and antibiotic (pill) combination. Due to the synergistic effect of both compounds, the therapeutic effect is achieved at a lower antibiotic concentration, which reduces the risk of antibiotic resistance.*

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registration number: 78

Advances in AI powered human activity recognition and biomarkers measurement based on smartphone onboard sensors

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It is estimated that over 60% of worldwide population uses a smartphone in their daily life, apart from it typical use cases, smartphones can play a big role in medical screening tests, without the need for additional equipment. Smartphones are typically equipped with inertia sensors such as accelerometers and gyroscopes, data from which can be analyzed using AI models, allowing for fitness and general well-being assessment, as well as for detecting biomarkers corelated with progress in rehabilitation or mental health issues.

However, the tasks are often hindered by large heterogeneity of the data, with factors such as differences in sensors, sampling rates, individual patterns in gait as well as phone placement, and it changes during the day. All these issues showcase a huge need for generalizable and adaptable AI models, that can easily adapt to each user.

To address these challenges, recent advancements in Foundation Models for time-series data offer a promising solution. Inspired by the success of Large Language Models in Natural Language Processing, these models are pre-trained on vast, diverse datasets spanning across different domains, enabling greater versatility and performance in downstream tasks like human activity recognition.

Furthermore, to expand generalization capabilities of foundation models, a few-shot approach has been also suggested, which is a technique for adapting a pretrained model to a new setting with few samples of data. This technique could also be used to adapt models to individual users, their smartphone specifications and usage patterns with minimal data, to allow for a robust, personalized and user-centric solution.

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registration number: 52

Beyond conventional superalloys: Mo–Si–B alloys for ultra-high temperature applications investigated via sessile drop experiments and Hot-Dipping fabrication

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The demand for materials capable of operating at ultra-high temperatures has directed significant attention toward **boron-doped molybdenum silicides (Mo-Si-B alloys)**, considered as potential candidates for both structural components and protective coatings. Their appeal stems from the unique combination of high-temperature mechanical strength, relatively low density, and excellent oxidation resistance, which surpass the performance limits of conventional heat-resistant metallic alloys. Nevertheless, to enable the transition of Mo–Si–B materials from laboratory-scale research to practical engineering implementation, it is necessary to develop clean, efficient, and scalable fabrication routes.

In the present project, we explore the feasibility of a pressureless Reactive Melt Infiltration (RMI) process as an alternative manufacturing method. The study was initiated with fundamental investigations of interfacial phenomena using the sessile drop technique under various temperature–time conditions. These experiments were followed by small-scale hot-dipping trials to assess the process under more application-relevant conditions. Subsequently, a dedicated reactor system was employed to produce upscaled specimens. The phase constitution and microstructural features of the fabricated materials were characterized using SEM/EDS, XRD and TEM analyses.

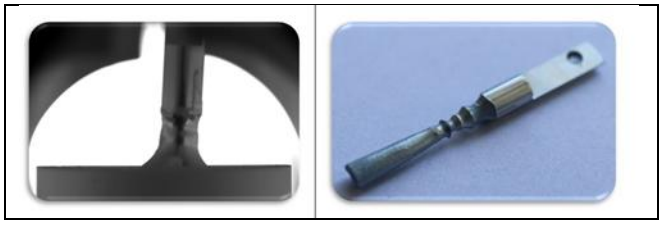

Fig. 1. RMI process applied to the fabrication of Mo–Si–B alloys.

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Carbon quantum dots as luminophores in LEDs

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Carbon quantum dots (CQDs) are innovative nanomaterials which exhibit promising luminescent properties and have been the subject of intensive research in recent years. Unlike classic semiconductor nanocrystals, CQDs are characterized by low toxicity, high biocompatibility, ease of surface modification, and simple and low-cost synthesis from commonly available raw materials [1]. These properties open up a wide range of applications in areas such as bioimaging, chemical and biological sensors, energy , and modern light sources [2].

Despite intensive progress, the technology for obtaining CQDs requires further optimization, especially in the context of controlling structural and surface parameters that determine emission efficiency. An important challenge remains to obtain stable radiation across the entire visible light spectrum (RGB) and to maximize quantum yield (QY), which is crucial for applications in light-emitting diodes (LEDs).

This presentation discusses the most important properties of carbon quantum dots, presents examples of synthesis procedures and methods of modifying their surface. It also presents the results of our own research on the structure, optical characteristics, and application potential of CQDs. An analysis of the impact of synthesis parameters on the luminescent properties of CQDs will be carried out, as well as the impact of surface modification on the color of the emitted light. The research indicates promising opportunities for further improvement of synthesis methods and directions of research that may contribute to a more complete use of this material in future technological solutions.

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registration number: 56

Sustainable Leaching of Lithium-Ion Battery Black Mass with Levulinic Acid: A Deeper Look at Process Efficiency and Kinetics

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The rapidly increasing global demand for lithium-ion batteries (LIBs) is accompanied by a significant growth in post-consumer waste, which offers opportunities for recycling and reuse. Due to the hazardous nature of this waste and the limited availability of the valuable metals like Li, Co, Ni it contains, the development of environmentally sustainable recovery methods is important. Currently, most industrial processes rely on harmful, though effective, mineral acids such as sulfuric acid for leaching spent battery electrodes.

Levulinic acid (LA), a biomass-derived compound, is proposed as a greener and more sustainable alternative, consistent with the principles of green chemistry. In this study, the leaching efficiency of levulinic acid (6.86 M) was investigated at 90°C over a wide range of time intervals (0.5–48 h) for the recovery of critical metals from industrial black mass obtained from LIB recycling. Additionally, the effect of hydrogen peroxide (30%) as an oxidizing agent in the levulinic acid system was evaluated under similar conditions. The results were directly compared with a conventional sulfuric acid(30%) leaching process. Characterization techniques such as SEM-EDS, XRD, NMR,TG-DSC and ICP-OES confirmed efficient transfer of Mn (~80%), Co and Ni (~90%), and Li (~100%) from the solid phase into solution. The results also provided insight into the reaction mechanism and revealed an unusual reverse selectivity toward Fe and Al ions.

Kinetic modeling was employed to identify the leaching mechanism, testing four models over the time range of 0.5–6 h for LA: the Avrami model, the logarithmic model, and two variants of the shrinking core model—one with chemical control and one with diffusion control. The diffusion-controlled shrinking core model provided the best fit to the experimental data (R^2 = 0.88–0.99 for Co, Ni, Li, and Mn), indicating that the formation of a residual layer of insoluble products gradually limits mass transfer and governs the reaction rate.

These findings demonstrate that levulinic acid is a promising environmentally friendly solvent with strong potential for application in LIB leaching and recycling processes.

registration number: 32

Durable cathode materials enabled by Perovskite / Ruddlesden-Popper interface engineering for Solid Oxide Electrolysis Cells

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Rapid societal development has increased CO_2 emissions, driving climate change and sea-level rise. Solid oxide electrolysis cells (SOECs) enable CO_2 utilization by coupling high-temperature electrolysis with renewable electricity and heat [[1]]. In H_2O/CO_2 co-electrolysis, cathode performance controls syngas production, kinetics, and long-term stability, requiring rational material design. Although conventional Ni–YSZ cermet cathodes exhibit high activity and low cost, their operation requires a reducing H_2 atmosphere. However, Sr^{2+} A-site doping, while beneficial for enhancing oxygen vacancy concentration, leads to surface segregation at elevated temperatures, forming insulating $SrO/SrCO_3$ phases that block active sites and deteriorate electrochemical performance [**Błąd! Nie można odnaleźć źródła odwołania.**]. Existing mitigation strategies, such as alkaline infiltration and Sr-free surface coatings, remain inadequate due to persistent Sr migration or impaired oxygen exchange kinetics [[2]].

In this study, we investigate a phase-separation-driven strategy to construct Perovskite / Ruddlesden-Popper heterostructures to inhibit Sr segregation. In parallel, we explore the formation of heterojunctions on the electrode surface, focusing on how the morphology affects electrocatalytic activity and how phase transitions influence the properties of the resulting nanoparticles. The work focuses on perovskite-based materials and related derivatives for SOC applications. Specifically, nanofibrous $La_{0.9}Sr_{0.9}Fe_{1.4}Ti_{0.2}M_{0.2}(NiCoPdCu)_{0.2}O_6$ (M = Mo,Cr,Mn) cathodes were fabricated via electrospinning. The structural and physicochemical properties of nanofibrous perovskite cathodes are characterized by SEM, TEM, and XRD together with TG and conductivity measurements to assess oxygen non-stoichiometry and transport behavior. Sr surface segregation and its suppression will be quantified using depth-resolved XPS and HRTEM coupled with EDS and EELS to resolve Sr redistribution at surfaces. This work establishes a mechanistically grounded route for designing highly active and durable ceramic cathodes for CO_2–H_2O co-electrolysis in SOECs.

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registration number: 53

Manufacturing technology of multi-component AlCoCuFeNi high-entropy alloys using induction melting under semi-industrial conditions.

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High-entropy alloys are advanced materials that exhibit promising properties in certain applications when compared to currently used materials [1]. Numerous types of these materials have already been investigated, and research is ongoing regarding their potential large-scale implementation. However, due to their complex chemical composition, their production cannot be easily initiated using currently applied technologies. Chemical segregation within the ingot must be minimized to the greatest possible extent.
Induction melting is one of the most commonly used technologies in metal casting. One of the advantages of this manufacturing method is the relatively intense mixing of the molten metal bath caused by the magnetic field of the furnace coil. This represents a significant advantage compared to arc melting, which is frequently used in laboratory studies of such materials. The present study describes investigations carried out using an induction furnace with an inert gas (argon) atmosphere to prevent oxidation.
Alloys from the AlCoCuFeNi family contain elements with significantly different melting temperatures. Additionally, aluminum exhibits a strong tendency toward oxidation, particularly at temperatures substantially exceeding its melting point. Therefore, developing an appropriate melting procedure was crucial when using a non-sealed furnace. The study also demonstrated that mechanical stirring enhances material homogenization, which further improves the final ingot quality.
The authors conclude that it is possible to manufacture complex materials such as high-entropy alloys using equipment widely applied in industry. The implementation of a properly designed procedure, tailored to a specific material type, enables the production of materials of satisfactory quality. Consequently, these materials can be readily introduced into industrial production without the need for costly specialized equipment.

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registration number: 66

Development of Cyclodextrin-Containing Chitosan Nanoparticles for Improved Delivery in Diabetic Foot Infections

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Diabetic foot ulcer (DFU) infections remain a significant clinical challenge due to impaired wound healing, biofilm formation, and the rising prevalence of antibiotic resistance [1]. Conventional antibiotic therapies often fail to achieve adequate drug penetration and retention at the infection site, highlighting the need for advanced and localized drug delivery strategies [2]. In this study, chitosan-based nanoparticles (NPs) incorporating modified β-cyclodextrin derivative (β-CD) were developed to enhance drug solubility and therapeutic efficacy. Ciprofloxacin, a broad-spectrum antibiotic, and verapamil, a bacterial efflux pump inhibitor, were co-encapsulated to achieve an enhanced antibacterial effect against pathogens commonly associated with DFUs. β-CD was employed to improve the hydrophilicity and solubility of the loaded drugs, thereby increasing encapsulation efficiency and enabling controlled drug release.

The nanoparticles were prepared via ionic gelation and systematically characterized for particle size, polydispersity index, zeta potential, encapsulation efficiency (EE%), and drug loading (DL%). Surface morphology was analyzed using atomic force microscopy (AFM). *In vitro* cytotoxicity was evaluated on mammalian cell lines to assess biocompatibility, and antibacterial activity was determined against representative DFU-associated bacterial strains.

The optimized nanoparticles formulation exhibited a nanoscale size below 100 nm, with a narrow size distribution and a positive surface charge. AFM analysis confirmed a spherical morphology with uniform distribution. The formulation demonstrated favorable encapsulation efficiency and controlled drug release behavior. Cytotoxicity assays indicated acceptable biocompatibility, while antibacterial studies revealed enhanced antibacterial activity.

In conclusion, β-CD-modified chitosan nanoparticles co-delivering ciprofloxacin and verapamil represent a promising nanotherapeutic approach for improving antibiotic performance in DFU infections. This combinatorial system enhances drug solubility, provides sustained release, and improves antibacterial efficacy, highlighting its potential for localized treatment of diabetic foot ulcers.

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registration number: 15

Catalytic activity of new biomass-based Ni@C – type composites for CO_2 methanation

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A set of new, nickel-based catalysts supported on activated carbons sourced from biomass was synthesized and tested in CO_2 conversion to methane. The carbons were obtained through pyrolysis of dried leaves of maple, goldenrod and knotweed. Then, they were impregnated with nickel nitrate solution, dried and calcined to obtain nickel deposits on their surfaces. Each of these composites was placed in a custom-made flow reactor, and activated with the stream of hydrogen. After activation, these materials catalyzed the reduction of carbon dioxide to methane at different temperatures and pressures, but at the same reagents' ratio. Catalytic output was measured by analyzing methane concentrations in post-reaction mixtures with the use of a gas chromatograph. By changing reaction pressure and temperature, it was possible to find optimal operating conditions for each catalyst and determine its catalytic performance. Materials were also analyzed with SEM-EDS technique to check Ni particles' distribution across carbon support in three states: before activation, after activation and after methanation. These observations allowed to track changes of materials' composition and structure at different environmental conditions. They also showed connections between nickel displacement and catalytic properties of studied materials.

Safety and Process Intensification of 4-Nitrophenol Reduction Using Sodium Borohydride in a Flow Microreactor System

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The reduction of 4-nitrophenol (4-NP) to 4-aminophenol (4-AP) using sodium borohydride is widely applied as a model catalytic reaction, although both catalyst synthesis and catalytic testing are typically performed in open batch systems despite the hazardous nature of $NaBH_4$ and 4-NP. In this work, a continuous-flow microreactor was employed to integrate palladium nanoparticle (PdNP) synthesis with catalytic application under controlled and safer conditions.

Under the applied experimental conditions, stopped-flow measurements showed that PdNP formation reached a steady state after approximately 2.1 s. This kinetic parameter was used to establish the appropriate flow rate and residence time in the microreactor system. For comparison of batch, hybrid (flow synthesis + batch catalysis), and fully continuous-flow configurations, the volumetric ratio of reagents was maintained at 1:1 while keeping concentrations constant across systems.

Palladium nanoparticles synthesized in the microreactor were smaller (3.0 ± 0.5 nm) and more homogeneous than those produced in batch (4.0 ± 0.5 nm). Kinetic analysis of 4-nitrophenolate reduction at 400 nm showed pseudo-first-order behavior, with rate constants increasing in the order k_batch = 0.058 s^{-1} < k_hybrid = 0.095 s^{-1} < k_microreactor = 1.076 s^{-1} (Fig. 1). The fully continuous-flow system achieved complete conversion within seconds.

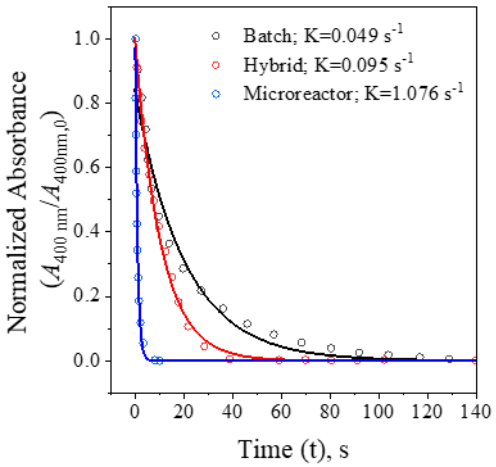

Fig. 1. Kinetic comparison of 4-nitrophenol reduction under batch, hybrid (flow synthesis + batch catalysis), and fully continuous-flow microreactor conditions, expressed as normalized absorbance ($A_{400}/A_{400,0}$) versus time.

Mechanistic interpretation of the catalytic pathway was supported by DFT calculations, and reaction progress was additionally visualized using a transmittance-based color coding approach. The results demonstrate that combining nanoparticle synthesis and catalytic transformation within a microreactor platform improves kinetic performance while enhancing operational safety and process control.

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registration number: 74

Analysis of phase composition in Compacted Graphite Iron using ML techniques

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This study focuses on the application of machine learning techniques for the analysis of phase composition in the microstructure of Compacted Graphite Iron (CGI). The main objective was to investigate the capability of selected machine learning methods to identify and differentiate key microstructural constituents based on metallographic image data. Accurate identification of phases such as ferrite, pearlite, and graphite is essential for assessing material quality and predicting mechanical performance. Therefore, both unsupervised and supervised learning approaches were examined to determine their effectiveness, robustness, and suitability for automated microstructure analysis.

In the unsupervised approach, clustering algorithms such as K-Means and Gaussian Mixture Models (GMM) were applied to group microstructural features extracted from images. These features included color intensity values, Sobel edge gradients, and Local Binary Patterns (LBP), which describe texture characteristics. The results indicated that unsupervised methods can detect general structural patterns; however, their accuracy in distinguishing phases with similar visual and textural properties was limited.

To address the limitations observed in the initial unsupervised clustering results, an intermediate iterative refinement approach was introduced. In this method, regions identified as pearlite were isolated and placed on a uniform background to reduce the influence of tonal similarities between phases and to improve feature separability. The modified images were then reprocessed using unsupervised segmentation techniques, allowing the algorithms to operate on more clearly defined feature distributions. This iterative procedure reduced the misclassification of graphite as pearlite, which had been a major source of error in the original clustering results, and improved the overall separation of individual phases. However, some inaccuracies were still observed in regions where graphite and pearlite were in direct contact, as overlapping boundaries and local texture similarities continued to affect segmentation precision. Despite these limitations, the iterative approach contributed to more reliable estimation of phase composition.

