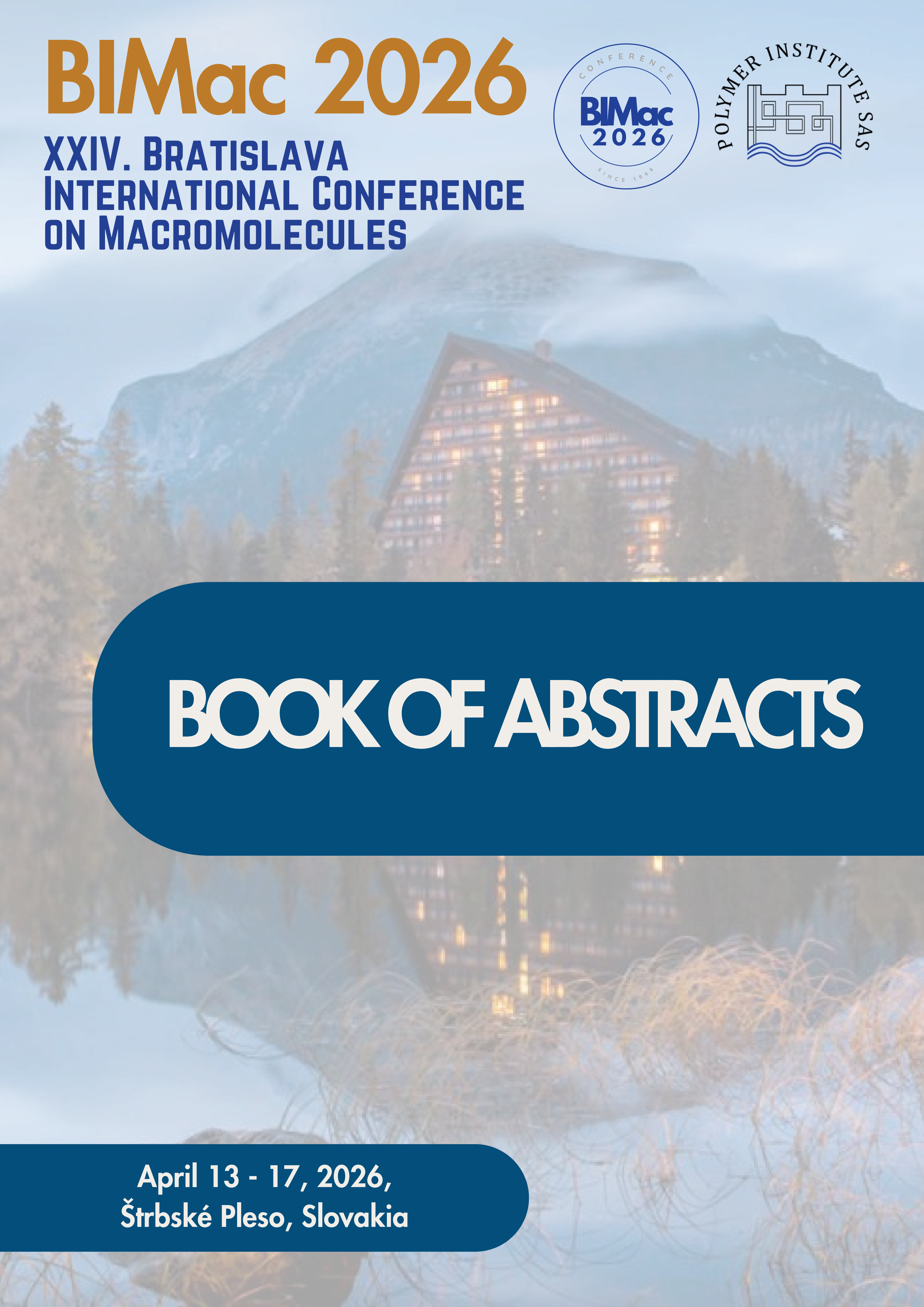

BIMac 2026

XXIV. Bratislava International Conference on Macromolecules

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ORGANICKÁ ANALÝZA A SEPARAČNÉ TECHNIKY

MIKROSKOPIA A PRÍPRAVA VZORIEK PRE METALOGRAFIU

FYZIKÁLNE A MATERIÁLOVÉ ANALÝZY

kvapalinová chromatografia spotrebný materiál pre metalografiu FTIR
hmotnostná spektrometria príprava metalografických vzoriek DVS
iónová chromatografia elektrónová mikroskopia analýza častíc
plynová chromatografia metalografia centrifúgy | koncentrátory
automatické dávkovanie leštičky reológia | extrúzia | nanočastice
príprava vzoriek | LIMS meranie tvrdosti | trhačky ICP-OES | XPS | UV-VIS
spotrebný materiál nanoindetory lyofilizátory | termostaty
GC-MS | HPLC | NMR analýza brúsky ICP-MS | analýza povrchov | XPS
LC-MS | GC-MS | HPLC | IRMS metalografia elektrochémia
TOC analýza | AOX/EOX | TN/TX/TS | CHNSO rezačky XRF
LC-MS | GC-MS | HPLC | IRMS TGA | DSC Raman a FTIR mikroskopia

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EDITORIAL

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Bratislava, 2026

On behalf of the organizing committee, it is our great pleasure to welcome you to the XXIV. Bratislava International Conference on Macromolecules – BIMac 2026, organized by the Polymer Institute of the Slovak Academy of Sciences. This long-standing conference series, established in 1968, continues to provide an important international platform for discussing advances in polymer science and related disciplines.

The conference brings together researchers, students, and industry professionals to share their latest scientific results and exchange ideas in key areas of polymer science, including the synthesis and characterization of polymers, composite polymeric materials, polymeric biomaterials, and molecular simulations of polymers. These diverse topics reflect the dynamic, interdisciplinary nature of modern macromolecular research and its growing relevance to both fundamental science and practical applications.

This conference is also dedicated to our former colleague, Dr. Mária Omastová, in recognition of her distinguished career, significant contributions to polymer science, and continuous inspiration and support for colleagues and young scientists.

Beyond the scientific program, we believe that conferences are also about people—about the conversations that continue after presentations, the new collaborations that arise during poster discussions, and the friendships that begin over coffee breaks or social events. We sincerely hope this meeting will create a stimulating environment where new ideas emerge and lasting professional partnerships form.

This year’s conference takes place in the beautiful surroundings of the High Tatras, providing a unique opportunity to combine scientific exchange with moments of relaxation and inspiration in nature. Surrounded by mountains and the fresh alpine air, we encourage you not only to actively engage in the scientific sessions but also to enjoy the region's natural beauty, the hospitality and wellness facilities at the conference venue, and the informal social activities prepared for participants.

We hope that BIMac 2026 will be an inspiring and memorable event for all participants—scientifically rewarding, intellectually stimulating, and personally enriching. May this meeting strengthen our scientific community and open the door to new collaborations and friendships.

We wish you a productive conference, stimulating discussions, and an enjoyable stay in the High Tatras.