To improve phase recognition accuracy, a supervised learning method based on the Mask R-CNN neural network was implemented. The model was trained using manually annotated microstructure images prepared in COCO format, where specific regions corresponding to individual phases were precisely labeled. Data augmentation techniques were additionally employed to increase dataset. The trained network demonstrated high effectiveness in detecting and classifying individual phases, providing results comparable to expert manual analysis.

The obtained results confirm that machine learning methods provide an effective tool for automated microstructure analysis of CGI. Their implementation can significantly reduce analysis time, improve repeatability, and minimize subjective interpretation. Furthermore, these approaches have strong potential for integration into intelligent quality control systems and decision support systems in the foundry industry, enabling more efficient material characterization and supporting process optimization and materials engineering.

registration number: 24

Synthesis and characterization of W and SiC-based coatings for tritium permeation barriers in fusion breeding blankets

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Fusion reactors provide a promising path towards sustainable energy generation by merging light atomic nuclei like deuterium and tritium, releasing large amounts of energy with little environmental impact and inherent safety advantages. Among the critical components of magnetic confinement reactors, breeding blankets play a crucial role by enabling in-situ tritium generation (which is essential to guarantee tritium self-sufficiency), extracting heat and shielding structural materials from neutron irradiation. These systems typically employ lithium-based materials for tritium breeding (such as the PbLi eutectic alloy), which impose severe requirements on structural and protective materials, mainly when it comes to tritium permeation, irradiation exposure and chemical compatibility.

Advanced coatings are required in fusion breeding blanket environments to mitigate irradiation-induced degradation and limit tritium permeation in contact with lithium-based breeders. In this context, W/SiC multilayer architectures offer a promising prospect by combining the plasma-facing robustness and mechanical integrity of tungsten (W) with the low hydrogen isotope diffusivity, lithium compatibility and irradiation tolerance of amorphous silicon carbide (a-SiC). However, the performance of such systems strongly hinges on film densification, interface quality, and deposition-induced microstructure.

In this work, magnetron sputtering (MS), a plasma-based physical vapor deposition method, was employed to synthesize tungsten thin films. Coatings grown using different MS working modes (namely, DC, pulsed-DC and High-Power Impulse Magnetron Sputtering (HiPIMS)) were systematically compared so as to address the influence of energetic bombardment on film growth and functional performance. Films deposited using HiPIMS exhibited higher hardness, enhanced densification, reduced surface roughness, and stronger hydrogen permeation barrier behavior, signaling improved microstructural quality.

Silicon carbide coatings were subsequently synthesized using pulsed-DC sputtering. Deposition conditions were optimized to obtain amorphous structures with hardness values comparable to those of tungsten, thereby promoting mechanical compatibility within the multilayer architecture. This sequential process optimization paved the way for the synthesis of the W/SiC multilayer coatings with a total thickness of 1.5 µm. Multilayer architectures with an increased number of interfaces exhibited improved adhesion, as revealed by mechanical testing, likely due to more effective defect staggering and enhanced structural integrity.

Ongoing work focuses on engineering smoother interfacial transitions and multilayer design to further suppress hydrogen transport and enhance coating performance. Complementary functional characterization of the SiC films assessing hydrogen barrier effectiveness and compatibility with lithium environments is also underway.

registration number: 57

From Powders to Nanofibers: Morphology Controlled Exsolution and Electrochemical Activity in SOC Electrodes

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Solid oxide cells (SOCs) are promising technology of future clean energy systems because they can store excess renewable power as hydrogen in electrolysis mode and later deliver electricity and heat in fuel cell operation. Their widespread deployment is still hindered by the very high working temperatures (>800 °C), which intensify thermo-mechanical stresses, accelerate degradation, and ultimately raise system costs [1]. Lowering the temperature toward the intermediate/low temperature range (below ~600 °C) typically causes a steep loss of electrode kinetics, so new electrode concepts that remain active at reduced temperatures are essential. Tailoring electrode morphology can boost transport and reaction kinetics and in combination with *in situ* exsolution of nanoparticles technique shows markedly enhanced catalytic activity and SOC performance [2, 3]. In this study, we investigate how morphology engineering influences both electrochemical behavior and *in situ* exsolution of nanoparticles process, based on perovskite electrodes $Sr_{0.9}Fe_{0.7}Ti_{0.1}Cr_{0.1}Ni_{0.05}Co_{0.05}O_{3-\delta}$. The material is designed for symmetric SOFC operation and, as a cathode, delivers a high peak power density of >1.2 $mW \cdot cm^{-2}$ at 850 °C; moreover, in a symmetric configuration it exceeds 300 $mW \cdot cm^{-2}$ at 750 °C. We demonstrate that the nanofibrous material, compared with a conventional powder based, offers a larger surface to volume ratio and shorter diffusion pathways, translating into higher area specific conductivity; consequently, the electrode exhibits over a 35% decrease in polarization resistance at 650 °C (0.34 vs 0.22 $\Omega \cdot cm^2$). At intermediate temperatures, the nanofibers remain fully stable during a 100 hour test, with no visible signs of degradation. Importantly, the nanofiber architecture also boosts exsolution process with higher nucleation density and nanoparticles remain more than 50% smaller than those obtained on powders, helping to maintain a finely dispersed and highly active catalytic population. These results position morphology engineering as powerful design strategy for next generation of SOC electrodes.

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Optimization of Key Technological Parameters in the Production of Hydrogel-Based Therapeutic Systems

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Hydrogels based on natural polymers such as chitosan and alginate represent a promising class of biomaterials for advanced drug delivery applications. Owing to their biocompatibility, biodegradability, low toxicity, and structural similarity to the extracellular matrix, these polysaccharide-based systems provide a favorable microenvironment for the incorporation and controlled release of therapeutic agents [1]. The electrostatic interaction between cationic chitosan and anionic alginate enables the formation of polyelectrolyte complexes under mild conditions, leading to three-dimensional networks with tunable physicochemical properties [2].
In this work, alginate–chitosan hydrogels are designed as matrices for the incorporation of nano-sized drug carriers containing hydrophobic active compounds. The hydrogel network acts as a secondary delivery platform, enabling localized administration, improved retention at the target site, and sustained release behavior. The structural characteristics of the hydrogels—including porosity, swelling capacity, crosslinking density, and mechanical stability—are tailored to regulate diffusion-driven transport and matrix relaxation mechanisms [2]. The incorporation of nanocarriers within the polysaccharide network may influence gel morphology, hydration behavior, and viscoelastic properties, highlighting the importance of polymer–nanocarrier interactions in system optimization. Environmental parameters such as pH and ionic strength further modulate swelling and release kinetics, supporting the development of responsive delivery systems [2]. Importantly, the long-term performance of hydrogels depends on the precise control of post-processing steps, including drying or freeze-drying conditions, which directly affect network architecture, porosity, and drug retention. Additionally, sterilization parameters must be carefully optimized, as exposure to radiation or elevated temperatures may modify the degree of crosslinking and consequently influence mechanical stability and release behavior.
Overall, chitosan–alginate hydrogels provide a versatile and sustainable platform for the development of hybrid drug delivery systems combining nanoformulations with biodegradable polymer matrices. Such systems hold significant potential for improving therapeutic efficacy while minimizing systemic exposure and adverse effects.

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Functionalization of Glycosaminoglycans as an effective strategy for designing advanced hydrogel biomaterials

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Glycosaminoglycans (GAGs), such as hyaluronic acid and chondroitin sulfate, are essential components of the extracellular matrix, playing a critical role in tissue hydration, structural integrity, and cellular signaling. Due to their inherent biocompatibility and bioactivity, they are highly attractive candidates for designing advanced hydrogel biomaterials for tissue engineering. However, to effectively incorporate these natural polymers into stable hydrogel networks, appropriate chemical modification is required. Generating reactive functional groups on GAG backbones allows them to act as efficient macromolecular crosslinkers without compromising their favorable biological properties.

This study focuses on the chemical modification of hyaluronic acid and chondroitin sulfate using sodium metaperiodate oxidation to cleave specific carbon bonds and generate reactive dialdehyde groups. The work included the optimization of this functionalization protocol and a comprehensive evaluation of its impact on the physicochemical and mechanical properties of the resulting hydrogels. Furthermore, TEMPO-mediated oxidation is considered and discussed as a potential alternative strategy for future selective modifications. The developed materials were characterized using Fourier-transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM). Additionally, their mechanical performance was thoroughly assessed through rheological measurements, including evaluation of viscosity, frequency sweeps, and time-dependent gelation behavior.

The results confirmed the successful functionalization of both hyaluronic acid and chondroitin sulfate via the sodium metaperiodate method. FTIR analysis verified the formation of the expected aldehyde groups, while SEM imaging revealed that the resulting hydrogels possess a highly interconnected and uniform porous architecture. Furthermore, rheological studies allowed for the precise determination of the viscoelastic properties of the materials, as well as their crosslinking time. Overall, these findings demonstrate that targeted periodate oxidation of glycosaminoglycans is an effective strategy for tailoring biomaterial properties, paving the way for comparative studies with other functionalization approaches, such as TEMPO oxidation, in developing versatile platforms for 3D bioprinting and tissue regeneration.

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registration number: 14

Defining the manufacturing window for support free thin walls in M300 maraging steel via laser powder bed fusion

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Supportless production of ultrathin metal walls by laser powder bed fusion (L-PBF) poses a critical challenge in metal additive manufacturing due to orientation-dependent heat dissipation, melt pool instability, geometric distortion, and balling. Although M300 maraging steel is widely used in high-performance tools and aerospace components, its technological limitations for producing thin-walled geometries without supports have not yet been determined. This study defines the manufacturing window for inclined thin-walled M300 steel walls produced by L-PBF at constant volumetric energy density. Walls with thicknesses of 0.2-1.0 mm (in 0.2 mm increments) and inclination angles of 30°-90° (in 15° increments) were produced without support structures. Geometric accuracy was assessed using 3D scanning, internal defects were characterized using computed tomography and optical microscopy, and surface roughness (Ra, Rz) and microhardness (HV0.1) were assessed to correlate geometric quality with heat dissipation conditions and material solidification behavior. The results indicate a strong interaction between wall thickness, inclination angle, and thermal process conditions. Ultrathin walls (0.2–0.4 mm) inclined at 30° and 45° exhibited the largest dimensional deviations, increased lack of fusion defects, and the highest surface roughness, indicating reduced thermal stability in highly inclined geometries. In contrast, vertical walls (90°) demonstrated the highest geometric accuracy, the lowest surface roughness, and a uniform microhardness distribution. Most samples were characterized by low porosity, confirming effective melting and densification of the material within the assumed process parameters. However, the results indicate that volumetric energy density alone is not a sufficient criterion for assessing process stability without considering the influence of component geometry and heat transfer conditions. Based on the obtained results, practical design recommendations can be proposed for unsupported fabrication using the L-PBF process. For unsupported structures, walls thinner than 0.4 mm should be avoided due to limited dimensional stability and increased surface roughness. It is recommended to use inclination angles of at least 45° to ensure acceptable geometric accuracy and surface quality, while wall thicknesses of 0.6–1.0 mm provide the most robust manufacturing window in various orientations. These investigations of M300 maraging steel processing using L-PBF contribute to filling the existing research gap regarding the application of this material for the fabrication of thin-walled structures.

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registration number: 20

Analysis of the thermal field in a high-temperature melt for BBO crystal growth

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Thermal conditions in high-temperature melts govern the position and stability of the solid–liquid interface, the thermal driving force for crystallization, and the development of thermal stresses. These factors are therefore critical for the growth of high-quality BBO single crystals. In this study, vertical and radial temperature gradients, together with the position of a characteristic temperature isotherm, were experimentally investigated in a BaB_2O_4–Na_2O melt for different lid aperture sizes. The isotherm position was defined as the depth at which the melt temperature at the center equals the surface temperature measured 25 mm from the center. Temperature profiles were obtained using a rotating thermocouple system, as shown in Fig. 1, enabling quantitative characterization of thermal gradients in the melt.

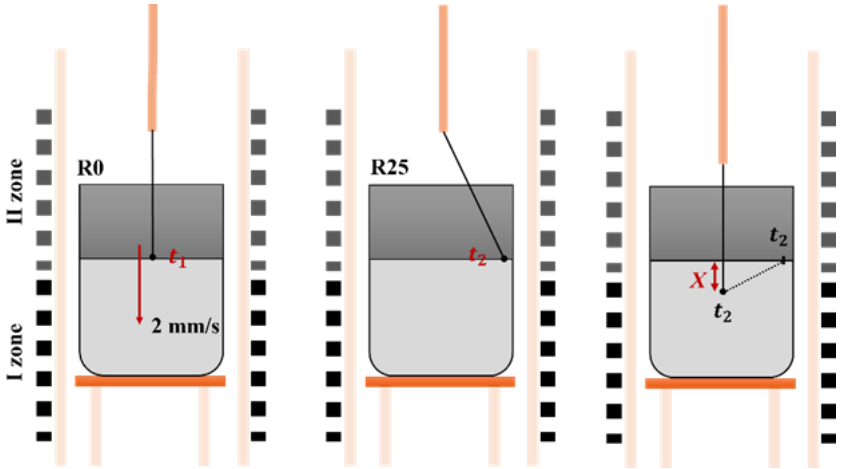

Fig 1. Methodology for measuring temperature distribution in the melt

The results demonstrate that increasing the lid opening leads to larger vertical and radial temperature gradients, while simultaneously shifting the characteristic isotherm closer to the melt surface. Large axial gradients were found to be beneficial for stabilizing the growth interface; however, excessively shallow isotherm positions complicate crystal growth. Conversely, small gradients provide insufficient thermal driving force, also hindering stable growth. In addition, larger lid apertures were associated with increased temperature fluctuations, indicating reduced thermal stability. These findings reveal a trade-off between gradient magnitude, isotherm depth, and thermal stability.

An optimal lid aperture size was identified, providing sufficiently large axial gradients while maintaining a favorable isotherm position and acceptable temperature stability, thereby creating favorable conditions for BBO crystal growth. The presented approach offers practical guidance for thermal field engineering and supports improved process reproducibility through controlled modification of furnace boundary conditions.

registration number: 7

Molecular Engineering, Synthesis, and Atomistic Structure-Property Relationship of Indoloquinoxaline-Capped Small Donors for Efficient Organic Solar Cells

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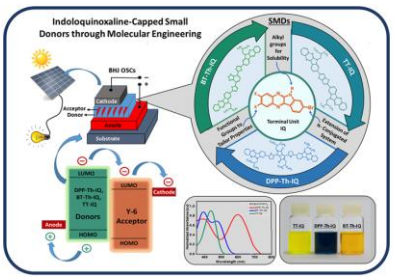
The growing demand for high-performance organic photovoltaics has sparked great interest in small-molecule donor (SMD) materials that offer well-defined structures and superior batch-to-batch consistency. In this study, we report the molecular design, synthesis, and atomistic structure-property characterization of three indoloquinoxaline (IQ)-capped SMDs named as DPP-Th-IQ, BT-Th-IQ, and TT-IQ for potential applications in all-small-molecule organic solar cells (ASM-OSCs). Each SMD features a distinct central core, including diketopyrrolopyrrole (DPP), benzothiadiazole (BT), or thieno[3,2-b]thiophene (TT) with thiophene as bridging units in the DPP and BT derivatives, to systematically tune electronic structures, optical profiles, and charge transport properties. Electrochemical analysis confirmed that all three SMDs possess well-aligned HOMO-LUMO levels conducive to pairing with the Y6 non-fullerene acceptor. Density functional theory (DFT) calculations revealed low hole/electron reorganization energies with extensive frontier-orbital delocalization, indicative of efficient charge transport. Photophysical experiments based on UV-Vis, photoluminescence, and solvatochromic analysis and complementary computational characterization showed strong intramolecular charge transfer in SMDs. Electron density difference analysis explained that particularly benzothiadiazole-based BT-Th-IQ donor exhibits the lowest exciton binding energy coupled with high charge transfer excitations, indicating efficient exciton dissociation. Donor-acceptor interfacial modeling further predicted robust face-on π–π stacking and favorable donor-Y6 orientations that support interfacial charge transfer. Importantly, all three SMDs demonstrated initial thin-film stability: films retained ≥ 90% of their initial absorbance after 30 hours of continuous AM 1.5G irradiation, and thermogravimetric analysis showed decomposition temperatures (5% weight loss) exceeding 250 °C. Overall, this study clarifies the interplay between molecular design, electronic structure, interfacial interactions, and stability, providing a strategic path toward next-generation high-efficiency ASM-OSCs based on IQ-capped donors.



Three novel indoloquinoxaline-capped small-molecule donors named as DPP-Th-IQ, BT-Th-IQ, and TT-IQ are rationally designed, synthesized, and systematically investigated using experimental and computational approaches. Atomistic insights into electronic structure, photophysical properties, and intrinsic charge-transfer dynamics identify benzodithiophene-based BT-Th-IQ molecule as a highly promising candidate, characterized by low exciton binding energy, enhanced charge separation, optimized electronic characteristics, and high stability, paving the way toward sustainable and efficient all-small-molecule organic solar cells.

registration number: 70

Handheld laser braze-welding of galvanized steel limitations

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Braze welding is one of the most commonly used processes for joining galvanized steel due to its significantly lower joining temperature, which causes less damage to the anti-corrosion zinc layer on the joined components. This is due to the use of a Cu-based filler metal, which has a significantly lower melting point than steel. The GMAW method can be used for braze welding, but the welding arc produces a significant amount of spatter. For this reason, research was undertaken into the use of a handheld welding laser. This presentation presents the results of tests on butt joints of galvanized sheets..., made using a CuSi3 filler metal and a laser power ranging to 1.5kW. Macroscopic analysis revealed significant problems with filler metal filling the brazing space. To explain this limitation, tests were performed on the wettability of steel (without the Zn layer) by the CuSi3 filler metal. These studies revealed that an oxide layer on the CuSi3 filler surface can block wetting, thereby limiting the filler metal's flow between the joined components. Furthermore, it was observed that the joints can exhibit a highly diverse microstructure, largely dependent on the transfer of iron from the joined components into the weld. In these areas, the welds also exhibit significantly higher hardness. Furthermore, measurements of the geometrical dimensions characterizing individual joints were taken using different parameters. The figure 1 shows the plates prepared for the brazing experiment using a handheld welding laser.

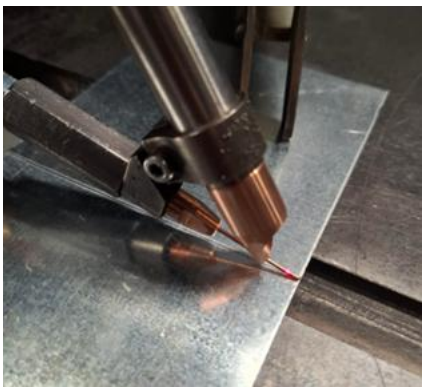

Fig 1. Braze-welding joint - process preparation.

registration number: 75

Low-temperature Optical Photothermal Infrared spectroscopy: signal enhancement and submicron characterization of thermosensitive materials

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Infrared (IR) spectroscopy is among the most extensively employed techniques for material characterization, as it provides detailed information on molecular structure of a sample. In recent years, significant progress has been achieved in approaches based on photothermal expansion detection, particularly Optical Photothermal Infrared (O-PTIR) spectroscopy, which has gained considerable attention. Unlike conventional Fourier Transform Infrared (FT-IR) microscopy, O-PTIR overcomes the diffraction limit, enabling submicron spatial resolution without requiring extensive sample preparation.[1,2]

To date, most studies employing vibrational spectroscopic techniques have been conducted at room temperature (RT) or above RT conditions, whereas the behaviour of materials at sub-zero temperatures remains largely unexplored. In this study, a temperature-controlled stage was integrated into an O-PTIR microscope, allowing spectroscopic investigations of thermally sensitive materials, including triglycerides and polymers, at temperatures as low as –100 °C. All measurements were carried out in co-propagating mode using a 40× objective.

The experiments demonstrated a pronounced enhancement in O-PTIR signal intensity under cryogenic conditions, reaching up to a threefold increase compared with room temperature. This improvement in signal strength enhances spectral sensitivity and enables in situ characterization of thermosensitive materials. To elucidate the underlying mechanisms, systematic investigations were performed under varying experimental conditions, including different gaseous environments and substrates with distinct thermal conductivities. The experimental observations were further supported by theoretical modelling, which facilitated evaluation of the temperature dependence of the O-PTIR signal. These results address a current knowledge gap in low-temperature O-PTIR spectroscopy and underscore the potential of this technique for high-resolution material studies under cryogenic conditions.

Acknowledgments: Measurements were performed at the CIRI beamline of the SOLARIS synchrotron facility. The work is funded by the Ministry of Higher Education and Science of Poland within grant "Implementation Doctorate VII" no. DWD/7/0263/2023.

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registration number: 11

Electrodeposition of samarium cobalt alloys from aqueous electrolytes

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This study introduces a novel approach to the aqueous electrodeposition of Samarium-Cobalt (Sm-Co) alloys by utilizing L-Arginine as a complexing agent to overcome the fundamental challenges associated with reducing rare-earth metals in water-based systems. While standard aqueous methods are often hindered by hydrogen evolution and the formation of hydroxides, this research demonstrates that L-Arginine effectively stabilizes the pH at the cathode surface and facilitates the co-deposition of Samarium ions. Using a three-electrode chronoamperometric setup on copper substrates, Sm-Co films were synthesized across a range of negative potentials. Comprehensive characterization via Scanning Electron Microscopy and X-Ray Fluorescence spectroscopy confirmed the successful formation of the alloy, revealing a distinct relationship between electrochemical parameters and film properties. Specifically, applying increasingly negative potentials resulted in a higher Samarium content and measurable variations in grain structure. These findings establish L-Arginine as a sustainable, cost-effective, and eco-friendly solution, offering a scalable alternative to conventional high-energy manufacturing processes for high-performance rare-earth magnetic materials.

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registration number: 81

Forced β-SiC crystallization in pyrolyzed phenylformaldehyde/methylphenylsiloxane composites

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Polymer-derived ceramics are an emerging group of materials used for the precision moulding and manufacturing of lightweight structures capable of operating at high temperatures in oxidising environments. With appropriate heat treatment, it is possible to transform the organic precursors used into refractory ceramic structures. This method enables the synthesis of amorphous materials that cannot be obtained by traditional sintering, such as turbostatic carbon or silicon oxycarbie (SiOC). Silicon oxycarbide is often called "black glass" due to the characteristic dark gloss of the material. Various microstructures of SiOC materials have been described, depending mainly on the organic precursor used. In the case of commercial polysiloxane resins, the existence of a homogeneous, single-phase material with the empirical formula SiO_xC_y consisting of bonded together carbon graphene-like sheets, SiO_2 nanodomains and tetrahedra of Si-O-C is postulated [1]. Compared to classic SiC ceramics, it has significantly lower thermal conductivity, allowing it to serve as a thermal insulator. At the same time, its thermal stability in an oxygen-rich environment reaches 1400 °C, while for SiC can be as high as 1600 °C. However, it is possible to increase the temperature stability of SiOC ceramics through partial crystallisation. In this paper, a controlled method of crystallising SiOC to β-SiC using a carbon phase precursor, phenyl-formaldehyde resin, is presented for the first time.
The research hypothesis was verified by synthesising five polymer composites containing different proportions of two precursors: methylphenylsiloxane resin as a precursor of the SiOC phase and phenylformaldehyde resin as a precursor of the carbon phase. The samples were subjected to pyrolysis in an argon atmosphere using thermogravimetry. A significant influence of the phase composition on the pyrolysis process was observed, including the occurrence of carbothermal reduction above 1400 °C. The phase composition was determined using the XRD method, showing the optimal ratio of both resins to achieve complete conversion to crystalline β-SiC. At the same time, the nature of the remaining carbon phase was investigated using Raman spectroscopy, showing its evolution and role in the system.

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registration number: 72

Highly exposed active sites of MOFs-derived N-doped nanoporous carbon decorated with platinum for enhanced energy storage application

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The depletion of traditional energy sources, such as fossil fuels, has prompted the direct synthesis of materials with high-capacity performance for energy storage applications. Nitrogen-doped porous carbon (NPC) derived from zeolite imidazole framework (ZIF-8) stands out as a prime candidate for the development of electrochemical double-layer capacitors (EDLCs) due to their high stability and versatile morphology.

In this study, the surface of NPC supported onto nickel foam was decorated with platinum nanoparticles (PtNPs) using an efficient and cost-effective electrodeposition method. The electrodeposition conditions were evaluated in the form of deposition potential and time. PtNPs-NPC electrode deposited at -0.4 V for 120s shows extraordinary properties compared to other electrodes. The electrochemical properties of fabricated electrodes were assessed in 6 M KOH using cyclic voltammetry (CV), galvanostatic charge-discharge (GCD), and electrochemical impedance spectroscopy (EIS). The PtNPs-NPC at -0.4 V electrode demonstrated a remarkable characteristic specific capacitance of 1700± 1.12 F /g at 0.2 A /g.

This electrode displayed high cyclic stability, with only a 2.0 % reduction in its capacitance retention over 5000 cycles. The specific capacitance of PtNPs-NPC at - 0.4 V smoothly declined in the first 1000 cycles from 1164.73± 1.02 to 1153.20 ± 1.16 F /g, with a retention of 99.01%. Even after 5000 cycles, it becomes 1142.25± 1.16 F /g with a retention of 98.07%. PtNPs-NPC at - 0.4 V also showcased the highest energy density and power density of 80± 1.11 Wh/kg, and 1038.42 ± 1.32 W/kg, respectively. In contrast, the pristine NPC exhibited an energy density and power density of 25. ± 1.92 Wh/kg, and 882.00± 1.52W/kg, respectively.

Our strategy demonstrates an entirely novel gateway for decorating NPC surface, opening up possibilities for further exploration of different nanoparticles to engineer promising electrode materials for supercapacitor applications.

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registration number: 44

Composition-dependent carrier transport in PM6:Y6 non-fullerene organic solar cell blends

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Although PM6:Y6 organic solar cells have reached record power conversion efficiencies, the mechanisms governing charge carrier transport and extraction across different bulk heterojunction blend compositions remain insufficiently understood. In particular, the role of donor–acceptor stoichiometry in determining the balance between mobile charge carrier populations, recombination, and trapping during extraction has yet to be fully clarified. In this work, we systematically investigate charge carrier extraction dynamics in PM6:Y6 bulk heterojunctions with varying donor-to-acceptor mass ratios.

Transient photocurrent and time-delayed extraction field techniques were employed to quantify free carrier generation, transport, and recombination under controlled donor phase excitation intensities and overall applied electric fields. The results show that the yield of extractable charge carriers remains relatively insensitive to composition within an intermediate (near-optimal) stoichiometric range but degrades markedly outside this window. Donor-rich blends exhibit a pronounced reduction in mobile carrier density, consistent with enhanced recombination during transport and limited electron extraction. In contrast, acceptor-rich compositions display a significantly stronger sensitivity to stoichiometric variation, with a sharp decrease in extracted charge attributed to carrier trapping in aggregated acceptor domains.

These findings demonstrate that stoichiometry governs charge extraction not only through its impact on carrier generation but also by modifying recombination and trapping pathways during transport. The results emphasize the importance of optimizing blend composition to minimize extraction losses in high-performance PM6:Y6 organic solar cells.

registration number: 80

Multimodal bioimpedance for early detection of pulmonary edema in heart failure

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Heart failure (HF) is a condition in which the heart becomes unable to supply the organs with the blood volume necessary to meet metabolic and venous circulation requirements. One of its most severe complications is cardiogenic pulmonary edema, associated with high mortality and frequent hospitalizations.

This study presents a developed multimodal algorithm combining bioimpedance spectroscopy (BIS) and impedance cardiography (ICG) for the early detection of pulmonary edema in patients with heart failure.

A multi-parameter cardiac telemonitoring system (CardioBIS) integrating single-lead ECG, impedance cardiography (40 kHz), and bioimpedance spectroscopy (10 kHz–1 MHz) was used for signal acquisition. An automated signal-processing algorithm based on maximal overlap discrete wavelet transform (MODWT) was developed to detect characteristic ICG points (B, C, X, O) and calculate hemodynamic parameters: heart rate (HR), left ventricular ejection time (LVET), stroke volume (SV), and cardiac output (CO). Algorithm validation was performed using the ReBeatICG database (24 signals with expert annotations) and a cohort of 20 healthy volunteers. To obtain the clinical data necessary for the development of an algorithm to predict the onset of heart failure exacerbation through periodic monitoring of lung hydration, cooperation was established with the Cardiology Department of the Military Institute of Medicine – National Research Institute (WIM-PIB) in Warsaw. The study included 20 patients who were diagnosed with pulmonary edema during heart failure. The obtained signals were used to perform bioimpedance analysis. The hydration parameters, such as extracellular water (ECW), intracellular water (ICW), total body water (TBW), and ECW%TBW, were estimated using Moissl equations with a BMI-dependent correction.

The algorithm demonstrated high detection accuracy for ICG characteristic points (C: 96.28%, B: 94.67%, X: 84.10%, O: 73.74%). The relative errors were 0.042% for HR and 7.95% for LVET compared with expert assessment. In hospitalized HF patients, elevated ECW and ECW%TBW were observed at admission and decreased during treatment. Changes in hydration parameters were associated with variations in CO and SV and, in selected cases, preceded clinical improvement, suggesting the potential for early detection of decompensation.

Multimodal integration of bioimpedance spectroscopy and impedance cardiography enables simultaneous assessment of fluid status and cardiac function, offering a promising non-invasive tool for early detection of pulmonary edema and personalized management of heart failure. Further studies in larger patient cohorts are warranted to confirm predictive performance.

registration number: 45

Biocompatible tantalum (V) oxide layers on an overelastic substrate: stability analysis under deformation conditions

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This study focuses on evaluating the structural and mechanical stability of tantalum (V) oxide (Ta_2O_5) layers deposited via Atomic Layer Deposition (ALD) onto a superelastic nitinol (NiTi) alloy substrate. The primary objective of the surface modification was to enhance biocompatibility and establish a diffusion barrier to mitigate nickel ion release, while maintaining the mechanical functionality required for cardiovascular implants. The ALD process was conducted at 300°C for 400 cycles, utilizing tantalum (V) ethoxide and water vapor as precursors. To verify the protective layer's performance, a series of analyses were performed, including adhesion testing (scratch-test), nanoindentation (Oliver & Pharr method), surface wettability measurements, and electrochemical stability analysis under deformation in a Phosphate Buffered Saline (PBS) environment.

The results demonstrated high coating to substrate adhesion, with a critical force (L_{C3}) of 22.04 N. Mechanical characterization provided a nanohardness (H_{IT}) of 2724 MPa and a Young's modulus (E_{IT}) of 73.4 GPa. Contact angle measurements confirmed the hydrophilic nature of the surface, which is conducive to biocompatibility. Crucially, deformation stability analysis revealed that the coating maintains its integrity up to an angle of approximately 42º. Beyond this threshold, a drop in potential was observed, indicating coating fracture and subsequent substrate exposure.

The application of ALD technology to synthesize Ta_2O_5 layers on NiTi alloys enables the production of biocompatible coatings with high thickness precision and robust mechanical resistance. These findings confirm the application potential of this modification for the development of superelastic intravascular stents operating under dynamic loading conditions.

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registration number: 54

Effect of Spraying Distance on Mechanical and Corrosion Properties of Fe-Mo-Cr-Y-C-B APS Coatings

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Protection of components operating in severe conditions is a key challenge in modern materials engineering, driving the development of advanced protective coatings. Among available techniques, thermal spraying enables the deposition of high-quality powder-based coatings. Nanocrystalline and amorphous coatings are of particular interest due to their high hardness, wear resistance, and corrosion resistance [1]. Fe-based amorphous and nanostructured coatings have gained attention for their excellent mechanical, thermal, and corrosion-resistant properties. Their performance strongly depends on processing conditions, with glass-forming ability (GFA), microstructure, and functional properties being especially sensitive to parameters such as spraying distance [2].

The powder used for testing and coating deposition had the composition $Fe_{48}Mo_{15}Cr_{14}C_{15}Y_2B_6$ (at.%). Powder was produced by gas atomization and sieved to obtain a particle size fraction of +15/−50 μm. Coatings were deposited using Atmospheric Plasma Spraying (APS) at spraying distances of 90, 100, and 110 mm to systematically investigate the influence of this process parameter on coating structure and functional properties. Comprehensive characterization, including phase analysis, tribological testing, microhardness measurements, and electrochemical corrosion evaluation, was performed to establish the relationship between spraying conditions, microstructure, and functional performance.

The coatings exhibited a predominantly non-crystalline structure. Spraying distance significantly affected the tribological behaviour of Fe-based amorphous coatings. The lowest COF was observed at 90 mm, while the best wear resistance was achieved at 100 mm. The 110 mm coating showed intermediate performance. Microhardness depended on spraying distance. The highest hardness among APS coatings was obtained at 110 mm, while lower values were recorded for 90 and 100 mm; all coatings were significantly harder than the substrate. Corrosion behaviour was also strongly influenced by spraying distance. The coating produced at 100 mm showed the lowest corrosion current density and the most stable OCP, indicating the highest corrosion resistance. The 90 mm sample exhibited intermediate performance, while the 110 mm coating showed slightly lower corrosion resistance.

Overall, APS proved to be an effective method for producing Fe-based amorphous coatings with desirable structural and functional characteristics. The results demonstrate that spraying distance is a key parameter controlling tribological, mechanical, and corrosion performance, with 100 mm providing the most favourable balance of properties. These findings confirm that precise control of spraying parameters is critical for tailoring the functional performance of Fe-based amorphous coatings.

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Metamaterials in vibration damping engineering

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Metamaterials are a class of artificially designed structures whose properties on a macro scale result primarily from the architecture of elementary cells (meta-atoms) rather than solely from the chemical composition and microstructure of the base material. Properly designed geometry makes it possible to achieve mechanical parameters that are not available for conventional materials, such as negative Poisson's ratio [1].

The development of additive techniques has enabled the realization of complex, three-dimensional architectures at various geometric scales, both in homogeneous and composite structures. Precise control of the geometry of elementary cells and their periodicity allows the design of materials with specified wave propagation characteristics, including the occurrence of band gaps resulting from Bragg scattering or local mass resonances [2].