Dr. Zdenko Špitálsky
Chair of BIMac 2026

Memorial to
Mária Omastová

Matej Mičušík, Jaroslav Mosnáček
Polymer institute SAS

Mária Omastová passed away far too soon, in May 2024, at the age of 62.

She has worked at the Institute of Polymers of the Slovak Academy of Sciences since 1982. From 2013 to 2016, she was the President and then Vice-President of the Slovak Chemical Society, and from 2015 to 2021, she served as a member of the Presidium of the Slovak Academy of Sciences and Deputy Vice-President for Foreign Relations.

Ing. Mária Omastová, DrSc., was born on March 7, 1962 in Batizovce. While studying at the Faculty of Chemical Technology in Bratislava, she worked at the Institute of Polymers of the Slovak Academy of Sciences (PISAS) as a student assistant, and she also wrote her diploma thesis at the institute. In August 1985, she joined PISAS for a study stay and three years later for her doctoral studies. From January 1994, she worked for a year at the Institute for Polymer Research (Leibniz-Institut für Polymerforschung Dresden e.V.) in Dresden, Germany, as a post-doc, where she focused on the preparation and characterization of antistatic polymer mixtures. After returning to PISAS, she joined the Department of Composite Thermoplastics, where she focused on the development of conductive polymers, composites and nanocomposites.

Dr. Mária Omastová, was one of the prominent representatives of materials research in the field of macromolecular chemistry. With her scientific work, she contributed significantly to the development of scientific disciplines associated with the research of conductive polymers, especially polypyrrole, but also the study of polymer composites and nanocomposites. She was especially devoted to the study of the influence of electrically conductive nanoparticles, such as carbon nanotubes, on conductivity, as well as other physical and mechanical properties of conductive composites with a polymer matrix. In recent years of her research, she has been devoted to applications of nanotechnology and research of nanomaterials, which include the preparation and modification of conductive polymer particles, carbon-based nanoparticles and their combinations with other nanoparticles or with polymers, organic or inorganic substrates with the aim of creating new types of materials, e.g. for the diagnosis and targeted treatment of cancer. She intensively studied a new type of 2D nanoparticles, MXenes, for the preparation of composites for electromagnetic shielding. The results of M. Omastová's scientific work have been published in more than 200 publications in renowned foreign journals.

The importance of her research and scientific-organizational activities is confirmed by various awards, as well as membership in various scientific societies, scientific councils and various committees at the national level. The most important awards she has received in recent times include the Scientist of the Year 2016 award, the Pribina Cross of the 1st Class awarded by the President of the Slovak Republic in 2019, and in 2020 she became a finalist for the ESET Science Award. An integral part of the work of Dr. M. Omastová, has long been popularization activities in various areas of materials science, while in recent times she has also tried to increase societal awareness in the area of environmental protection from plastic waste pollution.

Maria was a determined woman for whom every problem had a solution. That is why she embarked on bold projects and, thanks to her ability to immediately react to unexpected obstacles, she always managed to bring the given projects to a successful conclusion. It was enough to mention during informal meetings that something was not going well, or that it would be good to try something, and before the person had finished speaking, she had already called a specific person and solved the given problem. Thanks to her activity in official structures not only at the SAS, but also on the international scene (EPF, COST), she had a huge network of contacts and an incredible overview of project schemes. We will miss her hard work and dedication to her team and the scientific community very much.

She made a significant contribution to the history of not only the Institute of Polymers of the Slovak Academy of Sciences and the entire Slovak Academy of Sciences, but the results of her scientific work have influenced and will continue to influence the research of younger generations of scientists on an international scale for a long time to come. A special issue of the journal Emergent Materials was published in her memory in 2025 [1].

In Loving Memory of Maria!

References

1. Mičušík M., Chodák I., Chehimi M.M., Oksuz A.U. Polymer composites: Properties, Processing, and advanced Applications. In memory of Professor Mária Omastová (2025) Emergent Materials, 8 (8), pp. 6111 - 6112, DOI: 10.1007/s42247-025-01287-2.

CONTENT

ARYL DIAZONIUM SALTS IN POLYMER SURFACE SCIENCE AND ENGINEERING

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The exploration of aryl diazonium salt surface chemistry took off in 1992 and has since transformed the field of surface science at a remarkable pace. Although these salts have been known since the mid-19th century in organic chemistry, where they serve as versatile intermediates for the synthesis of a wide range of compounds, their impact in surface science and engineering has been particularly profound.

The reaction of diazonium salts with solid substrates, especially carbon-based materials, enables the covalent grafting of aryl groups and the formation of robust polyaryl thin films. This approach provides a powerful platform for creating stable, covalently bound functional interfaces that act as coupling layers for polymers, biomacromolecules, and nanomaterials.

Applications now span diverse fields, including electrocatalysis, theranostics, reinforcement of polymer matrices, and the attachment of polymer coatings via in situ surface-confined polymerization.

In this lecture, the fundamental principles of diazonium-based surface chemistry will first be briefly outlined, followed by selected major contributions from the author's research alongside representative advances from the literature. Particular emphasis will be placed on surface-confined polymerization strategies, such as ATRP, radical photopolymerization, and oxidative polymerization of conjugated monomers, performed on diazonium-modified substrates.

Highlighted applications will include chelating polymer-based sensors, molecularly imprinted polymer (MIP) grafts, diazonium-modified nanofillers for polymer reinforcement, and the fabrication of patterned functional surfaces, to name but a few.

The lecture will conclude with an overview of emerging trends in diazonium surface chemistry, with a focus on polymer surface science, engineering, and industrial applications.

POLYMERS IN WATER PURIFICATIONS TECHNOLOGIES

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The first part of the presentation discusses removing crude oil from kinetically stable oil-in-water (o/w) emulsions using specially modified recycled low-density polyethylene (LDPE) waste [1]. Since the oily droplets are smaller than 1 µm, these emulsions challenge traditional methods for cleaning oily-polluted industrial waters, such as produced water, with standard sorbents in deep-bed filtration systems. This study presents a new adsorbent: powdered LDPE coated with a specific polymeric layer that attracts negatively charged oil droplets. The polymer is created by radiofrequency plasma polymerization of allylamine directly onto the surface of the LDPE powder. Separation tests were carried out on emulsions with different compositions and acidity levels, in both batch and filtration modes. When used at pH=3, the new sorbent achieved approximately 70% separation efficiency for emulsions containing 100 ppm oil and droplets smaller than 1 µm. The second part examines the development of foamy oil absorbers from recycled polyethylene [2]. These materials effectively absorb oil spills from freshwater. These studies demonstrate that a cost-effective, easy-to-make, commodity-based adsorbent derived from polyethylene recyclates has great potential to clean emulsified, oily-polluted water and to absorb free oil from water surfaces.