Auxetic metamaterials, characterized by a negative Poisson's ratio, exhibit transverse expansion during stretching, which translates into increased resistance to indentation, shearing, buckling, and increased energy absorption capacity. In turn, structures with variable stiffness use controlled elastic instabilities and geometric reconfigurations, enabling adaptive adjustment of dynamic characteristics to changing load conditions. Quasi-zero stiffness metamaterials combine high static stiffness with very low dynamic stiffness, allowing for ultra-low natural frequencies and effective passive isolation of low-frequency vibrations [2-4].

As part of the research, a design was developed and a numerical analysis was performed of a three-dimensional, lightweight, arrowhead-type metamaterial structure with auxetic properties. The geometry of the meta-atom was described parametrically, which made it possible to assess the impact of geometric modifications on the dynamic response. A structure consisting of four cells in the horizontal direction and eight layers in the vertical direction was constructed. The structure is shown in Fig. 1.

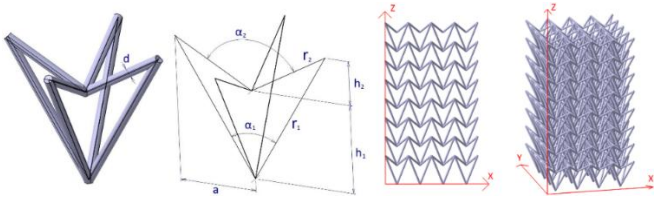

Fig 1. Graphical representation of the arrowhead structure

The FEM analysis was performed in the Ansys environment, assuming a single-degree-of-freedom model with a concentrated mass connected to a rigid substrate via the tested truss. The ribs were modeled with beam elements, the mass with solid elements; the material was assumed to be structural steel.

The results showed a strong, nonlinear dependence of the dynamic parameters on the geometry of the rib cross-section. Increasing their diameter causes a significant increase in the natural frequency and equivalent stiffness of the system, confirming the possibility of effective tuning of the dynamic response solely by changing the geometric parameters.

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Production time prediction as part of manufacturing process digitization

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Enterprises in the manufacturing sector widely deploy Enterprise Resource Planning (ERP) and Manufacturing Execution System (MES) software, which enables the systematic collection of technological and operational data. However, in many production environments, digitization is limited to data recording rather than providing active support for decision-making [1-2]. In particular, normative technological times stored in ERP systems are often used for scheduling, despite having limited predictive capability under real production variability.

This study focuses on predicting production time as a practical step toward digitizing the manufacturing process. Supervised machine learning models, including gradient boosting regression and random forest regression, were trained using historical ERP and MES data. This data incorporated technological time, operation identifiers, and textual descriptions of operations. These descriptions were preprocessed using TF-IDF vectorization to capture relevant linguistic patterns. The machine learning model's predictive performance was compared with a baseline approach that relied solely on normative technological time. The results demonstrate a substantial improvement in estimation accuracy. The machine learning model reduced the mean absolute error (MAE) by 51.11%. Root mean square error (RMSE) decreased by 22.93%, and the coefficient of determination increased from 0.003 to 0.408. The smaller reduction in RMSE compared to MAE suggests that the model still struggles with extreme outliers in production time, indicating areas for further improvement. Figure 1 provides a comprehensive overview of production time predictions. The scatter plot compares actual production times with predictions from normative estimates and the machine learning model. It highlights the poor correlation between normative times and actual durations and the improved alignment achieved by the machine learning (ML) model across a wide range of operations. The tables summarize the model's performance metrics and the schedule impact analysis. They show that using machine learning predictions for batch-level scheduling reduced the average schedule error by 34.68%. These results demonstrate that machine learning improves both individual predictions and overall schedule reliability.

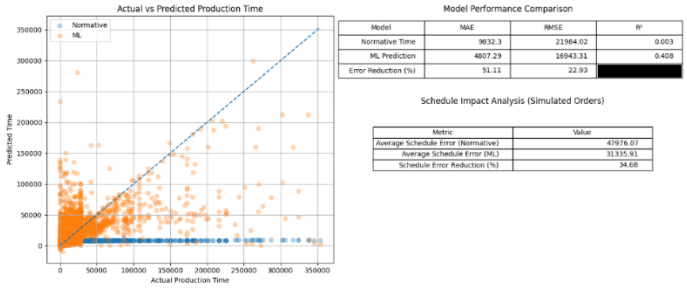

Fig 1. The results of the production time prediction

The findings confirm that production time prediction can serve as a digital intelligence layer that is integrated with the existing ERP and MES infrastructures. Rather than replacing established systems, machine learning augments them by dynamically adjusting operation time estimates based on historical performance. This approach is a measurable, implementable step toward digitizing manufacturing processes, enabling more realistic scheduling, improved temporal reliability, and better operational decision-making.

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registration number: 47

Graph neural network architecture search via hybrid genetic programming with parallel tempering in computational materials science: a JARVIS dataset case study

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The aim of this study was to develop and evaluate an automated framework for graph neural network (GNN) design in materials informatics. Building on Graph Neural Network Architecture Search via Hybrid Genetic Algorithm with Parallel Tempering study [1], this work shifts the optimization focus from a hybrid Genetic Algorithm (GA) pipeline to Genetic Programming (GP) with tree-based architecture representations and local MCMC refinement (parallel tempering / simulated annealing). Candidate models are assembled from classical message-passing operators, while jointly optimizing network depth, hidden dimensions, attention heads, dropout, initialization, and classifier structure. The framework was applied to atomistic graphs derived from JARVIS[2] resources in two supervised settings: (i) binary classification of metallic behavior (metal_opt) using a threshold on optb88vdw_bandgap, and (ii) regression of formation_energy_peratom. Model selection was based on validation performance (AUC for classification, MAE for regression), with early stopping and final test-set evaluation. In contrast to advanced, specialized architectures such as ALIGNN [2], we intentionally study the limits of simple/classical GNN families under strong automated search. The results show that GP-driven neural architecture search is a practical and scalable strategy for computational materials science, enabling reproducible experiments, clearer quality–complexity trade-offs, and more efficient AI-assisted materials screening.

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registration number: 55

Towards all solid state K-ion batteries: fast/SPS processed battery components

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The transition toward sustainable and large scale energy storage technologies has prompted intensive efforts to develop systems that rely less on critical raw materials (CRMs), particularly lithium. In this context, all solid state potassium ion batteries (KIBs) are emerging as a compelling alternative, benefiting from the wide availability and low cost of potassium. Progress in this field, however, requires solid electrolytes and electrode materials that can operate stably and effectively within fully solid state configurations. This work examines the capabilities of the Field Assisted Sintering Technology/Spark Plasma Sintering (FAST/SPS) for producing ceramic components intended for all solid state KIBs. Multiple electrolyte and electrode compositions were synthesized using this technique, enabling a shortening of processing times relative to traditional ceramic fabrication pathways. Structural analysis using X ray diffraction (XRD) was conducted to track phase formation, verify compositional stability, and identify any secondary phases that may arise during processing. Beyond consolidation of the studied materials, the results illustrate the usefulness of FAST/SPS as a tool for rapid materials design. Its ability to generate and densify diverse material systems on accelerated timescales positions the method as an efficient tool for identifying high performance, CRM reduced candidates tailored for all solid state KIB applications. Overall, this study indicates that FAST/SPS can serve not only as an advanced sintering approach but also as a means of expediting materials design. Leveraging this technique for the development of ceramic components in potassium-ion solid state batteries could contribute to more sustainable and resource efficient energy storage technologies.

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registration number: 12

Analysis of selected properties of fabricated HEA-Ti_3SiC_2-SiC hybrid composites in high pressure and high temperature environment

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Recent advances in material science, particularly in the field of composite materials, have led to the development of hybrid composites containing at least two reinforcement phases. When combined with an innovative matrix material, such systems may offer a promising route toward materials designed for operation in extreme environments. In this work, a high-entropy alloy (HEA) is proposed as the matrix material, reinforced with a Ti_3SiC_2 MAX phase and SiC particles.

The aim of this study is to investigate the influence of Ti_3SiC_2 MAX phase content, as well as high-pressure high-temperature (HP–HT) sintering parameters, on the microstructure and selected properties of HEA-based hybrid composites. Particular attention is given to microstructural features, hardness, microhardness, and thermal properties of the fabricated materials. The material design concept seeks to combine the high thermal stability and mechanical strength of ceramic reinforcement phases with the plasticity and stress-relaxation capability characteristic of HEA alloys.

Hybrid HEA–Ti_3SiC_2–SiC composites with varying MAX phase content and constant SiC content were prepared from powder mixtures and subsequently consolidated by HP–HT sintering under controlled pressure and temperature conditions. The obtained samples were characterized in terms of density, microstructure and chemical composition using SEM/EDS, hardness and microhardness testing, and thermal behavior assessed by dilatometric analysis.

The results demonstrate a clear influence of MAX phase content on the properties of the hybrid composites, manifested by microstructural refinement and increased hardness and microhardness. Moreover, distinct relationships between the applied HP–HT processing conditions and the resulting material properties were identified. As HEA–Ti_3SiC_2–SiC hybrid composites remain a relatively unexplored class of materials, this work addresses an existing knowledge gap and highlights their potential for applications in industries operating under extreme conditions, including aerospace, space, and energy sectors.

Controlled *in situ* exsolution in nanofiber double perovskites enables hollow core–shell nanostructures for high-performance symmetrical solid oxide fuel cells

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The growing use of renewable energy sources, such as solar and wind, increases the need for efficient energy conversion systems. Solid oxide fuel cells (SOFCs) are promising devices for clean and efficient energy conversion and storage. In particular, symmetrical SOFCs (S-SOFCs), which use the same material for both electrodes, are attractive because they can reduce fabrication complexity and improve compatibility between cell components. However, they require electrode materials with high catalytic activity and good redox stability in both oxidizing and reducing atmospheres [1–3]. Therefore, the development of multifunctional electrode materials that can operate efficiently at both electrodes in S-SOFCs remains a key challenge. In this work, we develop nanofiber $Sm_{0.9}(Ba, Sr)_{0.9}(Fe, Mn)_{1.8}(Co, Ni)_{0.2}O_{6-\delta}$ double-perovskite electrodes with controlled multi-elemental *in situ* exsolution. The redox-stable perovskite oxides crystallize in the tetragonal *P*4/*nmm* space group. A-site non-stoichiometry was introduced to intensify *in situ* exsolution and promote the formation of a more uniform surface distribution of nanocatalysts. Under reducing conditions (fuel electrode), Co–Ni–Fe metallic nanoparticles are *in situ* exsolved from the perovskite matrix, decorating the electrode surface. In an oxidizing atmosphere (air electrode), $Fe_{3-x-y}Ni_xCo_yO_4$-type hollow core–shell nanooxides are formed, consistent with a Kirkendall-type mechanism driven by asymmetric cation diffusion during oxidation. This atmosphere-dependent evolution of surface nanocatalysts enables the same electrode composition to be effectively used in both fuel- and air-electrode environments. Moreover, the nanofiber morphology promotes the formation of smaller and more densely distributed nanoparticles than in powder counterparts, leading to enhanced electrocatalytic activity. These results confirm that the nanofiber architecture is not only beneficial for high surface area and continuous porosity, but also for better control of exsolution-derived nanostructures. Consequently, anode-supported cell with a nanofiber air electrode decorated with hollow core–shell nanocatalysts achieves peak power densities of 1112 mW cm^{-2} at 850 °C and 877 mW cm^{-2} at 800 °C, with stable operation for 200 h. In addition, the S-SOFC delivers 816 mW cm^{-2} at 800 °C. These results show that nanofiber-based multi-element *in situ* exsolution is a powerful strategy for designing high-performance and durable S-SOFC electrodes, and they provide a new route for advanced materials engineering in electrochemical systems [3].

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registration number: 73

Novel polymeric nanoformulations for controlled drug delivery in hormone-dependent breast cancer

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Breast cancer remains one of the leading causes of cancer-related mortality worldwide. In HR+HER2+ tumors, crosstalk between hormone receptor and HER2 signaling pathways promotes therapeutic resistance and limits treatment efficacy [1]. To address these challenges, we are developing a novel polymeric nanoformulation designed for controlled co-delivery of synergistic chemotherapeutic and hormone-modulating agents. Nanoencapsulation of highly cytotoxic agents such as a topoisomerase I inhibitor (drug A) and a hormone-modulating agent (drug B), enables controlled and sustained drug release, improving pharmacokinetic profiles and therapeutic index. Polymeric nanocarriers enhance biocompatibility, modulate biodistribution, and reduce systemic exposure, thereby minimizing off-target toxicity [2,3].

To this end, we are developing and evaluating complementary polymeric and supramolecular delivery platforms designed to enhance drug loading, stability, and controlled release. Nanoparticles in the nanoscale range were obtained using an established emulsion-based method [2,3]. The formulation combines polymer-based encapsulation with molecular-level drug stabilization strategies. Preliminary in vitro studies performed for the cytotoxic agents confirmed preserved biological activity following complexation and nanoencapsulation, with no significant increase in nonspecific cytotoxicity observed. Further optimization is currently focused on improving drug encapsulation efficiency and refining release kinetics to enable effective integration with hormone-modulating agents within a dual-delivery strategy.

Particular emphasis will be placed on the rational identification of the most effective therapy combinations, with systematic evaluation of drug ratios to maximize therapeutic synergy and minimize systemic toxicity. By fine-tuning both formulation parameters and pharmacological pairing strategies, this approach aims to establish a precisely controlled dual delivery system capable of overcoming resistance mechanisms in HR+HER2+ breast cancer and advancing toward translational, precision-oriented nanotherapeutic applications.

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registration number: 90

Effect of Laser Power on The Fabrication of Fe-Cr-W Medium Entropy Coatings

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The influence of laser power on Fe–Cr–W medium-entropy alloy coatings was investigated, focusing on mechanical and corrosion performance. Hardness peaked at 857 HV at 1200 W due to rapid solidification and fine dendritic structures, while higher powers caused grain coarsening and reduced hardness. Corrosion behavior depended on the environment: in H_2SO_4, the 1600 W coating showed the lowest corrosion rate due to a dense passive film, whereas in NaCl, optimal resistance occurred at 1400 W, where balanced heat input produced a homogeneous microstructure and stable passive layer. These findings demonstrate that moderate laser power (~1400 W) provides the best compromise between hardness and corrosion protection, emphasizing the critical role of laser energy optimization in producing durable Fe–Cr–W coatings for aggressive environments.

registration number: 13

Nano-additive lubrication effects on friction and wear in Sucker Rod Pumps

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The durability and operational efficiency of sucker rod pumps (SRPs) are critical for sustainable oil and gas production, yet they are significantly impacted by wear and fatigue under cyclic mechanical loads. Wear at the rod-tubing interface not only reduces efficiency but also initiates fatigue cracks, which may lead to premature pump failure. This study investigates the tribological behavior of SRP materials under varying load and lubrication conditions, focusing on the effect of material selection, applied loads, and lubrication types on friction and wear performance. Controlled pin-on-disk wear tests were performed on three commonly used SRP materials: conventional AISI 4140 alloy steel, tungsten carbide-coated rods, and polymer-based composites. Tests were conducted under dry conditions, crude oil lubrication, and synthetic nano-additive lubrication containing 2% MoS_2 nanoparticles, at low (500 N), moderate (1000 N), and high (1500 N) loads. Sliding speeds of 30, 70, and 150 m/min were selected to simulate downhole conditions, while test durations ranged from 15 to 60 minutes.

The coefficient of friction (CoF) and specific wear rate (SWR) were measured continuously, and microstructural analyses of the wear tracks were conducted using scanning electron microscopy (SEM) and energy-dispersive spectroscopy (EDS). Results indicate that nano-additive lubrication effectively forms a protective tribo-film, reducing friction and wear, with the lowest observed CoF of 0.26 and a SWR of 2.1×10^{-3} mm³/Nm. Dry contact produced the highest friction (CoF up to 0.68) and wear (SWR up to 7.4×10^{-3} mm³/Nm), dominated by abrasive mechanisms and plowing of material. Crude oil provided moderate friction reduction, but boundary lubrication failure at higher loads led to increased adhesive wear and fatigue cracking. Among the tested materials, tungsten carbide-coated rods exhibited the lowest wear and highest durability, with a minimum SWR of 1.3×10^{-3} mm³/Nm. AISI 4140 steel showed moderate wear resistance, while polymer-based composites suffered the highest wear rates (up to 8.5×10^{-3} mm³/Nm) under high-load conditions.

SEM and EDS analyses revealed plastic deformation, fatigue-induced microcracks, delamination, and material transfer under high-load dry or insufficiently lubricated conditions. Nano-additive lubrication produced smoother wear tracks with minimal plastic deformation, indicating effective surface protection and friction reduction. Statistical analysis using ANOVA confirmed that lubrication type and material composition significantly influence wear behavior ($p < 0.05$), while load variations alone showed limited effect on CoF and SWR trends. The results highlight that friction and wear in SRPs are not only load-dependent but are also strongly controlled by lubrication efficacy and material hardness.

Overall, this study demonstrates that the combined optimization of material selection and nano-additive lubrication can substantially improve SRP performance, extend component service life, and reduce maintenance costs under harsh operational conditions. The findings provide practical guidance for the design of durable SRP systems, selection of advanced coatings, and implementation of friction-reducing lubricants.

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Corrosion Mechanisms of alloys under simulated Martian conditions

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Metallic materials used in planetary exploration rovers are subjected to extreme environmental conditions that accelerate corrosion-driven degradation processes and structural degradation. Stainless steel and aluminium alloys are particularly sensitive to the combined effects of low atmospheric pressure (~7 mbar), temperature cycling (0 ºC to – 30 ºC)[1], soil chemistry that formed saline deposits or brines, and intense cosmic radiation found in Mars. Evidences from previous missions, such as Curiosity (NASA, 2011), Exo-Mars (ESA-Roscosmos, 2016) and Perseverance (NASA, 2020),- undercores the need for a deeper understanding of the electrochemical and physicochemical mechanisms that govern material degradation on Mars [2].

To address this challenge, this project presents an integrated research framework combining thermodynamic and kinetic modelling with controlled exposure tests in a Mars simulation chamber. Corrosion behaviour will be evaluated under simulated Martian conditions by systematically introducing brines of variable composition and concentration, including perchlorates, sulphates, and chlorides, which are known to be commonly in Martian regolith [3].

This strategy aims to elucidate the synergistic interaction between environmental parameters and saline species on corrosion mechanisms, providing insights to support the development of more durable metallic materials for future Mars exploration missions [4].

Advanced computational simulation tools will be employed to identify oxides compounds and phases formed on aluminium (AA7075-T6) and stainless steel (11R51) alloys, assessing their stability as a function of pH and electrochemical potential. The identification of passives zones (chromite (Cr_2O_3) for steels and alumina for aluminium alloys (Al_2O_3)), corrosion zone (like spinels (Cr_2FeO_4) and nickel ferrite ($NiFe_2O_4$)), and protection zones [5] will be performed.

Furthermore, the kinetic parameters, such as corrosion rate, corrosion speed, current density and polarization behavior derived from current density measurements are carried out using finite element simulation tools [6].

The expected outcomes include the validation of theoretical models with experimental data, the identification of critical environmental variables influencing corrosion and the development of new materials characterization and design tools for future planetary applications.

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Heat treatment and characterization of novel CoCrNi based medium entropy alloys

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Medium-entropy alloys are gaining recognition as a promising alternative to conventional superalloys in sectors such as aerospace, energy, marine, and chemical processing, where structural components must simultaneously exhibit high strength, fracture toughness, and reliable resistance to corrosion and oxidation at elevated temperatures. In this study, we integrate design and processing strategies from multiple CoCrNi-based alloy systems to investigate the effects of targeted alloying and heat treatment on high-temperature performance. The alloys were dopped with Nb- Zr, Zr–Cu, and Zr–Sn additions to evaluate their influence on microstructure and properties. Production was carried out through vacuum arc melting, followed by a two-step heat treatment consisting of solutionising at 900 °C and subsequent isothermal ageing at 700 °C for 4–24 hours. Microstructural evolution and material properties were assessed using optical microscopy, nanoindentation, tribological testing, potentiodynamic polarization in HCl, H_2SO_4, and NaCl solutions, and high-temperature oxidation experiments. The incorporation of Zr–Sn produced significant grain refinement, activated precipitation strengthening, and facilitated the formation of adherent ZrO_2/SnO_2-rich surface layers. These changes collectively reduced corrosion current density and enhanced both wear and oxidation resistance compared to the undoped CoCrNi baseline. Among the compositions studied, the CoCrNi–$Zr_{2.5}Sn_{2.5}$ alloy aged for 12 hours at 700 °C exhibited the most favorable balance between mechanical performance and corrosion resistance, while higher Zr contents led to precipitate coarsening and embrittlement. When considered alongside complementary results from Nb- and Cu-containing CoCrNi alloys, the findings demonstrate that carefully designed Zr-based binary alloying, coupled with an optimized heat treatment schedule, provides a versatile and practical strategy to develop multifunctional CoCrNi medium-entropy alloys capable of long-term operation in demanding high-temperature and corrosive industrial environments.

Poly(*o*-aminophenol) imprinting on the Titanium Carbide MXene surface for sensing of Clorsulon: A theoretical study

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Molecularly imprinted polymers (MIPs) are synthesized through the polymerization of functional monomer(s) in the presence of a target analyte, referred to as the template, in the pre-polymerization solution. After polymerization, removal of the template leaves cavities in a polymer matrix, so-called binding sites, complementary in shape and functionality to the target molecule, enabling selective recognition during rebinding [1].

Density functional theory (DFT) and extended semiempirical tight-binding (xTB) methods were employed to investigate the effect of solvents in the pre-polymerization mixture and to determine the optimal molar ratio of monomers to template. The binding energies were computed using equation 1.

$$E_{Binding} = E_{Complex} - \left(E_{Analyte} + E_{Receptor}\right) \qquad (1)$$

The binding energy between *o*-aminophenol (monomer) and clorsulon (template) was screened at different template-to-monomer ratios, ranging from 1:1 to 1:14. Fig. 1 shows the optimized complex of clorsulon in ethanol, identified as the most suitable solvent for template extraction from poly(*o*-aminophenol), the polymeric receptor.

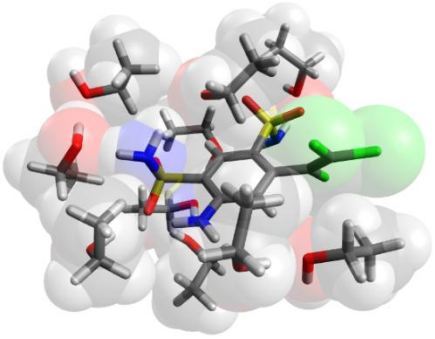

Fig 1. The explicit solvation of clorsulon analyte in ethanol was created by ORCA 6 software.

Next, titanium carbide MXene monolayers (Ti_2CT_x, where T_x = -O or -F) were modelled to investigate their electrochemical properties when used as a substrate modified with poly(*o*-aminophenol). The adsorption-induced changes in the electronic structure, charge transfer characteristics, and binding affinities were analyzed. The results revealed that modulation of the guest charge carriers near the Fermi level enhanced interfacial charge transfer.

Overall, the simulations enabled the identification of optimal conditions for the fabrication of poly(*o*-aminophenol)-based MIPs, thereby improving recognition performance. The sensing mechanism was elucidated, indicating the potential for boosted sensitivity and selectivity in the proposed sensor platform.

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Fabrication of Cu-Ag bimetallic GDEs via thermal evaporation for CO2 electroreduction

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The growing environmental impact of anthropogenic CO_2 emissions necessitates the development of advanced technologies for greenhouse gas mitigation through conversion into value-added chemicals (Nevola 2025).Electrochemical CO_2 reduction offers a promising pathway for producing hydrocarbons that can serve as energy carriers, enabling integration with renewable energy storage systems. Recent studies have demonstrated that chemically synthesized Cu–Ag bimetallic alloys exhibit enhanced stability and selectivity toward C_{2+} products, even at high current densities (Guo, Liu et al. 2024).
In this work, Cu–Ag bimetallic catalytic layers were fabricated on gas diffusion electrodes (GDEs) using thermal evaporation, enabling precise control over film thickness and morphology—key parameters governing catalytic performance. The study focuses on optimizing alloy composition, thickness, and operational current density to achieve high efficiency, selectivity, and stability in CO_2 electroreduction to hydrocarbons (Dlamini 2021).
The influence of Ag content in the catalytic layer on electrocatalytic performance was systematically investigated. Catalysts were evaluated at high current densities ranging from -1500 to -1900 $mAcm^{-2}$ (Chaliyawala, Bastide et al. 2023).Faradaic efficiencies were determined using GC-MS/TCD product analysis combined with charge balance calculations. Structural and compositional characterization was performed using XRD and XRF, respectively. Surface chemistry before and after electrolysis was analyzed by FTIR spectroscopy. Catalyst thickness was measured via profilometry, while morphology was examined using SEM (Su, Guo et al. 2023).

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Electrochemical properties of polyurethane-based electrode binders in aqueous sodium-ion batteries

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Aqueous sodium-ion batteries (ASIB) present a significant opportunity for large-scale energy storage due to the widespread availability and economic viability of sodium. The evolution and market adoption of ASIBs are primarily contingent upon the development of high-capacity electrode materials. In this context, the binder assumes a pivotal role enhancing battery performance. Poly(vinylidene fluoride) (PVDF) is widely used as predominant binder because of its good electrochemical stability, chemical inertness and binding capability [1]. However, the utilization of PVDF is not without its drawbacks. The inadequate hydrophilicity and weak adhesion to metal foil current collectors in aqueous systems serve as key incentives for investigating alternative binding materials. Moreover, a significant concern arises from the necessity of employing N-methyl-2-pyrrolidone (NMP) as the matching solvent, which is known for its high toxicity. This has profound implications for environmental sustainability and poses serious risks to human health [2]. Polyurethane (PUR) is a versatile class of polymers formed by the chemical reaction between diisocyanates and polyols. The resulting polymer chains can be tailored to produce wide range of materials, from flexible foams to rigid plastics, elastomers, coatings, adhesives and sealants. PUR can form strong bonds to many surfaces due to polar urethane groups, making PUR a promising candidate as an electrode binder [3]. In this study, a polyurethane binder was tested in $NaTi_2(PO_4)_3$ (NTP) based electrodes.

Electrode slurries were prepared using either 70 wt.% active material, 20 wt.% carbon black, and 10 wt.% PUR binder, or 55 wt.% active material, 30 wt.% carbon black, and 15 wt.% PUR. Several composition PUR were evaluated in aqueous sodium ion batteries. Polydiethylene glycoladipate (PDEA, $M_n \approx 2700$ g mol^{-1}, Covestro) was used as the primary polyol. To reduce high initial viscosity of PDEA, polyethylene glycol (PEG, $M_n \approx 200$ g mol^{-1}, Sigma Aldrich) was added as a reactive diluent and reacted with a trifunctional adduct of hexamethylene -1.6-diisocyanate (HDI3). The PUR components were mixed at different isocyanate-hydroxyl molar ratios of 1.0, 1.2, 1.5. Cyclic voltammetry and galvanostatic charge-discharge tests were employed to assess the electrochemical behavior.

Cyclic voltammetry measurements confirmed the electrochemical activity of the prepared electrodes, as evidence by the observed current response. Galvanostatic cycling was conducted in a beaker-type three-electrode cell. The results revealed a relatively high initial capacity. Electrode with more PUR binder resulted in different GCD compared to 10 wt.%. Overall, this work validates the application of PUR as a functional binder in aqueous sodium-ion systems.

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Effects of glass and flax fibres in a fly ash-based geopolymer matrix

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This research presents a comparative evaluation of fly ash-based geopolymer composites reinforced with short glass fibers (GF) and flax fibers (FF). Four formulations were prepared: an unreinforced reference mix (FA), a composite with 1 wt% GF, a composite with 1 wt% FF, and a hybrid system containing 0.5 wt% GF and 0.5 wt% FF. Specimens were cast into prismatic and cubic molds, cured at 75 °C for 24 hours, and examined after 28 days of maturation. Mechanical characterization involved compressive strength tests and three-point bending tests. Phase composition was determined using X-ray diffraction (XRD), while the microstructure was analyzed by optical microscopy and scanning electron microscopy (SEM). The composite reinforced with glass fibers exhibited the highest compressive strength, reaching mean values of approximately 28–34 MPa, compared to about 17 MPa for the reference material. The flax fiber-reinforced composite achieved intermediate compressive strength values ranging from roughly 11 to 22 MPa.In flexural testing, the unreinforced geopolymer showed the highest bending strength (approximately 5.5 MPa), whereas the fiber-modified composites exhibited values between 2.9 and 4.4 MPa. XRD results revealed the presence of a predominantly amorphous aluminosilicate gel matrix with residual crystalline phases. Microscopic observations indicated that GF-reinforced systems developed a denser and more homogeneous microstructure with reduced porosity. In contrast, the FF and hybrid composites displayed localized voids and fiber pull-out traces, which contributed to crack initiation and propagation. Overall, the incorporation of 1 wt% glass fibers significantly improved compressive strength and matrix compactness. However, at the applied fiber contents, reinforcement did not lead to enhanced flexural performance. Further optimization of fiber dosage, dispersion quality, and interfacial modification is therefore recommended to achieve improved mechanical behavior.

Centella asiatica and deferoxamine as promising biomaterials components enhancing angiogenesis

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Angiogenesis is a fundamental physiological process occurring during wound healing, tissue regeneration, and biomaterial integration. It involves the formation of new blood vessels from pre-existing vasculature, ensuring adequate oxygen and nutrient supply required for cellular survival, proliferation, and differentiation [1]. Proper vascularization is essential for successful tissue repair and regeneration. Insufficient angiogenesis remains one of the major limitations in tissue engineering and regenerative medicine. Therefore, the development of biomaterials capable of stimulating and supporting angiogenesis represents a key challenge in improving regenerative outcomes.

Centella asiatica (CA) is a medicinal plant widely used in traditional medicine due to its antimicrobial, antioxidant, anti-inflammatory, and wound healing properties [2]. It has been shown to enhance wound healing by stimulating collagen synthesis, promoting fibroblast proliferation, and regulating extracellular matrix remodeling through increased expression of fibronectin and collagen type I [2]. Furthermore, CA has demonstrated proangiogenic potential by promoting endothelial cell proliferation and migration, as well as vascular network formation, partially through upregulation of angiogenic growth factors such as vascular endothelial growth factor (VEGF). The biological activity of CA extracts strongly depends on the extraction method, which influences the concentration and composition of bioactive compounds.

Deferoxamine (DFO) is a clinically approved iron chelator produced by *Streptomyces* species and widely used in the treatment of iron excess disorders. In addition to its iron-binding properties, DFO is recognized as a potent inducer of angiogenesis. During wound healing, iron homeostasis is tightly regulated, and excessive free iron can contribute to oxidative stress and cellular damage [3]. DFO binds excess iron, reducing oxidative stress and protecting cells from iron-mediated toxicity [3]. Importantly, DFO acts as a hypoxia-mimicking agent by inhibiting iron-dependent prolyl hydroxylases, leading to stabilization and accumulation of hypoxia-inducible factor-1 alpha (HIF-1α) [3]. Stabilized HIF-1α translocates to the nucleus and induces transcription of multiple proangiogenic genes, including VEGF, platelet-derived growth factor (PDGF), and stromal-derived factor-1 (SDF-1), which promote endothelial cell recruitment, proliferation, and neovascularization.

The incorporation of CA and DFO into biomaterials represents a promising and potentially synergistic strategy to enhance angiogenesis through complementary molecular pathways. While CA may directly stimulate endothelial cell activity, extracellular matrix remodelling, and growth factor expression, DFO activates hypoxia-related signalling pathways and promotes sustained proangiogenic responses. Controlled delivery of these bioactive agents from biomaterial matrices may enable localized and prolonged stimulation of angiogenesis while minimizing systemic side effects.

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Porosity Optimization in Biomimetic Bone Models

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Biomimetic bone models provide important support for preoperative training in veterinary orthopedics. They enable safe planning and rehearsal of procedures under controlled conditions and allow the mechanical behavior of the implant-bone interface to be assessed. A key challenge is the selection and control of porosity to achieve a mechanical response as close as possible to that of animal bone while maintaining high manufacturing repeatability.

The aim of this study was to design and manufacture biomimetic long bone models with three variants of internal porosity. Mechanical properties were determined to identify the porosity level most similar to natural animal bone [1-3]. The pore architectures reflecting bone structure were designed in Autodesk Fusion 360, and the models were fabricated using Digital Light Processing (DLP) additive manufacturing. After fabrication, porosity was quantified based on calculations, while the fidelity of the geometry and pore network was verified through microscopic observations. Mechanical performance was evaluated in static compression test and static three-point bending test. In addition, pull-out tests of bone screws with different diameters were conducted to determine the forces required for screw removal, which is relevant, among others, in cases requiring implant replacement [4]. The results enabled comparison of the designed porosity levels in terms of compressive and bending strength as well as screw-bone interaction, indicating the solution most closely matching the mechanical response of natural bone and suitable as a biomimetic model in veterinary orthopedics [5, 6].

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Potential of geopolymer composites as hybrid shields with high impact resistance

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Increasing normative requirements for ballistic and impact shields stimulate the development of materials capable of effective energy absorption while reducing mass and the carbon footprint of the manufacturing process. Geopolymer composites, obtained through the alkaline activation of aluminosilicate waste resources, represent a promising alternative to traditional cementitious materials [1, 2, 3]. Due to the cross-linked structure of the amorphous N-A-S-H and C-A-S-H phases, geopolymers achieve compressive strengths exceeding 60–80 MPa, while offering improved chemical resistance compared to Portland cement [1, 6]. A key aspect regarding protective shields is their behavior at elevated temperatures; research on composites reinforced with amorphous metallic fibers demonstrates excellent thermal and mechanical stability compared to traditional cement composites exposed to fire [4, 5]. Studies on behavior under dynamic loading confirm that properly designed geopolymer systems effectively delay failure propagation through mechanisms of distributed micro-cracking and interfacial friction [5, 6]. A significant advantage of geopolymers is the possibility of microstructure engineering: the use of short polymer fibers substantially increases the ductility and fracture energy of the composite [7]. Furthermore, the use of lightweight fillers, such as vermiculite, allows for the production of panels with reduced density, enabling the design of multi-layered structures with varying wave impedance [8]. Such architecture facilitates effective impact energy dissipation and forms the basis for next-generation hybrid shield concepts. An additional benefit is the low carbon footprint—estimated CO_2 emission reductions range from 40% to 80% compared to Portland cement [2, 3].