Acknowledgment

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References

[1] Hailan, S., Ghosh, P., Sobolciak, P., Kasak, P., Popelka, A., Ouederni, M., Adham, S., Chehimi, M., McKay, G., Krupa, I. **Process Saf. Environ. Prot.** 2024, *183*, 771-781.

[2] Krupa, I., Mahmoud, A., Sobolciak, P., Popelka, A., Mrlik, M., Minarik, A., Gasmi, S., Ouederni, M., Adham, S. Sep. Purif. Technol. 2022, *302* 122118.

INNOVATING ADVANCED MATERIALS FOR HEALTH APPLICATIONS: BALANCING SAFETY AND PERFORMANCE

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Advanced materials (definition) are rapidly reshaping innovation, extending into all areas of our daily life. In particular, nanomaterial-reinforced or functionalized polymers offer a lot of promising applications. Their high surface area, tunable reactivity, and capability to steer the bio-interactions enabling next-generation solutions for prevention, early diagnosis or targeted treatment. Yet their accelerated development and growing deployment necessitates rigorous evaluation of their safety and sustainability to ensure responsible translation.

This talk synthesizes insights from the NOVA project and related research, focusing on the design, efficacy, and safety of light-activated antimicrobial surface coatings tailored for high-traffic, enclosed public spaces where airborne and multidrug-resistant pathogens spread swiftly [1]. A novel class of coatings incorporating hydrophobic carbon quantum dots (hCQDs) and up-converters (UPC) developed under Safe-by-Design (SbD) principles will be presented [2]. Beyond pathogen inhibition, critical safety dimensions: the potential for increased flammability, smoke release, and formation of harmful entities during fire-related incidents was examined. To probe real-world hazard scenarios, hCQDs and UPCs were applied to porous and non-porous substrates and incinerated to assess fume products; airborne soot particles were characterized for polycyclic aromatic hydrocarbon (PAH) content and evaluated for pro-inflammatory cytokine responses in human lung cells. Notably, no significant acute in vitro lung cytotoxicity was detected from nano-coated surfaces after incineration, marking an important intermediate milestone that sup-ports continued optimization and assessment.

Together, these findings highlight a pragmatic pathway to balancing performance with safety—integrating SbD throughout material development, benchmarking efficacy against pathogens, and systematically de-risking end-of-life scenarios.

Acknowledgment

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References

[1] Reina G. et al. EcoMat. 2025, 7e7009.
[2] Meier P., et al. Ecotoxicol. Environ. Saf. 2025, *300*, 118421.

TOWARDS SUSTAINABLE BIOBASED WATERBORNE ADHESIVES AND COATINGS

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Polymeric materials are an indispensable part of modern life. While polymers have undoubtedly facilitated daily living and industrial processes, their increasing consumption and expanding applications have raised growing concerns. These concerns can be categorized into three main areas. First, the reliance on petroleum-based feedstocks, which are neither sustainable nor environmentally friendly. Second, the environmental and health impact associated with polymer production processes. And third, the accumulation of polymer waste, primarily driven by the widespread use of single-use packaging materials. In this presentation I will share recent efforts carried out in our group towards the synthesis of sustainable waterborne polymer dispersions.

One direction towards sustainable dispersions is reducing the carbon footprint by substituting oil based monomers by biobased monomers. One option, the most preferred by industry, is to use biobased monomers which are already commercially available or can be easily scaled up. I will show the challenges and advantages that commercial and non-commercial monomers have in the synthesis of waterborne binders for adhesives and coatings when they substitute oil-based monomers.

In the second part, I will address a second challenge towards the production of sustainable polymer dispersions. In many applications it is interesting that polymer (bio)degrades after their use, especially in those applications where the polymer is disposed to environment after use (e.g, microcapsules, polymers in cosmetics, inks, paper and cardboard coating….). Two different chemistries will be discussed: cyclic ketene acetals and thio-lene chemistry. Within the CKAs, 2-methylen-1,3-dioxepane (MDO) is one of the most promising building blocks, but it presents several drawbacks that need to be solved before it can be incorporated into emulsion polymerization formulations. Unfavorable reactivity ratios with other monomers, hydrolysis in water and protic media as well as its incorporation in the closed formed are aspects that we analyzed based on experimental and fundamental theoretical investigations.

Finally, I will present the synthesis of waterborne degradable polymer particles produced by the radical thiol-ene step-growrth polymerization of ester containing dithiols and dienes carried out in emulsion polymerization. These polyester dispersions show excellent biodegradability and water and oil repellency that makes them ideal candidates for cardboard packaging applications.

COVALENT ADAPTABLE NETWORKS BASED ON POLYESTERS; EXAMPLE OF TULIPALIN A AND ε-CAPROLACTON COPOLYMER CROSS-LINKED WITH ALKYLATED THIOETHER

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During the last decades polymeric networks containing dynamic covalent bonds have received high interest as a result of the possibility of increasing their lifetimes by self-healing, reprocessing or recycling upon triggering the reversibility or exchange between their dynamic bonds by different stimuli (heat, p*H*, UV, ox.-red. agents) without or with relatively low loss of their original mechanical properties and stability [1].

In this work, linear and star-shaped poly(ε-caprolactone-co-α-methylene-γ-butyrolactone) P(CL-co-MBL) copolyesters with a pendant functional double bond of MBL comonomer were used as polymeric precursor for organo-gels formation [2]. Crosslinking was carried out by photo-initiated thia-Michael reaction using di- and/or tetra-thiol. The gel content and the crosslinking density varied based on MBL comonomer and crosslinker content and were highest for -SH/vinyl; 2/1 molar excess. Formed thioether bond within the network were not reversible up to 150 °C as it was found based on temperature sweep rheology. PCL segments provides toughness into the material at r.t. while material becomes malleable after melting of these physical crosslinks at 50 °C. Following, the activation and conversion of thioether bonds into trialkylsulfonium salts was attained through the alkylation. The dynamic nature of the transalkylation at 150 °C allowed network rearrangement, which was proved by stress relaxation and creep recovery experiments [3].

Acknowledgment

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References

[1] Zhang, W.; Jin, Y.; Imato, K.; Otsuka, H.; Dynamic Covalent Chemistry: Principles, Reactions, and Applications. Wiley 2018.
[2] Ismael, I.; Mrlík, M.; Vykydalová, A.; Annušová, A.; Halahovets, Y.; Mosnáček, J.; Danko, M. *Polym. Adv. Technol.*, 2024, 35, e6404.
[3] Ismael, I.; Vykydalová, A.; Mičušík, M.; Peidayesh, H.; Shaalan, M.; Kroneková, Z.; Mrlík, M.; Mosnáček, J.; Danko, M. *Polym. Degrad. Stab.*, 2026, 244, 111780.