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Effect of processing parameters on B2 phase formation and mechanical behavior in $Cu_{45}Zr_{48}Al_7$ bulk metallic glass composites

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Cu–Zr–Al bulk metallic glass matrix composites (BMGMCs) have attracted significant attention due to their potential to overcome the intrinsic brittleness of metallic glasses while maintaining high strength. This study aims to improve the mechanical performance of a Cu–Zr–Al alloy by promoting the coexistence of amorphous and crystalline phases, with particular emphasis on the formation of the B2 CuZr phase and its deformation-induced martensitic transformation into B19′ CuZr (Figure 1).

$Cu_{45}Zr_{48}Al_7$ (at.%) alloys were prepared by arc melting and suction casting under an argon atmosphere into rods with diameters ranging from 5 to 10 mm. The effects of cooling rate and melting current on phase formation were systematically investigated. Structural characterization was performed using X-ray diffraction (XRD) and scanning electron microscopy (SEM), while thermal behavior was examined by differential scanning calorimetry (DSC). Mechanical properties were evaluated through uniaxial compression testing.

The results show that appropriate processing conditions facilitate the precipitation of the B2 CuZr phase within an amorphous matrix, resulting in enhanced yield strength and plasticity. The stress-induced B2 to B19′ martensitic transformation plays a critical role in strain accommodation and toughness improvement. These findings demonstrate an effective strategy for optimizing Cu–Zr–Al BMGMCs for structural applications.

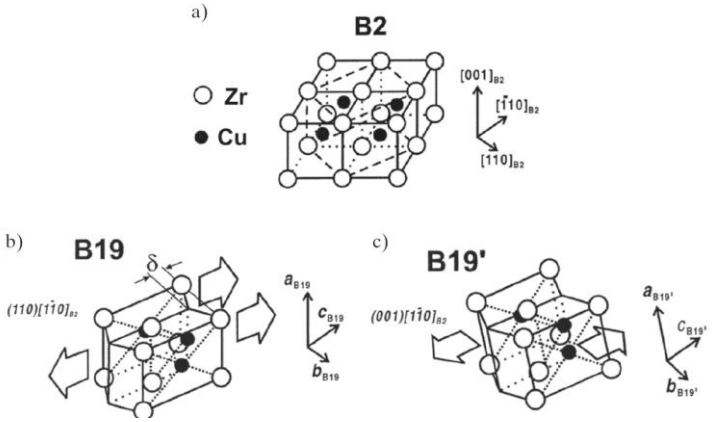

Fig 1. Sequential transformation from B2 to B19' via an intermediate B19 phase

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Alternative reagents in MXenes synthesis

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The first reports on a new family of two-dimensional materials known as MXenes were published in 2011 by the research group of Prof. Yury Gogotsi at Drexel University. Since then, global interest in MXenes has been growing exponentially due to their unique properties and the wide range of potential applications, particularly in electronics. Structurally, MXenes resemble graphene, which inspired their name. They are obtained by selective etching of the A-layer metal from nanolaminated MAX phases with the general formula $M_{n+1}AX_n$ (M – early transition metal, A – group 13/14 element, X – C or N).

Despite more than 15 years of intensive research, chemical etching with concentrated HF remains the most common method for MXene synthesis. However, increasing attention is being paid to alternative approaches that use more environmentally friendly reagents or physicochemically assisted processes capable of significantly reducing reaction time. One of the advantages of MXenes over graphene is their chemical diversity — changes in elemental composition allow tailoring of their physical and chemical properties. Consequently, many MXenes remain unexplored and may find applications in new research areas. Titanium-based MXenes are the most widely studied, with $Ti_3C_2T_x$ being the best characterized. Nevertheless, other MAX-derived MXenes also deserve attention.

In this work present the etching results obtained for Ti_2AlC and Cr_2AlC MAX phases, including the etchants used for selective removal of the A-layer, the reaction conditions applied, and the key challenges encountered during the synthesis process.

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Tuning Magnetic Behavior of $CoFe_2O_4$ nanoparticles using Differently Functionalized Surfactants.

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Magnetic nanoparticles exhibit tunable size-dependent physicochemical and magnetic properties, making them attractive for applications in data storage, magneto-optical devices, photocatalysis, and biomedicine [1,2,6]. Cobalt ferrite ($CoFe_2O_4$) is a technologically important ferrite due to its high magnetocrystalline anisotropy, chemical stability, and mechanical hardness. However, its structural and magnetic properties are strongly governed by particle size, morphology, and surface chemistry, which are highly sensitive to synthesis conditions.

Established synthesis routes such as hydrothermal, sol–gel, and co-precipitation methods enable modulation of nucleation and growth kinetics through parameters including temperature, pH, and stirring rate [3,4,5]. Despite these advantages, $CoFe_2O_4$ nanoparticles typically exhibit strong agglomeration arising from high surface energy and magnetic dipole interactions, which limits their functional performance. Surface modification using surfactants or capping molecules has been shown to mitigate aggregation through electrostatic and steric stabilization while enabling controlled particle growth and surface functionalization [6].

Herein, $CoFe_2O_4$ nanoparticles were synthesized via a hydrothermal co-precipitation route in the presence and absence of amino acids acting as capping agents [1,7]. The role of amino acid functionalization on crystallographic structure, morphology, and magnetic behavior was systematically examined. The results demonstrate that amino acid capping significantly enhances nanoparticle dispersion and tailors magnetic properties, thereby improving functional performance. These findings suggest that amino acid-modified $CoFe_2O_4$ nanoparticles are promising candidates for magnetically recoverable adsorbents and catalytic systems in wastewater treatment.

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Optimization of the Composition and Properties of Foamed Waste-Based Composites for 3D Printing

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The aim of this study was to develop and optimize foamed composites dedicated to extrusion-based 3D printing technology, incorporating fly ash, coal slag, and ground demolition brick waste. Cement-based and alkali-activated systems were compared, both reinforced with a hybrid combination of glass fibers and merino wool fibers.

After 28 days of curing, cementitious composites exhibited lower shrinkage, whereas alkali-activated systems showed higher shrinkage strains accompanied by a significant increase in mechanical performance, both in compressive and flexural strength. A particularly notable improvement was observed in interlayer bond strength, which is crucial for structural integrity in 3D printing applications. The developed materials achieved density and thermal conductivity values typical of lightweight structural–insulating composites. Water absorption tests demonstrated reduced moisture penetration in alkali-activated systems, which was associated with their denser and more homogeneous microstructure.

The results indicate that the combination of alkali activation and hybrid fiber reinforcement enables the production of 3D-printed elements with satisfactory durability while maintaining thermal insulation properties. At the same time, the use of secondary raw materials reduces Portland cement clinker consumption, limits landfill waste, and supports circular economy principles. The proposed solution demonstrates strong implementation potential, combining material efficiency, reduced carbon footprint, and improved economic viability of additive manufacturing in construction.

registration number: 43

Possibilities of using diatomites in water treatment processes and producing synthetic zeolites based on them

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Diatomites are sedimentary rocks with a high silica (SiO_2) content, formed from the accumulation of fossilized diatom shells (unicellular algae). These light, highly porous minerals have a wide range of applications in various fields, including agriculture, environmental engineering, and the chemical and medical industries. Their unique structure makes them particularly effective for applications such as filtration, prevention of eutrophication, and the sorption of petroleum substances and other contaminants. Recent studies have also highlighted the potential of diatomites to be processed into synthetic zeolites with tailored properties. Such zeolites can be used in advanced water purification processes, where they enhance the removal of pollutants due to their high surface area and ion-exchange capabilities. This presentation outlines preliminary findings on the feasibility of producing zeolites from diatomites occurring in Poland. It further explores the potential applications of these materials in water treatment and environmental protection, including their use in sorption beds and filtration systems. Although Polish diatomites are not of the highest purity compared to global deposits, they still demonstrate significant potential for practical use. The results of the initial studies suggest that diatomite-based materials can serve as efficient, cost-effective solutions for improving water quality and mitigating pollution, offering a promising avenue for sustainable environmental engineering.

Functionalization of magnesium alloy surface using hybrid PEO/P(L/G/TMC) coatings for orthopedic applications

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Magnesium alloys are promising materials for use as temporary orthopedic implants due to their biodegradability, favorable mechanical properties, and biocompatibility [1]. However, their rapid corrosion in physiological environments and excessive degradation prior to complete bone fusion limit their widespread clinical application [2]. The aim of this study was to develop and characterize hybrid coatings produced on WE43 magnesium alloy to improve corrosion resistance and ensure controlled material degradation.

Cylindrical samples were cut from WE43B (Mg–4Y–3Nd) magnesium alloy rods (Goodfellow, Germany). Surface modification was performed by plasma electrolytic oxidation (PEO) using a combination of alternating and direct current. The treatment was carried out in two stages, first in an electrolyte containing phosphates and then in an electrolyte with added calcium salts [3]. Subsequently, a biodegradable layer of poly(L-lactide-co-glycolide-co-trimethylene carbonate) (P(L/G/TMC)) was applied to the PEO-treated surfaces using an ultrasonic spraying technique (ExactaCoat, Sono-Tek, USA), creating a hybrid ceramic-polymer system.

The coatings were characterized in terms of morphology, surface topography, and wettability. Structural stability and degradation behavior were evaluated after 28 days of immersion in a buffered phosphate solution (PBS). In addition, ion release studies into the solution were performed to evaluate the degradation kinetics. Corrosion resistance was tested using potentiodynamic polarization tests.

The results showed that the PEO/P(L/G/TMC) hybrid coatings significantly reduced ion release and improved corrosion resistance compared to uncoated substrates. The polymer layer effectively sealed the porous structure of PEO, contributing to improved barrier properties. After 28 days of immersion, the hybrid coatings showed better structural integrity compared to samples coated only with PEO.

The developed hybrid system shows great potential for controlled degradation and functionalization of magnesium implant surfaces for orthopedic applications.

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Harnessing the power of ChatGPT: transforming evaluation and feedback in education

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The rapid integration of information and communication technologies in education has accelerated the adoption of artificial intelligence (AI) to enhance teaching and learning processes. The emergence of ChatGPT in November 2022 marked a significant advancement, offering human-like responses and interactive academic support. This paper aims to explore the potential role of ChatGPT in educational settings and to examine how it can be effectively and responsibly integrated into teaching and learning practices. The study adopts a conceptual and analytical approach by reviewing existing literature on AI in education and critically examining the opportunities, challenges, and pedagogical considerations associated with ChatGPT. The analysis indicates that ChatGPT can support self-directed learning, provide instant feedback, enhance student engagement, and assist educators in instructional tasks. However, concerns related to ethical use, academic integrity, and over-reliance on AI require careful management. ChatGPT presents significant potential as a supportive educational tool when integrated thoughtfully within pedagogical frameworks and institutional guidelines. The study provides practical recommendations for educators and institutions to ensure the responsible, strategic, and effective use of AI tools in educational environments while maintaining academic integrity and learning quality.

registration number: 67

Optimizing MXene-titania interfacial adhesion via changing substrate wettability

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Hydrogen is increasingly regarded as a cornerstone of future sustainable energy systems due to its high energy density and carbon-free application. Water, being abundant and universally accessible, represents an ideal feedstock for large-scale hydrogen production [1]. However, the development of efficient and economically viable water-splitting technologies remains a central challenge, particularly because state-of-the-art noble-metal catalysts, despite their excellent catalytic activity, are limited by high cost and scarcity [2], [3]. This has motivated intensive research into advanced materials and interfacial-engineering strategies capable of enabling scalable hydrogen generation at reduced cost. Two-dimensional (2D) materials such as Mxenes have emerged as promising candidates for next-generation electrocatalytic systems, with MXenes distinguished for their metallic conductivity, hydrophilicity, and tunable surface chemistry [3], [4], [5]. Nevertheless, the fabrication of high-performance hybrid electrodes that integrate MXenes with conventional substrates is often hindered by insufficient interfacial adhesion and suboptimal surface wettability. These factors critically influence catalyst loading, electrochemical stability, and electrolyte interaction [6], [7]. In this study, titania (TiO_2) metal, a biocompatible, low-cost, and chemically stable material was chosen as the substrate for MXene integration. A facile, solution-processed route was developed to fabricate Ti–MXene hybrid electrodes with improved interfacial robustness. To systematically enhance TiO_2 wettability and MXene adhesion, four distinct surface-modification strategies were employed: anodization, plasma treatment, HF etching, and HF–HNO_3 activation, followed by a multimodal surface-engineering approach for synergistic optimization. These treatments effectively tailored the surface chemistry and morphological features of TiO_2, promoting stronger anchoring of the MXene nanosheets. The resulting hybrid electrodes were comprehensively evaluated for electrochemical water-splitting applications. The findings demonstrate that engineered surface wettability and strengthened interfacial interactions significantly enhance catalytic activity and electrochemical stability. This study highlights the critical role of substrate engineering in realizing efficient MXene-based electrodes and provides a scalable pathway toward high-performance water-splitting systems.

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Photocurable chitosan and polydopamine-derived bioinks: development, optimization, and characterization for 3D/4D bioprinting

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Tissue engineering increasingly relies on advanced biofabrication strategies to create biomimetic constructs capable of restoring, replacing, or regenerating damaged tissues. The growing demand for personalized and structurally complex implants has accelerated the development of additive manufacturing techniques. In particular, 3D printing enables precise spatial control over scaffold architecture, pore geometry, and material distribution, while 4D printing introduces time-dependent functionality, allowing constructs to respond dynamically to environmental stimuli such as pH, temperature, or biochemical signals. Together, these technologies offer unprecedented opportunities to fabricate structurally organized and biologically active scaffolds that closely mimic the native extracellular matrix.

Despite rapid technological progress, the development of suitable bioinks remains a major challenge. An ideal bioink must exhibit appropriate rheological properties to ensure print fidelity and shape retention, sufficient mechanical strength to maintain structural stability after fabrication, and high cytocompatibility to support cell adhesion, proliferation, and differentiation. However, many currently available systems fail to simultaneously meet these requirements, often sacrificing biological performance for printability or mechanical robustness. In this context, the present study focuses on the design and development of multifunctional bioinks based on photocrosslinkable chitosan and polydopamine derivatives.

Chitosan, a naturally derived polysaccharide, is widely recognized for its biocompatibility, biodegradability, and inherent antibacterial properties, yet its limited mechanical stability and poor printability restrict its standalone application in advanced biofabrication. To overcome these limitations, chitosan was chemically modified with methacrylic anhydride to introduce photocrosslinkable groups, enabling rapid and controllable network formation under light exposure. Additionally, polydopamine nanoparticles were incorporated to enhance mechanical reinforcement, bioactivity, and potential cell–material interactions due to their adhesive and multifunctional surface chemistry.

Polydopamine nanoparticles were synthesized via the self-oxidation of dopamine hydrochloride under alkaline conditions. The modified chitosan derivatives were subsequently crosslinked using different photoinitiators to optimize curing efficiency and material performance. Comprehensive physicochemical characterization was conducted, including UV–Vis and FT-IR spectroscopy to confirm chemical modifications, as well as evaluation of mechanical properties, swelling behavior, and structural stability after photocuring. Biological performance was systematically assessed through cytotoxicity and genotoxicity testing, antibacterial activity evaluation, and biodegradation studies to determine material stability under physiological conditions. The developed bioinks demonstrated improved print fidelity, enhanced post-printing structural integrity, and superior biological performance compared to conventional chitosan-based formulations.

Overall, the results suggest that photocrosslinkable chitosan–polydopamine bioinks represent promising candidates for next-generation biofabrication platforms. Their tunable physicochemical and biological properties make them particularly attractive for the fabrication of dynamic, responsive scaffolds in advanced 3D/4D tissue engineering applications.

registration number: 36

Influence of welding parameters on microhardness distribution in robotic CMT-PMC twin welding of 6082-T6 aluminium

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Aluminium alloys of the 6xxx series are widely used in lightweight structures; however, arc welding results in a local reduction in hardness at the joint, limiting service performance. The mechanical performance of the joint is primarily determined by the minimum microhardness value (HVmin), typically located near the fusion line.

This study aimed to analyse the influence of welding parameters and arc control modes on the microhardness distribution in robotic TWIN-wire welding of 6082-T6 aluminium alloy. Welded joints were produced using the GMAW TWIN process with combinations of PMC (Puls Multi Control) and CMT (Cold Metal Transfer) as leading (LEAD) and trailing (TRAIL) arcs, including the Synchropulse mode – the Fronius company systems. Welding current, travel speed, and arc configuration were varied while maintaining identical joint preparation conditions and shielding gas protection (100% Ar).

HV2 microhardness measurements were performed at eleven defined locations across the weld cross-section, including the base material, heat-affected zone, fusion line, and weld metal. The minimum hardness value HVmin was used as the comparative parameter.

Figure 1a) shows an example of the macrostructure of the tested welded joint with the edges of the elements marked before welding, while Figure 1b) shows a diagram of the arrangement of the microhardness measurement points.

The results showed that HVmin is located in the fusion line region rather than in the weld metal. Increasing welding speed from 75 to 85 cm/min decreased HVmin. Arc control configuration also significantly affected the hardness distribution - welding without the Synchropulse mode yielded higher hardness values, whereas its use produced the lowest HVmin. In repeated welds produced with identical welding settings, different hardness profiles were observed, indicating the high sensitivity of precipitation-hardened aluminium alloys to thermal cycles.