MORPHOLOGY FORMATION DURING INJECTION MOLDING OF SEMI-CRYSTALLINE THERMOPLASTICS

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Semi-crystalline thermoplastics develop complex internal structures during injection molding, as cooling rates and thermo-mechanical stresses influence molecular orientation, crystallinity and crystalline phases along the flow path. In addition, injection-molding-induced interfaces and pronounced skin–core gradients lead to distinct morphological zones that strongly affect mechanical properties. These effects become even more pronounced when scaling down to thin or micro-structured components. Thin-section preparation enables the selective characterization of these zones and supports simulation-based predictions of structure formation. The relevance of these findings is demonstrated for film hinges, a common application produced under extreme processing conditions in very narrow flow channels. A dedicated specimen design enables the investigation of morphology and mechanical behavior under application-relevant conditions.

Acknowledgment

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References

[1] Spoerer, Y., Androsch, R., Jehnichen, D., and Kuehnert, I., *Process Induced Skin-Core Morphology in Injection Molded Polyamide 66.* Polymers, 2020. 12(4): p. 9.
[2] Spoerer, Y., Boldt, R., Androsch, R., and Kuehnert, I., *Pressure- and Temperature-Dependent Crystallization Kinetics of Isotactic Polypropylene under Process Relevant Conditions.* Crystals, 2021. 11(9): p. 1138.
[3] 41. Fischer, M., Blanco, C., Spoerer, Y., Stommel, M., and Kuehnert, I., *Correlations between molecular weight, mechanical properties and morphology of micro-injection molded polyoxymethylene (POM).* Polymer Testing, 2024. 140.
[4] Fischer, M., Wiegand, J.J., and Kuehnert, I. *New characterization methods for micro-injection molded specimens in polymer material development*. in *38th International Conference of the Polymer-Processing-Society (PPS)*. 2023. St Gallen, SWITZERLAND: Amer Inst Physics.
[5] Spoerer, Y. and Kuehnert, I., *Correlation between process-induced crystallization and mechanical properties in injection-molded isotactic polypropylene (iPP).* Final Report (Project DPI #816). 2025. Dutch Polymer Institute (DPI).

PLASMA FUNCTIONALIZATION FOR ENHANCED INTERFACIAL ADHESION IN HIGH-PERFORMANCE FRP COMPOSITES

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Fiber-reinforced polymer (FRP) composites are widely used as an alternative to traditional materials; however, improving their manufacturing processes and performance remains an important research topic. This study focuses on enhancing fiber–matrix interfacial adhesion in composites reinforced with aramid, glass, and flax fabrics using various dielectric barrier discharges (DCSBD; VDBD, also called the industrial corona; DCSBD linear APPJ) shown in Fig. 1. Plasma treatment represents a rapid and effective method for surface functionalization of fibers and fabrics, leading to increased surface energy and improved wettability [1]. Enhanced wetting promotes more efficient matrix infiltration into the fabric structure, resulting in a significant reduction of porosity in the composites. Reduction of porosity by plasma treatment enhances matrix infiltration and promotes more uniform contact between fibers and the polymer, thereby minimizing pathways for moisture and oxygen penetration. This improvement enhances fibre–matrix stability and significantly increases the environmental durability and long-term performance of the composites.

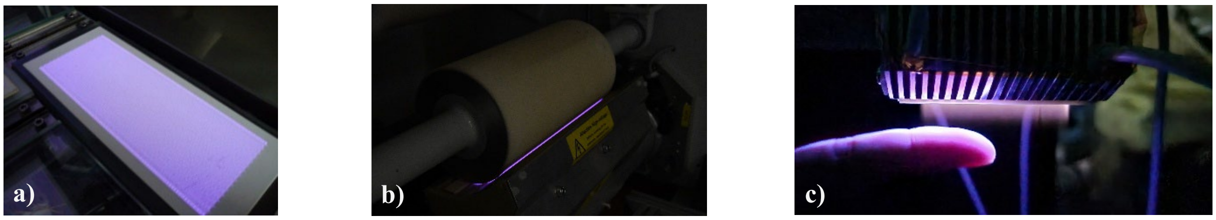

Fig. 1. Photographs of discharges used for the plasma treatment of fabrics for FRP composites: DCSBD (a) and VDBD (b) generated in ambient air, and a DCSBD linear APPJ (c) operating with N_2 into ambient air.

Acknowledgment

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References

[1] Skácelová D., Rapcová E., Böhm P., Stupavská M., Drdlová M., Kováčik D. in: *Advances in Composites Manufacturing and Applications*. ASC 2024. Proceedings of the American Society for Composites Annual Technical Conferences. Springer, Cham., 2026, https://doi.org/10.1007/978-3-032-05224-7_15.

HYBRID BIO-BASED MATERIALS AS FUNCTIONAL PLATFORMS FOR NEXT-GENERATION SCAFFOLDS

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Rapid developments in biomaterials show that biopolymer-based materials can serve as versatile building blocks for creating functional scaffolds with tailored mechanical, chemical and biological properties. Materials such as polyhydroxyalkanoates (PHA), bacterial cellulose (BC) and lignin-derived systems offer renewability, biocompatibility and structural adaptability. They can therefore be used in many different material and engineering applications.

This lecture presents an integrated view of how natural polymer architectures can be modified or combined to enhance their performance. A central idea is that bio-origin polymers can be transformed into multifunctional materials through controlled structural modification. One example is a PHA material coated with polypyrrole that retains its original viscoelastic properties while gaining bioactive features and electrical conductivity.

Bacterial cellulose represents another promising avenue for the development of functional biomaterials. Its clean nanofibrous network provides high purity, strong water interaction and a hierarchical structure. These features enable BC to form uniform, robust composites with conducting polymers, yielding free-standing materials with large surface areas and adjustable interfacial properties.

Additionally, natural polyphenols introduce unique benefits. When incorporated into films, hydrogels or thin coatings, these components provide intrinsic antioxidant and antimicrobial activity.

Collectively, these strategies highlight how hybrid bio-based materials can integrate structure, functionality and sustainability to support the development of next-generation material solutions.

Acknowledgment
This study was funded by the project GA 25–15806S of the Czech Science Foundation (GACR).

NOVEL HYBRID MATERIALS BASED ON ORGANO-MODIFIED MONTMORILLONITES FOR DECONTAMINATION OF HAZARDOUS MOLECULES

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Organo-modified layered clay minerals including montmorillonites (Mt) play an important role as hybrid advanced materials in many (bio)applications, e.g., as sorption materials and flocculants, catalysts, fillers for (nano)composites, drug delivery systems, or materials for tissue engineering [1-2]. The structure of MMT allows for the incorporation and exchange of various cations, such as Na^+, Ca^{2+}, and Mg^{2+}, with different organic molecules or macromolecules. In this context, polycation-modified clay minerals have been extensively studied as catalysts or adsorbents for organic pollutants [2].
In this contribution, cationic copolymers prepared by partial hydrolysis of poly(2-ethyl-2-oxazoline) have been used as a new type of polymeric modifier of clay minerals with improved biocompatibility toward potential utilization in biomedical and environmental applications [3]. Prepared organo-modified Mt exhibited improved biocompatibility *in vitro* and they were successfully used for decontamination of paraoxon as model organophosphate (Fig.1).

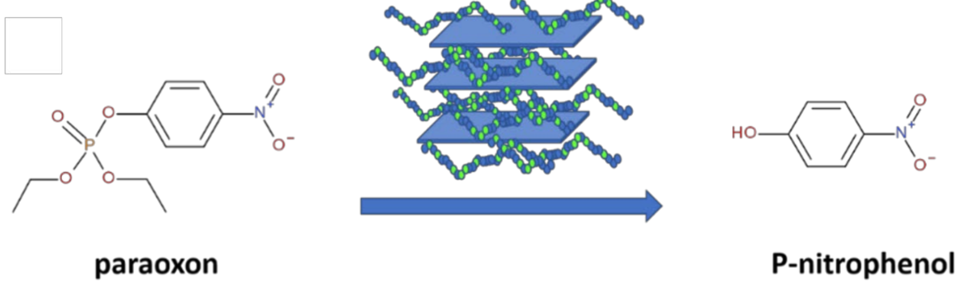

Fig.1. Decontamination effect of montmorillonites modified with cationic polymers on paraoxon

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References

[1] Ruiz-Hitzky E., van Meerbeek A. in: *Handbook of Clay Science, Developments in Clay Science*, Vol. 1, p. 583–621. Elsevier, 2006.
[2] Churchman G.J.,Appl. Clay Sci. 21, 2002, 177–189.
[3] Kroneková Z., Jankovič L., Mošková Z., Minarčíková A., Zhukouskaya H., Kučka J., Vetrík J., Hrubý M., Kronek J. Coll. Surf. A. 713, 2025, 136534.

POLYMERS MIMICKING FUNCTIONALITY OF NEURONAL SYNAPSES

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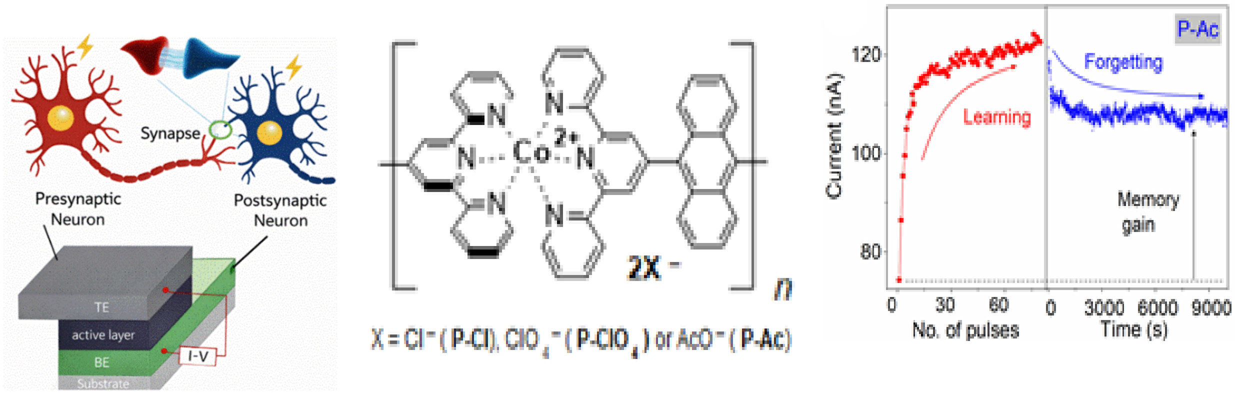
Polymer semiconductors often show a hysteresis in their current-voltage characteristics, which can be used to store information in resistive memory devices. Some of them show the properties of memristor, a two-terminal analog electronic element that exhibits non-linear current-voltage characteristics. Its resistance depends on the amount of charge that has previously passed through. Synapse is a connection between two neurons (or a sensory cell and a neuron) used to transmit excitations. Memristors designed for neuromorphic applications must exhibit reliable analog characteristics, in particular, a switching transition with a continuously variable resistance state and a predictable response. These properties are required in order for the memristor to be used for the construction of physical autonomous artificial neural networks that are independent of programming by other external software means. Synaptic plasticity (SP) is central to Hebbian learning. SP can be divided into a short-term (STP), and long-term plasticity (LTP).

We present such functionality on thin films of ditopic π-conjugated carbazole or anthracene based bis-terpyridine (tpy-) ligands forming supramolecular structures in which the ligands are interconnected by complexation with metal ions. These molecules offer a low energy operation with improved reproducibility of memristive characteristics. The nature of counterions was found to directly influence memristive behavior and device stability due to a synergistic action of ionic and electronic charge transport underlying the synapse-mimicking behavior of the polymer.



Mimicking learning and forgetting behavior of the polymer devices during repeated stimulation and subsequent memory retention in the anthracene based polymer with acetate counterions (P-Ac) as active layers. Conductance recorded during the stimulation with 80 identical trigger pulses (+1.1 V, 20 ms). The ability of the devices to retain the increased conductance was monitored during relaxation (forgetting) using low-amplitude pulses.

Acknowledgment

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PREPARATION OF BIODEGRADABLE POLYLACTIC ACID/POLYHYDROXYBUTYRATE BLENDS AND MODIFIED BIOGLASS COMPOSITES

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In the treatment of bone diseases and fractures, surgical removal of implants is often necessary after the bones have healed, which leads to additional trauma, costs, and waste. BioImplant aims to eliminate these surgeries while supporting the healing process of affected bones, using new composites that are metabolized and serve as sources of beneficial substances with gradual release for the formation of osteosynthesis. Therefore, it would be beneficial to develop new biocompatible, biodegradable osteosyntheses, which will improve the treatment of bone diseases and fractures by reducing the need for secondary surgical procedures and supporting the healing process. The components of the proposed composite can affect various mechanisms through which bone repair occurs. Biopolymers, such as polyhydroxyalkanoates (PHA) and polylactic acid (PLA), are commonly used in the medical industry and exhibit favorable biocompatibility and biodegradability.

In the case of PLA/PHB we used weight ratio 85/15 wt. and added 10 wt. % of plasticizer. Two different plasticizers were studied, namely, acetyltributyl citrate (ATBC) and triethyl citrate (TEC). Adding of PHB is increasing toughness of the final polymer composites, what might be very crucial at higher bioglass loadings. By adding PHB we are tuning also the biodegradability. TEC as plasticizer containing -OH group able to interact with carbonyls of PLA/PHB resulted in higher Youngs modulus of polymer composites containing TEC as plasticizer when compared to ATBC. Bioglass was also modified by (3-Aminopropyl)-triethoxysilane (APTES), which thanks to active NH2 group resulted to the better interaction with polymer matrices and relatively high Youngs modulus. Surface chemistry and composition of modified Matexcel 58S bioglass was characterized by XPS, FTIR, TGA and SEM-EDX..

Acknowledgment

This work was supported by H2020 - ERA-NET/M-ERA.NET3/BIOIMPLANT project No. 11132 and by the Slovak Research and Development Agency (APVV-23-0224).