The obtained results confirm that proper selection of arc configuration and heat input is crucial for controlling the minimum hardness in welded joints of 6082-T6 aluminium alloy.

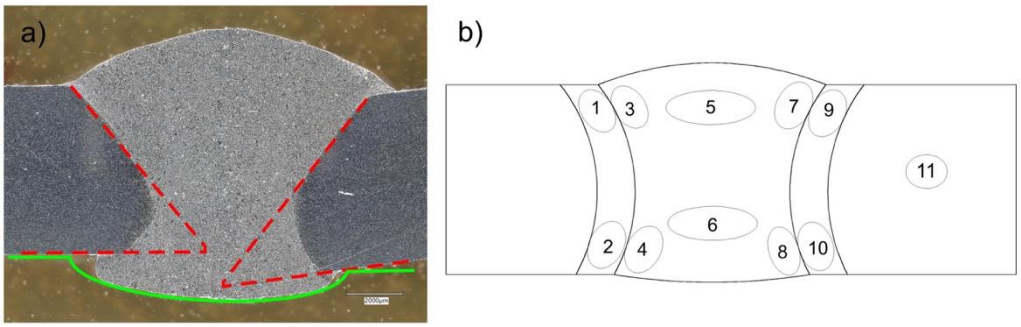

Fig. 1.a) Welded joint of Al 6082-T6 alloy with the outline of the edges of the joined elements (the red) and the washer forming the root (the green); b) the hardness measurement points

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Fluorine-free Binder Materials for Aqueous Potassium-ion Batteries

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Mitigating climate change requires rapid decarbonization of the transportation sector, where lithium-ion batteries (LIBs) play a pivotal role due to their high energy density and superior electrochemical performance. Despite significant technological advances, further improvements in energy density, long-term cycling stability, operational safety, and sustainability remain critical challenges. In addition to optimizing cathode and anode materials, electrolyte formulations, and separator technologies, less-emphasized components such as electrode binders and electrolytes present substantial opportunities for innovation. Although binders constitute only 2–5% of the electrode mass, they are essential for maintaining structural integrity, electrical connectivity, and cycle stability. Conventional binders such as poly(vinylidene difluoride) (PVDF) suffer from environmental and safety drawbacks, including the use of toxic N-methyl-2-pyrrolidone (NMP) during processing and the release of hazardous species during recycling. Alternative binders, including carboxymethyl cellulose (CMC), polyacrylic acid (PAA), and polyethylene glycol (PEG), present their own limitations in mechanical or chemical performance. [1-4]

In this work, we report the synthesis of a novel binder material specifically designed for application in potassium-ion batteries employing a WIS electrolyte. The electrochemical performance, mechanical integrity, and cycling stability of the new binder were systematically investigated. The results demonstrate its potential to enhance electrode durability while contributing to safer and more sustainable battery systems.

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registration number: 59

Impact of sulfur impurities on copper-based catalysts in electrochemical reduction of CO_2 in flow reactor

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Electrochemical CO_2 reduction (eCO_2RR) powered by renewable electricity is a promising route to convert CO_2 into value-added chemicals and Cu remains the benchmark catalyst for producing multicarbon (C_{2+}) products such as ethylene via C-C coupling pathways. Flow-cells with gas-diffusion electrode (GDE) reactors are widely adopted to reach technologically relevant current densities by alleviating CO_2 mass-transport limitations typical of conventional aqueous (H-cell) testing [1]. Operating under industrially relevant conditions creates critical challenges where extrinsic factors, such as reactor design and CO_2 distribution efficiency, dominate over the specific nature of active sites, leading to significant performance discrepancies compared to optimized lab-scale results [2]. In addition, alkaline and near-neutral CO_2 electrolysis commonly suffers from parasitic CO_2 consumption and (bi)carbonate formation, which lowers single-pass CO_2 utilization and can contribute to durability challenges and system complexity at larger scale [3,4]. These issues motivate intensified efforts to define operating windows and materials designs that preserve high ethylene selectivity and stable activity under practical reactor conditions [2]. From a sustainability deployment perspective, it is also desirable to operate on realistic industrial or capture-derived CO_2 feeds rather than highly purified CO_2, because real feeds can contain reactive impurities and deep purification adds cost and additional energy demand [3,4]. Among common contaminants, sulfur-containing impurities such as SO_2 are frequently considered especially critical because they can strongly interact with active sites and rapidly suppress eCO_2RR performance and selectivity [5].

In this study, we present ethylene-focused eCO_2RR on copper-based catalysts supported on GDE in a flow-cell reactor, comparing baseline operation under impurity free CO_2 with controlled exposure to a CO_2 stream containing 10 or 100 ppm of SO_2 as a model sulfur impurity. We tracked time-dependent changes in catalytic activity and product selectivity and discussed the observed trends in terms of sulfur-driven deactivation processes, relevant to industrially sourced CO_2 streams.To connect the observed performance changes with underlying material transformations, we further characterized the electrodes before and after eCO_2RR using various techniques, e.g. X-ray Diffraction, Scanning Electron Microscopy, X-ray Fluorescence, Infrared Spectroscopy and X-ray Photoelectron Spectroscopy.

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registration number: 5

SiC reinforcement in DMLS fabricated AlSi10Mg alloy

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This study investigates the effect of 10% Silicon Carbide (SiC) reinforcement on the mechanical and thermal properties of AlSi10Mg made by Direct Metal Laser Sintering (DMLS). The research optimised laser energy density to study the effect on density, hardness, surface roughness, tensile strength and thermal behaviour. A comparison between unreinforced AlSi10Mg and SiC reinforced AlSi10Mg shows the complex interactions between laser processing parameters, thermal conductivity and phase stability. The introduction of SiC changes the material's response to laser energy, affecting melt pool dynamics, solidification behaviour and residual stress formation. The results show SiC reinforcement improves hardness and wear resistance but increases thermal stresses, so process control is required to avoid defects like porosity, microcracking and SiC decomposition. The composite also has a change in optimal process parameters due to thermal conductivity, laser absorption and powder bed packing density compared to base alloy. These results highlight the need to balance laser power, scan speed and hatch spacing to get defect free structure with desired mechanical and thermal properties. This study provides insights into the role of SiC in Metal Matrix Composites (MMCs) and practical guidelines to refine DMLS parameters to get the best combination of strength, hardness, ductility and thermal stability in SiC reinforced AlSi10Mg parts. The results contribute to the understanding of MMCs for high performance applications in aerospace, automotive and thermal management systems.

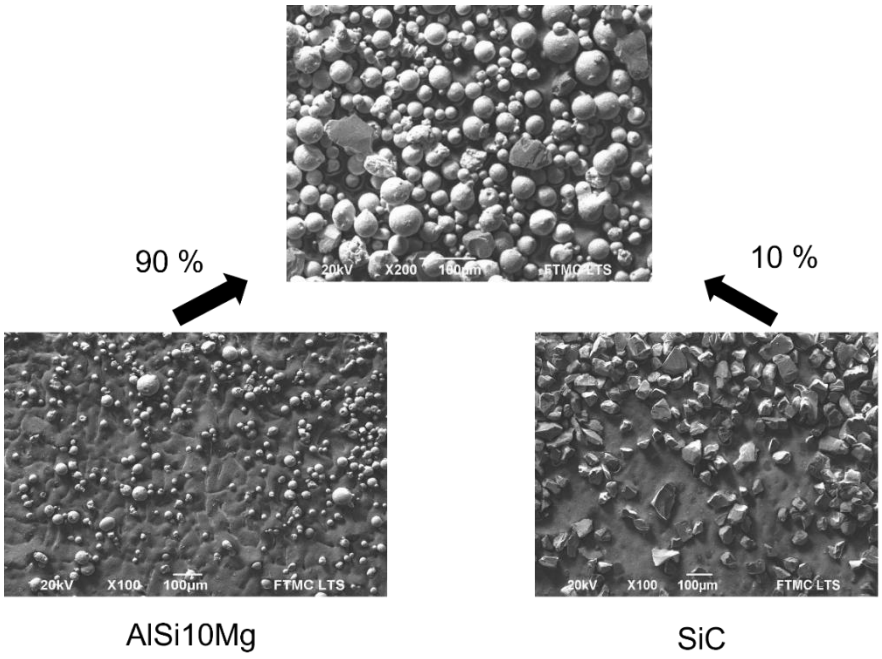

Fig. 1. *SEM images of powders used for DMLS: AlSi10Mg and SiC*

Assessment of $La_{2-x}Sr_xFe_{1.4}Ti_{0.2}Co_{0.2}Mn_{0.2}O_{6-\delta}$ perovskite oxides as high-performance oxygen electrode materials for intermediate temperature solid oxide fuel cells

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Solid Oxide Fuel Cells (SOFCs) are one of the most prominent energy conversion and storage devices that convert the chemical energy of the fuel into electricity. Although conventional SOFCs operate at high temperatures, making them unmarketable. Lowering the operational temperature while maintaining a high-power output is essential for SOFCs. For intermediate temperature SOFCs (IT-SOFCs), novel electrode materials with long-term stability and improved electrocatalytic activity are important to provide stable and high-performance cells. In the last few decades, perovskite-structured oxides (ABO_3) have attracted significant attention because of their promising applications in IT-SOFCs, offering great potential in chemical composition modifications, yielding the design and gain of anticipated physicochemical and electrochemical properties [1]. The A-site and B-site modification in perovskite oxide is a widely employed strategy to enhance the overall electrochemical performance of IT-SOFCs [2].

In this work, novel $La_{2-x}Sr_xFe_{1.4}Ti_{0.2}Co_{0.2}Mn_{0.2}O_6$ (LSFTCMO; x = 0, 0.5, 1, 1.5, and 2, named as LSFTCMO-0, LSFTCMO-0.5, LSFTCMO-1, LSFTCMO-1.5, and LSFTCMO-2, respectively) perovskite oxides have been fabricated as high-performance oxygen electrode materials for IT-SOFCs using the Sol-gel method. At the B-site, the different electronic structures of metal ions provide perovskite oxides with many different properties, in terms of lattice defect, electronic conductivity, structural stability, and catalytic activity [3]. The ratio of Co/Ti has a strong influence and enhances the performance of the LSFTCMO electrode materials. The Fe with a variable oxidation state, together with Mn cations, introduces mixed ionic-electronic conductivity, confirming high phase stability in working conditions. The room-temperature crystal structure of all oxides have single phase with a space group of *Pm*-3*m*. The long-term compatibility evaluation conducted at 800 °C for 100 hours showed that LSFTCMO has excellent chemical compatibility with GDC, LSGM, and YSZ electrolytes. Electrochemical impedance spectroscopy (EIS) results disclose that the LSFTCMO-1 electrode demonstrated superior performance, achieving the lowest polarization resistance of 0.07 $\Omega \cdot cm^2$ at 700 °C among the investigated $La_{2-x}Sr_xFe_{1.4}Ti_{0.2}Co_{0.2}Mn_{0.2}O_6$ electrodes, and remained stable for a period of 200 hrs. The full cell performance of the LSFTCMO-1 cathode was conducted with a laboratory-made anode support cell, presenting an excellent power density of 802 $mW \cdot cm^{-2}$ at 800 °C in humidified H_2 and stably operated for over 200 hrs. These results confirmed that LSFTCMO-1 perovskite oxide can be potentially qualified as a promising cathode candidate for IT-SOFCs.

Acknowledgement
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Bipyrimidine powder for potential applications in integrated photonics on polymer materials for the creation of a broad spectrum

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Organic materials for nonlinear optics have created a wide range of applications in the field of photonics, optics and in the area of biological science. A series of bipyrimidine based chromophores are prepared with alkoxy styryl groups and connected with electron accepting 2,2'-bipyrimidine cores. Their linear and nonlinear optical properties are investigated through various techniques such as light transmission measurements, optical measurements and as well as the size properties are characterized through scanning electron microscopy. So, from all the characteristics thus bipyrimidine for nonlinear optics confirms the size, behavior and nano size range between 10-100 nm. Bipyrimidine seems too attractive because the electron affinity of the pyrimidine rings is much higher than that of the pyridine ring and this property has been rooted for designing the pyrimidine contains conjugated systems with an interesting way of motion of complementary colors for luminescence and two photon absorption properties. Orange crystals are suitable for the X-ray diffraction analysis for the crystalline nature and detect various phases and helps to know about the good planarity of conjugated systems, so it is applicable for to mix with polymers and also help in the optoelectronic applications such as the sensors and micro resonators as of in the area of integrated photonics and for creation of broad band spectrum emission for the non-linear optics.

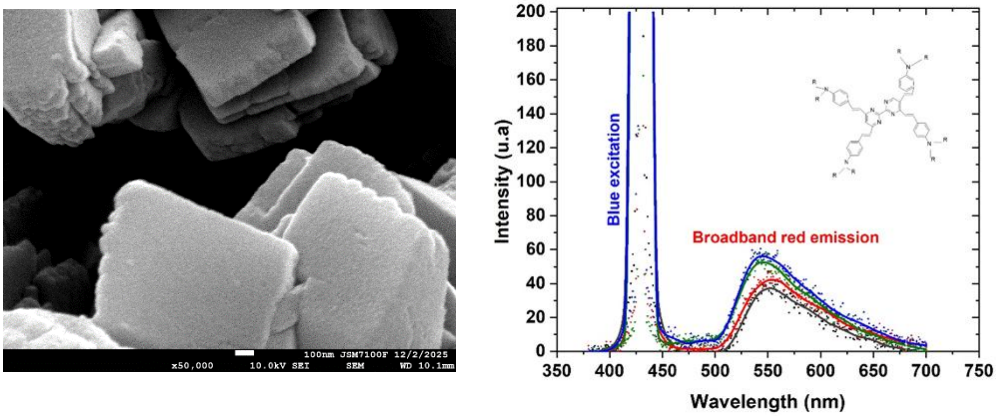

Fig 1. (a) SEM image of bipyrimidine powder with size 100 nm. From this figure shows the cubic structure of the material with cottage like structural at a nanoscale range between 10-100 nm. (b) Structure of bipyrimidine powder for nonlinear optics with optical spectra excitation in blue and emission in red.

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registration number: 60

Impact of emulsion-based fabrication parameters on antibiotic-loaded nanoparticles

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Nanoparticles are increasingly investigated for their potential applications in medicine. One of the most promising applications is drug delivery, where nanoparticles can serve as carriers, enabling the targeted transport of therapeutic agents to specific cells or tissues within the body. In addition, nanoparticles can be designed to release their cargo in a controlled manner, allowing for continuous drug delivery over time. The degree and rate of release of the active substance from the nanoparticle depend, among other things, on its shape and morphology, as well as the type of active substance. These parameters can be controlled by the method of nanoparticle production – the choice of production method, substrates, variability of the parameters of a given method, etc. [1].

The main problems associated with nanoparticle production are issues with the scalability and repeatability of the process. Although there are scientific articles that analyze and compare the variable parameters of the emulsion method for obtaining polymer nanoparticles for ciprofloxacin, in the case of metronidazole, studies more often focus on other production techniques. In addition, articles on the preparation of ciprofloxacin focused on comparing other process parameters and mainly concerned its hydrochloride form. Therefore, investigating the impact of various parameters of the production process on nanoparticles remains crucial.

The aim of this study was to investigate the influence of various preparation-process parameters on the properties of nanoparticles loaded with selected antibiotics prepared by emulsion methods. Nanoparticles were obtained by the double emulsion (w/o/w) method (for ciprofloxacin) and by the single emulsion (o/w) method (for metronidazole), taking into account their solubility in various solvents, followed by evaporation of the organic solvent. The obtained carriers were characterized by determining the surface morphology using a scanning electron microscope (SEM); measurements of the size and zeta potential of particles dispersed in solution (using the DLS/SLS/ELS method), process efficiency, drug loading capacity, and active substance release studies using UV-Vis spectrometry.

Our results demonstrate that the choice of active substance and thus the method and parameters of production fundamentally shape the physicochemical properties of nanoparticles including the elution profile.

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registration number: 50

Unconventional methods of shaping deep holes using electrochemical machining (ECM)

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The paper concerns problems of barrel rifling. It focuses on the electrochemical machining of grooves in gin barrels with diameters between 30-40 mm used for short-range air defense systems. There is discussed rationale for undertaking investments aimed at expanding technological capabilities in the context of manufacturing barrels for weapon systems being implemented for the needs of the Polish Armed Forces is presented.

The study addresses technological challenges associated with the electrochemical shaping of deep holes. The proposed concept concerns shaped drilling operations (rifling), together with an analysis of equipment requirements conducted for the purpose of designing and implementing a dedicated machining workstation. There are also presented initial results of machining groves with stationary electrodes.

Fig 1. Example of short range air defense system - Self-Propelled Gun System SA-35mm

Electrochemical machining (ECM), although still classified as a so-called non-conventional material processing method, is finding increasingly widespread application in manufacturing processes and significantly influences their quality. Therefore, numerous studies are being conducted in various industrial sectors as well as in academic research centers, aimed at the development of more efficient and precise machine tools, processes, machining workstations, and process control systems.