PREDICTIVE CHARACTERIZATION OF RECYCLED PLA VIA RHEOLOGICAL, MOLECULAR, AND MECHANICAL INDICATORS

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There is a steady increase in the amount of plastic waste generated. One strategy to address this challenge is the replacement of conventional petrol-based plastics with bio-based and biodegradable alternatives. Until recently, research on biopolymers has primarily focused on their compostability. However, several studies have highlighted that composting is not necessarily the most effective end-of-life management option when evaluated in terms of carbon footprint, with mechanical recycling often representing a more sustainable alternative [1].

Consequently, industrial interest in the mechanical recycling of bioplastics has been increasing, with poly(lactic acid) (PLA) – one of the most widely studied representatives – receiving considerable attention [2]. Mechanical recycling typically involves grinding and reprocessing plastic materials, usually using the same equipment employed in primary production [3]. However, repeated processing is commonly associated with molecular degradation, which can significantly influence mechanical and physical properties as well as rheological behavior.

In the present study, two polymer processing techniques, injection molding and extrusion, were applied to investigate how successive reprocessing cycles affect the properties of PLA. Mechanical, physical, structural, and melt flow characteristics were examined. Changes in molecular weight were correlated with functionally relevant material properties. The melt flow index was identified as an easily measurable and unifying parameter that can be used to predict key material properties after multiple recycling cycles.

Acknowledgment

The research was supported by the National Research, Development and Innovation Office (Hungary) through the project STARTING 150339.

References

[1] Arjona P., Velásquez E., López-Carballo G., Hernández-Muñoz P., Gavara R., López-de-Dicastillo C. Resour. Conserv. Recycl. 2026, *225*, 108597.
[2] Pérez-Fonsecaur A.A., González-López, M.E., Robledo-Ortíz, J.R. J. Polym. Environ. 2023, *31*, 4143-4159.
[3] Lendvai L., Bódi V.L., Danko M., Varbanov P.S., Jakab S.K. Macromol. Mater. Eng. 2025, *Early View*, e00349.

MULTIFUNCTIONAL ORGANOSILICONE MODIFIERS – UNLOCKING THE MATERIALS TOMORROW

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This lecture focuses on the innovative applications of multifunctional organosilicon compounds within materials engineering, placing particular emphasis on their role in modifying polymers, composites, and functional coatings. Novel compounds, such as multifunctional silsesquioxanes and spherosilicates, will be presented. Due to the presence of reactive Si-H or S-H groups, these compounds enable the statistical design of molecular architectures. Unlike traditional nanofillers, they exhibit unique modifying properties—such as improved nanofiller dispersion, the alteration of polymer crystallinity, and viscosity reduction—which result in significantly enhanced mechanical, thermal, and rheological material properties. Practical applications of these compounds will be discussed in the context of additive manufacturing technologies, where they improve interlayer adhesion and axial strength, as well as in the development of hydrophobic and icephobic coatings for the energy and industrial sectors. The lecture will also highlight the importance of sustainable development by presenting examples of biopolymers, including PLA-based composites. An important aspect of this presentation is the interdisciplinary nature of the research, which bridges organosilicon chemistry, nanotechnology, and materials engineering, alongside the challenges related to the commercialization of these novel modifiers. Future research directions will also be outlined, including the potential use of these compounds as emulsifiers in polymer systems. The lecture is aimed at scientists, engineers, and entrepreneurs interested in advanced material technologies, offering inspiration for further research and practical implementation.

Acknowledgment

The research was financed by the Future Mold 2025 project of the M-ERA.NET 3 Call 2023 program.

MOLECULAR DYNAMICS SIMULATIONS OF KNOTTED, CATENATED AND SUPERCOILED DNA MOLECULES FOR AI ENHANCED TOPOLOGY RECOGNITION

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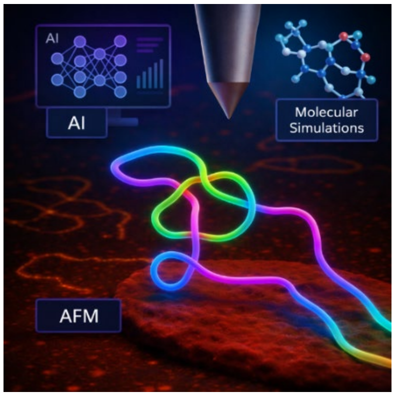

In this contribution, we present our recent work on molecular simulations of topologically complex DNA molecules. DNA is a long polymer whose structural organization gives rise to rich topological behavior. In living cells, DNA molecules often become supercoiled as a result of the action of proteins that maintain genome organization and ensure proper biological functioning. Other biological processes further modify DNA topology: recombination events can generate knots, while replication of circular DNA molecules inevitably leads to catenated structures.

Understanding the pathways of biological unknotting and the mechanisms that preserve genome organization requires reliable information about DNA topology, which can be obtained, for example, from high-resolution atomic force microscopy (AFM) imaging. In collaboration with experimental partners abroad, we employed advanced molecular modeling techniques to simulate conformations of topologically complex DNA molecules. The generated structures were used to enrich training datasets for machine-learning algorithms designed to identify DNA topology from AFM images. In addition, the simulations provided insight into the interactions between DNA molecules and the mica surface commonly used in AFM experiments.

Acknowledgment

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References

[1] HOLMES, Elizabeth P. - GAMILL, Max C. - PROVAN, James I. - WIGGINS, Laura - RUSKOVÁ, Renáta - WHITTLE, Sylvia - CATLEY, Thomas E. - MAIN, Kavit H.S. - SHEPHARD, Neil - BRYANT, Helen E. - GILHOOLY, Neville S. - GAMBUS, Agnieszka - RAČKO, Dušan - COLLOMS, Sean D. - PYNE, Alice L.B. Quantifying complexity in DNA structures with high resolution Atomic Force Microscopy. Nature Communications, 2025, vol. 16, no. 1, art.no. 5482, [20] pISSN 2041-1723. https://doi.org/10.1038/s41467-025-60559-x.

OBSERVING THE STRUCTURE OF NON-FOULING BRUSHES

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Hydrophilic polymer brushes are widely used in biomedical systems to minimize unwanted interactions with biological media. Although chemical composition is central to antifouling and biological performance, the physical state of the polymer chains also plays a major role although has rarely been examined directly. Understanding chain conformation, interfacial behavior, and stimulus-induced structural changes in aqueous environments is crucial for the rational design of biomaterials. We will report our comprehensive studies of the chemical composition and physical organization of surface-grafted polymer brushes synthesized via grafting-to [1, 2] and grafting-from [3-5] reactions. By adjusting the density of surface-bound initiating sites employed for surface-initiated controlled radical polymerizations, we obtained polymer brushes spanning a range of grafting densities [6]. Their chemical and structural properties were then examined in detail using complementary interfacial characterization methods. We also evaluated the swelling behavior of these brushes under both dry and hydrated conditions, which revealed how grafting density influences the scaling properties and conformational responses of end-tethered chains [6]. Particular attention was paid to their behavior when exposed to anions from the Hofmeister series. Finaly, the antifouling coatings were functionalized with a fluorescent label to enable further assessment of their structure, uniformity, and responsiveness to external stimuli [7].

Acknowledgment

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References

[1] A. de los Santos Pereira, A. Cernescu, J. Svoboda, R. Sivkova, I. Romanenko, B. Bashta, F. Keilmann, O. Pop-Georgievski, *Anal. Chem.* 2020, *92* (*7*), 4716-4720.
[2] O. Kopilec, J. Svoboda, R. Sivkova, O. Sedlacek, O. Pop-Georgievski, *Macromol. Chem. Phys.* 2025, *226 (14)*, 70001.
[3] D.F. Dorado Daza, A. de los Santos Pereira, O. Kopilec, R. Sivkova, J. Svoboda, O. Sedlacek, O. Pop-Georgievski, *Polymer*, 2025, *323*, 128175.
[4] Y.M. Wang, A. Kálosi, Y. Halahovets, H. Benes, A.D. Pereira, O. Pop-Georgievski, *Pol. Chem.* 2024, *15 (20)*, 2070-2080.
[5] Y.M. Wang, A. Kalosi, Y. Halahovets, I. Romanenko, J. Slaby, J. Homola, J. Svoboda, A. de los Santos Pereira, O. Pop-Georgievski, *Poly. Chem.* 2022, *13 (25)*, 3815-3826.
[6] I. Romanenko, R. Sivkova, J. Svoboda, T. Riedel, A. de los Santos Pereira, O. Pop-Georgievski, *Polymer* 2025, *332*, 128569.
[7] R. Sivkova, J. Svoboda, J. Pánek, D. Appelhans, O. Pop-Georgievski, *Prog. Org. Coat.* 2023, *178*, 107447.

FROM CONCEPT TO CREATION: THE EVOLUTION OF 3D PRINTING AT PISAS

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Additive manufacturing, commonly known as 3D printing, has undergone rapid development over the past decades, transforming from a prototyping tool into a versatile manufacturing technology with applications across engineering, medicine, and materials science. This presentation provides a comprehensive overview of the historical evolution of 3D printing, highlighting key milestones and the emergence of major techniques, including fused deposition modelling, stereolithography, and selective laser sintering. Particular emphasis is placed on the technological advancements that enabled improved material processing, precision, and scalability.

The second part of the presentation focuses on the development and implementation of 3D printing technologies in our department. The gradual adoption of additive manufacturing tools, expansion of technical capabilities, and integration into research and educational activities are discussed. This institutional perspective illustrates how global technological trends have been translated into local research infrastructure and expertise, enabling interdisciplinary collaboration and innovation.

Finally, the presentation showcases selected previously published results from our team related to the development and processing of polymer composite filaments for FDM-based 3D printing. The preparation of composite materials incorporating various fillers to tailor mechanical and functional properties is presented, along with processing strategies and the optimisation of printing parameters. The influence of material composition on printability, structural integrity, and performance of the final printed objects is critically evaluated.

Acknowledgment

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References

[1] Kováčová etal. Appl. Sci. 2020, vol. 10, no. 9, art. no. 3062, [15]p
[2] Kovalčik etal. Int. J. Biol. Macromol. 2021, vol. 183, p. 880-889
[3] Sztorch etal. Solids, 2022, vol. 3, no. 3, p. 508-548
[4] Kováčová etal. Processes 2023, vol. 11, art.no. 395, [12] p.
[5] Bhandari etal. Additive Manufacturing 2024, vol. 88, 104238, [19] p.
[6] Ghonim etal. Int. J. Adv. Manufactur. Technol. 2024, vol. 135, p. 4119-4146.
[7] Shaalan etal. Polym. Bull. 2024, vol. 81, p. 13009-13025.

FROM FURAN MONOMERS TO SUSTAINABLE (CO)POLYMERS VIA CONTROLLED RADICAL POLYMERIZATION

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Furan derivatives derived from renewable biomass represent a promising sustainable alternative to conventional petroleum-based monomers. Their polymers can be synthesized using various techniques, including condensation, ring-opening, and radical polymerization, enabling access to materials with diverse structural and physicochemical properties [1]. Among these approaches, controlled radical polymerization (CRP) offers precise control over molar mass, dispersity, and macromolecular architecture.

This work investigates the synthesis of furan-based (co)polymers from two derivatives of 5-hydroxymethyl furfural via two CRP techniques: Photo-induced atom transfer radical polymerization (photo-ATRP) and nitroxide-mediated polymerization (NMP) [2, 3]. The choice of polymerization method was guided by monomer structure and reactivity. The resulting copolymers were thoroughly characterized and subsequently explored for advanced applications, including the fabrication of nanofibrous materials via electrospinning, the development of functional carriers for fluorescent compounds, and the preparation of polymer networks (Figure 1).

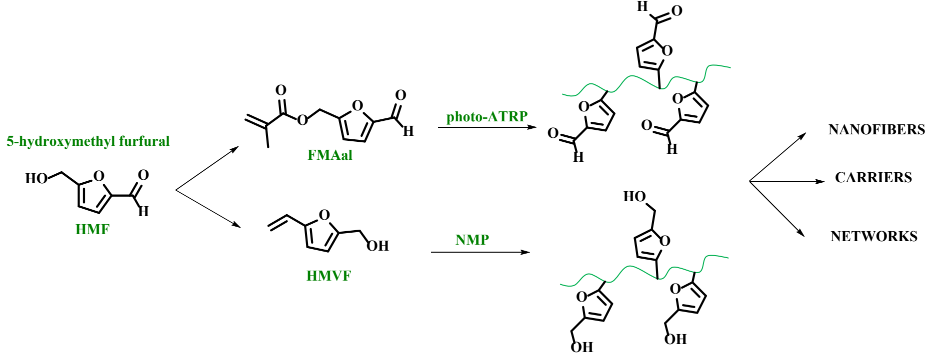

Figure 1: Strategy for the synthesis of furan (co)polymers and their potential applications.

Acknowledgment
The authors thank for financial support of the research to projects 2022-17633/NP/DANUBE 2022 CALL/BioTape and VEGA 2/0172/26.

References

[1] Lalanne L., Nyanhongo G.S., Guebitz G.M., Pellis A., *Biotechnol. Adv.,* **2021**, 48, 107707.
[2] Zain G., Bondarev D., Doháňošová J., J. Mosnáček J., *ChemPhotoChem.,* **2019**, 1138–1145.
[3] Marić M., *Can. J. Chem. Eng.,* **2021**, 99 (4), 832–852.