The process involves shaping products made of metals and their alloys through electrochemical dissolution, provided that the materials exhibit an appropriate level of electrical conductivity. Electrochemical machining is distinguished by its capability to machine very hard materials while maintaining high productivity and superior surface quality of the workpiece. Following the process, the workpiece is virtually free of residual stresses, and the cathode, i.e., the working tool, does not undergo wear. This ensures an efficient and cost-effective method for machining components with complex geometries made of difficult-to-machine materials with electrical conductivity greater than 0.01 S/cm.

registration number: 64

Magnetic buckwheat hull-Fe_3O_4 nanocomposite: synthesis, characterization, and biosorption efficiency for Pb(II) and Cd(II) ions in aqueous media

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In the present study, magnetic buckwheat hull–Fe_3O_4 nanocomposite was successfully synthesized and evaluated as an efficient biosorbent for the removal of Pb(II) and Cd(II) ions from aqueous solutions. The structural, morphological, and physicochemical properties of the prepared nanocomposite before and after sorption were analyzed using FTIR, SEM, XRD, EDX, BET, and point of zero charge (pH_{pzc}) techniques. FTIR analysis confirmed the successful synthesis of the magnetic nanocomposite and revealed the presence of functional groups actively involved in metal ion binding. Under optimized conditions (pH 6, contact time 180 min, sorbent dose 0.1 g, agitation speed 150 rpm, and temperature 25 °C), the maximum removal efficiencies reached 96.63% for Pb(II) and 69.34% for Cd(II) at an initial concentration of 25 mg/L, while even higher efficiencies of 98.02% for Pb(II) and 86% for Cd(II) were achieved at 10 mg/L. The sorption mechanism was evaluated using kinetic, isotherm, and thermodynamic models to better understand the adsorption behavior of Pb(II) and Cd(II) ions in aqueous media.

The results demonstrate that the magnetic buckwheat hull-Fe_3O_4 nanocomposite possesses excellent adsorption capacity, strong affinity toward heavy metal ions, and promising potential for sustainable wastewater treatment applications.

registration number: 39

Hydrosolubility and interactions of chitosan oligomers: new computational insights

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Chitosan can be utilized to obtain various functional materials. Computational modelling may aid in the optimization of material properties by predicting physicochemical properties, which is not in itself a novel concept. However, new avenues of implementing this concept are proposed.

Two methods of hydrosolubility prediction were employed with respect to chitosan oligomers. In one method, empirical information was used to estimate thermodynamic parameters. The COSMO-RS (conductor-like screening model for real solvents) framework formed a basis in the subsequent calculation of solute mole fractions and solvation free energies. In the other method, graph neural networks allowed predictions of melting points, activity coefficients and molar solubilities. The two methods are compared regarding computational characteristics and feasibility of the respective solubility data.

A chitosan tetramer was sequentially a computational dock for 11 antibiotics. All found values of the binding free energy are negative, suggesting that these antibiotics have some affinity for chitosan. The binding free energy in the most favorable mode increased in this order: doxycycline, vancomycin, levofloxacin, ciprofloxacin, amoxicillin, cephalexin, sulfamethoxazole, trimethoprim, azithromycin, clindamycin, metronidazole. Using the docking results, intermolecular interactions were also studied and visualized. Unfavorable interactions and hydrogen bonds were automatically identified and counted where this was technically practicable. Structural implications of the molecular docking results are discussed.

Despite certain limitations, this study paves the way for further research. Envisaged areas for the future are drug delivery, drug dosage and antibiotic pollutant removal. The current work can be continued with computations on new systems based on chitosan as well as with laboratory experiments which may validate the results.

Early remarks by Nicoleta Badea and Maria Mihaly during a doctoral school meeting are acknowledged for helping in guiding the design of the study.

Development of a multifunctional injectable system for cancer treatment

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Cancer is a major public health problem and an increasing worldwide death cause. Its most common treatments are systemic chemotherapy and radiotherapy which have several limitations including unpredictable and ineffective outcomes, toxicity to healthy tissues, long-term nefarious side effects to patients' quality of life, expensive multi-therapeutic approaches for treatments as well as management of concurrent side effects, necessity of multiple dosing strategies due to lack of targeted applications and low therapeutic drug concentrations at tumor sites (1).

This study focuses on the development of a multifunctional injectable system for cancer theranostics. We characterized the thermo-responsive nature and injectability of the optimized hydrogels, measured the magnetic properties, induced hyperthermia and enzyme-like activity of the synthesized superparamagnetic iron oxide nanoparticles (SPIONs), performed drug delivery assays and tested the biocompatible carrier feature of our clay minerals (Montmorillonite) and of the developed magnetic clays, aiming to develop an injectable magnetic system able to control and target-release a therapeutic drug for long periods of time, along with other possible synergistic therapeutic effects such as boosted enzyme activity (Catalase and Peroxidase) for advantageous tumor microenvironment modulation [2][3][4][5].

The synthetized magnetic nanoparticles were successfully stabilized with three different coatings and efficiently intercalated and bound into the interlaminar space of two types of clay mineral, by cation exchange reactions, without compromising their magnetic properties and therapeutic hyperthermia. The ability and efficacy of our clay minerals to act as vehicles for therapeutic biomolecules and be used for sustained drug delivery purposes was tested and found to be fully preserved in the produced magnetic clays with sustained drug delivery from 30 days to up to 4 months. Throughout this development phase, cell viability assays were conducted to ensure the safety and biocompatibility of our optimized systems. Two different modulated Chitosan and Pluronic formulations were developed and extensively characterized, resulting in a suitable thermo-responsive and injectable hydrogel with appropriate gelation temperature and adequate hydrogel structural integrity to support the developed multifunctional system for the intended drug delivery application.

Clay minerals used as carriers are very promising candidates in sustained drug delivery applications and conveyed this system the capability to concurrently induce localized hyperthermia between 42 and 46 °C to debilitate cancer cells, locally deliver anticancer drugs with long-term sustainable release profiles, and possibly overcome tumor microenvironment hypoxia and low oxygenated tissues as well as contribute to direct tumor cell damage.

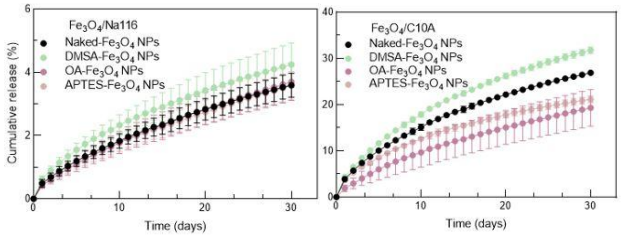

Fig 1. Methylene blue rug Delivery Assays of Fe3O4/Na116 and Fe3O4/C10A magnetic clays

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From metal alloys to polymers – advances in personalized implant design

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Personalized orthopedic implants manufactured using SLM (Selective Laser Melting), DMLS (Direct Metal Laser Sintering), or PBF (Powder Bed Fusion) technologies are an important element of modern biomedical engineering and widely used in the treatment of degenerative diseases and congenital defects of the musculoskeletal system. One of the most used metal biomaterials is the Ti6Al4V alloy, which has favorable mechanical and physicochemical properties. However, the presence of vanadium and aluminum in its composition can lead to undesirable biological reactions, including inflammatory processes and metallosis. In response to these limitations, alternative titanium alloys have been developed, such as Ti6Al7Nb and Ti13Nb13Zr, which aim to eliminate toxic alloying elements and improve corrosion resistance [1,2].

Modern medicine is also developing dynamically towards the use of advanced polymer biomaterials in orthopedic implantology. Non-biodegradable polymers are particularly widely used, among other things, to produce bone fracture stabilizing elements. The most used polymer materials in FFF (Fused Filament Fabrication) technology include polyetheretherketone and polymethyl methacrylate, with PEEK being particularly useful in knee and hip arthroplasty, as well as in spinal stabilization systems [3,4].

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Lightweight, robust, thermoplastic polyurethane-based sandwich-structured rGO/ Fe_3O_4/rGO nanocomposites for efficient electromagnetic interference shielding

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The increasing prevalence of electronic devices necessitates effective electromagnetic interference (EMI) shielding materials to mitigate unwanted electromagnetic radiation. Incorporating conductive and magnetic fillers into a suitable polymer matrix, along with their layered architecture, offers a promising approach for achieving substantial EMI shielding effectiveness through synergistic effects. This work focuses on utilizing reduced graphene oxide (rGO) as a conductive filler and Fe_3O_4 (IO) nanoparticles (NPs) as the sole magnetic filler in a thermoplastic polyurethane (TPU) matrix and the fabrication of sandwich-structured nanocomposites with configurations IO/IO/IO, rGO/rGO/rGO, IO/rGO/IO, and rGO/IO/rGO. Among them, the rGO/IO/rGO with a thickness of 2.2 mm demonstrated the highest total shielding effectiveness of 32.4 dB in the X-band frequency range. This is a first-time study report on the fabrication of a high-performance sandwich-structured nanocomposite rGO/IO/rGO consisting of an IO-TPU layer embedded between two rGO-TPU layers. The synergistic effect of the fillers, attributed to their conducting and magnetic properties, as well as their multi-layered arrangement, provides a feasible strategy for developing flexible, lightweight nanocomposite materials with significant thermal stability, mechanical robustness, effective EMI shielding, and moderate Joule heating performance, which hold promise for use in defense, communication, and radar security sectors.

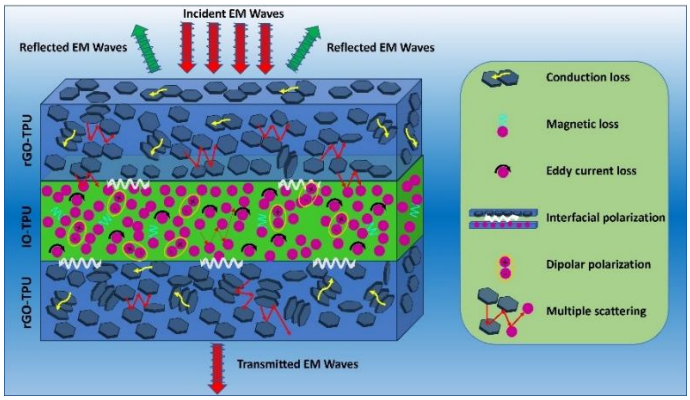

Fig 1. Illustrative representation of the EMI shielding mechanism in rGO/IO/rGO sandwich-structured nanocomposite

Synthesis and Characterization of Magnetic Activated Carbon/Polyaniline Composite for Enhanced Pb (II) Adsorption

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Lead (Pb) contamination in water poses a significant threat to both human health and the environment, as it is toxic even at very minimal concentrations. In the scope of this study, a novel magnetic composite material as AC/Fe_3O_4/PANI-SDS, was synthesized to efficiently eliminate Pb^{2+} ions from polluted water. Each component in the composite has a significant impact: the activated carbon provides a large surface area for adsorption, the magnetic iron oxide (Fe_3O_4) allows the material to be easily magnetic recovery from water systems using a magnet, and the polyaniline (PANI) and sodium dodecyl sulfate (SDS) improve the capability of the material to attract and hold onto Pb^{2+} ions. To assess the surface, magnetic, and structural properties of the prepared material, several characterization techniques were applied, such as FTIR, XRD, SEM-EDS, BET analysis, VSM, and zeta potential measurements. These tests confirmed that the composite has the right structure, and functional groups to work as a capable and efficient adsorbent. Batch adsorption studies were used to evaluate the effect of pH, interaction time, initial Pb^{2+} ions concentration, and temperature on removal efficiency. The findings highlight the composite's remarkable adsorption efficiency after 220 minutes at optimal conditions, specifically at pH 6. Adsorption kinetic studies demonstrated strong agreement with the pseudo-second-order model, while isotherm analysis showed that the Langmuir model provided the highest correlation coefficient within the investigated concentration range. This fitting suggests apparent Langmuir-type adsorption behavior with a maximum adsorption capacity of 348.39 mg/g. Thermodynamic assessment demonstrates that the elimination of Pb^{2+} ions is an endothermic and spontaneous process. In addition, the composite can be reused and recycled repeatedly without significantly reducing its effectiveness, offering an economical and ecologically sustainable approach. The findings of this research highlight the potential of AC/Fe_3O_4/PANI-SDS composite as new, efficient, and eco-friendly adsorbents for the elimination of Pb^{2+} ions from solutions. In real-world applications, its high capacity for adsorption, ease in separation, and reusability make it a promising treatment for heavy metal contamination.

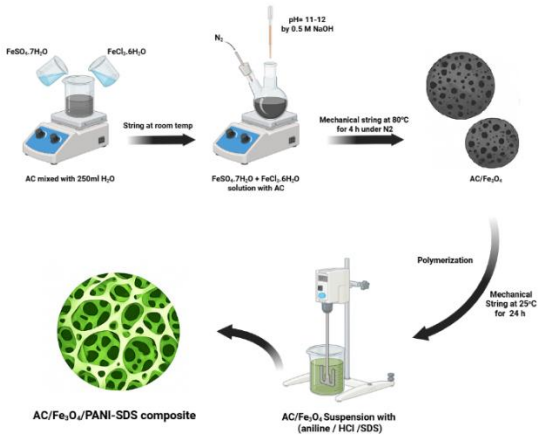

Fig 1. Synthesis process for AC/Fe_3O_4/PANI-SDS composite.

Engineering Synergistic A-Site Deficiency and B-Site Substitution in NdBa-Based Double Perovskites toward High-Performance IT-SOC Electrodes

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Intermediate-temperature solid oxide cells (IT-SOCs) represent a promising technology for green energy generation from diverse fuels and for energy storage via hydrogen production, contributing significantly to mitigating climate change driven by fossil fuel consumption. However, operating at reduced temperatures (600–700 °C) leads to slower electrochemical kinetics compared with conventional high-temperature SOCs (800–1000 °C). Therefore, the development of highly active electrode materials tailored for intermediate-temperature operation is essential. Barium-based cobaltites ($LnBaCoO_{5+\delta}$, Ln = lanthanide) are attractive candidates due to their mixed ionic–electronic conductivity and superior electrochemical activity [1]. Nevertheless, their high thermal expansion coefficient (TEC), primarily associated with cobalt, often results in thermomechanical mismatch and long-term instability. To address these challenges, B-site substitution has been employed to reduce TEC and mitigate mismatch, while A-site deficiency is introduced to enhance oxygen vacancy concentration, promote oxygen ion transport, and induce favorable lattice distortions that improve electrochemical performance and structural stability [2, 3].

In this work, A-site deficient and B-site Co-substituted double perovskites, $(NdBa)_{2-\alpha}CoFe_{1-x}Mn_xO_{5+\delta}$ (α = 0, 0.1, x = 0, 0.25, 0.5, 0.75 and 1), were systematically investigated as electrode materials for IT-SOCs. Comprehensive physicochemical characterization, including XRD, HT-XRD, dilatometry, SEM–EDS, TGA, TEM, EIS, and full fuel cell testing, was performed to evaluate crystal structure, thermomechanical behavior, microstructure, transport properties, and electrochemical performance. Among the compositions studied, $(NdBa)_{1.9}CoFeO_{5+\delta}$ exhibited outstanding electrochemical performance, achieving a very low polarization resistance of 0.094 $\Omega \cdot cm^2$ at 700 °C. Notably, it demonstrated excellent durability, with only a 0.018 $\Omega \cdot cm^2$ increase over a 100-hour stability test, whereas the stoichiometric $(NdBa)_2CoFeO_{5+\delta}$ showed significant performance degradation. Furthermore, enhanced activity under higher oxygen partial pressure confirms its suitability as an oxygen electrode. These results clearly demonstrate that the synergistic combination of A-site deficiency and B-site substitution is an effective strategy for designing high-performance and durable electrode materials for intermediate-temperature solid oxide cells.

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registration number: 48

SOFC air electrode materials based on a new group of $SrCo_{0.7-x}Ta_{0.1}Mo_{0.1}Mn_{0.1}TM_xO_{3-\delta}$ (TM: Cu, Ni, Fe) oxides

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One of the most promising directions in the development of cathode materials for solid oxide fuel cells (SOFCs) involves the multicomponent modification of cobalt-based $SrCoO_{3-\delta}$ perovskite. The resulting doped oxides are typically characterized by excellent mixed ionic-electronic conductivity and high oxygen reduction reaction activity. However, the main disadvantage of this group of perovskites is related to the too high value of the thermal expansion coefficient, linked with a high Co content. In this work a new group of materials $SrCo_{0.7-x}Ta_{0.1}Mo_{0.1}Mn_{0.1}TM_xO_{3-\delta}$ (where TM: Cu, Fe, Ni, and x = 0.1) has been synthesized and studied for the first time. Characterization of structural and functional properties included XRD, SEM, DIL, 4-probe DC, and XAS (Co K-edge, Ta and Mo L3-edge) techniques. The results showed a strong impact of the additional elements on the materials properties. For example, when Fe is replaced by Cu as the dopant, the total conductivity is enhanced tenfold in a broad temperature range, with metallic-like behavior above ca. 400 °C. For symmetrical cells based on GDC20 solid electrolyte and $SrCo_{0.6}Ta_{0.1}Mo_{0.1}Mn_{0.1}Cu_{0.1}O_{3-\delta}$ electrodes, electrode polarization resistance of 0.538 $\Omega \cdot cm^2$ was measured at 700 °C. However, it was significantly decreased down to 0.081 $\Omega \cdot cm^2$ at the same temperature when the electrode was prepared in a form of a composite comprising 40 wt.% addition of the GDC20 powder. This enabled achieving a peak power density of approx. 0.49 $W \cdot cm^{-2}$ at 700 °C and 1 $W \cdot cm^{-2}$ at 800 °C in the button-type full cell configuration (Ni-YSZ|YSZ|GDC|composite air electrode).

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