SYNTHESIS OF NOVEL FUNCTIONAL POLYAMIDES USING RENEWABLE ITACONIC ESTERS AND DIAMINES

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Itaconic acid and its derivatives are versatile bio-based building blocks widely used in the synthesis of sustainable polymeric materials. [1] However, a major structural limitation of itaconic acid is its highly reactive methylene group. While this functionality is beneficial for radical polymerization processes, straightforward polycondensation reactions with amines often lead to the formation of pyrrolidone rings via intramolecular cyclization following a Michael addition. [2,3] This side reaction prevents the formation of the desired polyamide structures and limits the direct use of itaconic acid derivatives in step-growth polymerization.

The aim of this work is to develop effective protection and deprotection strategies for the methylene group in order to preserve its reactivity during polyamide synthesis. Such an approach would enable the preparation of a novel class of polyamides derived from itaconic acid derivatives and diamines while maintaining the functionality of the unsaturated group.

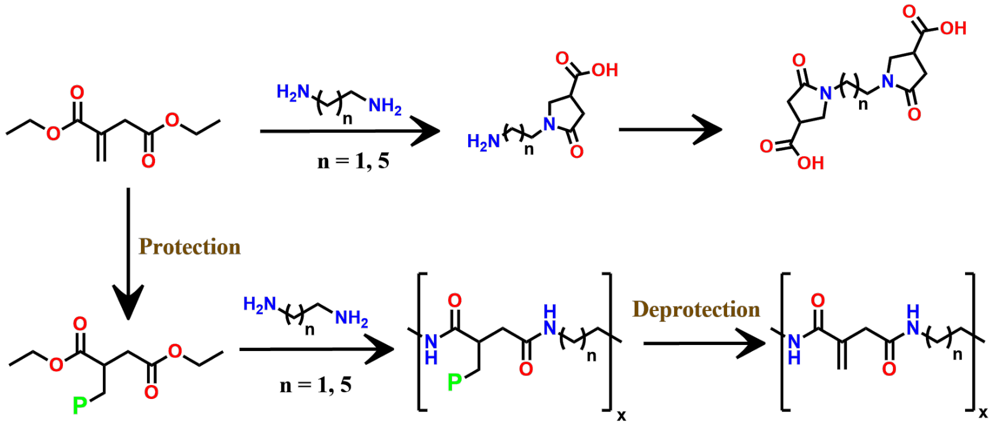

Figure 1 – Synthesis of polyamidoamines from itaconic acid ester and diamines

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References

[1] Bragato N., et al. Green Chem. 2026.
[2] Paytash P.L., Sparrow E., Gathe J.C. J. Am. Chem. Soc. 1950, *72, 1415–1416.*
[3] Medway A.M., Sperry J. Green Chem. 2014, *16, 2084–2101.*

EMISSIVE POLYIMIDES: PREPARATION, CHARACTERIZATION AND APPLICATION

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Polyimides (PI) represent a class of high-performance polymers whose properties can be effectively modified through the molecular design of the monomers. In this work, a series of new push–pull chromophore-based monomers was synthesized and incorporated into polyimide matrices either as non-reactive additives or as functional diamine or monoamine building blocks. The aim was to systematically evaluate how the chromophore structure and its mode of incorporation affect the emissive, thermal, and optical properties of the resulting materials. The synthesized chromophores were based on triazine, anthracene, triphenylamine and pyridine structure units, which were introduced into PI films to modulate their electronic structure and photophysical behavior. A comprehensive study of the prepared films revealed that the combination of commercially available monomers with a suitable push–pull chromophore, used either as an additive or as part of the polymer backbone, enables precise control over light emission, transparency, coloration, and thermal stability. Importantly, the results show that the monomer structure has a decisive influence on emission intensity and color tuning, while maintaining the intrinsic robustness typical of high-performance PI. Overall, this work demonstrates a practical route to emissive and optically tunable polyimides by combining commercially available monomers with designed push–pull chromophores used either as additives or as functional diamines. The main result we achieved is a flexible, highly transparent, colorless polyimide film with intense emission while preserving the thermal robustness of high-performance PI.

DIMETHACRYLATE MICROSTRUCTURE: ROLE OF COMPOSITION AND PREPARATION

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Photopolymerization is widely used in applications ranging from coatings to advanced technologies such as biomedicine and 3D printing. The polymerization of di(meth)acrylates often leads to heterogeneous crosslinked networks accompanied by significant shrinkage and internal stress. A promising way to influence the polymerization process is the addition of chain transfer agents (e.g., thiols), addition–fragmentation chain transfer reagents, or fillers, resulting in more homogeneous networks, reduced shrinkage, and improved toughness.

Previous PALS studies have shown that thiol-regulated dimethacrylate networks exhibit altered free volume and isotropic expansion compared to classic networks [1]. Building on this, recent microstructural analysis of di(meth)acrylates with varying thickness and photoinitiator content revealed gradients in microstructure [2]. Moreover, the composition of the reactive mixture [3] and the preparation method can be key factors in enhancing material properties. Moreover, the photopolymerization process and the resulting material properties are influenced by the composition of the reactive mixture [3], the preparation method, and external factors.

In this study, the Positron Annihilation Lifetime Spectroscopy (PALS) is used as a powerful tool to understand how formulation and processing govern microstructure and ultimately control material properties.

Acknowledgment

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References

[1] Consolati G., Quasso F., Yaynik E., Briatico Vangosa F., Šauša O., Ehrmann K., Švajdlenková H. Phys. Chem. Chem. Phys. 2022, *24*, 14299–14309.
[2] Cifraničová K., Šauša O., Královič D. P., Švajdlenková H. *Polym. Chem.* 2023, *14*, 3372–3380.
[3] Cifraničová K., Šauša O., Rosskopfová O., Sedničková M., Švajdlenková H., *Sci. Rep.* 2025, *15*, 20494.

MULTICOMPONENT REACTIONS: A VERSATILE PLATFORM FOR THE PREPARATION OF FUNCTIONAL POLYMERS

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Advanced functional polymers with controllable properties, including self-assembly, thermoresponsiveness, and aggregation-induced emission (AIE), are increasingly important for applications in bioimaging, smart drug delivery systems, and catalysis. The main aim of our study is the development of amphiphilic polymeric materials with precisely tunable structure and functionality, enabling systematic control over their organization and responsive behavior. The synthetic concept is based on the combination of multicomponent reactions (MCRs), in particular the Passerini three-component (P3CR) and Ugi four-component (U4CR) reactions, with free radical polymerization (FRP) as well as atom transfer radical polymerization (ATRP). Our research group has demonstrated that Passerini three-component reaction performed in aqueous media represents an efficient and robust tool for the synthesis of functional methacrylic ester–amide monomers. Using water as the reaction medium, high monomer yields and high purity were achieved, confirming the suitability of aqueous MCR conditions for the preparation of polymerizable building blocks. The resulting carbamoyl methacrylate monomers were subsequently polymerized to obtain poly(carbamoyl methacrylate)s with well-defined thermal properties and good stability. Importantly, the synthesized polymers exhibited spontaneous self-assembly in water, forming stable micellar nanoparticles characterized by low critical micelle concentrations and long-term colloidal stability.

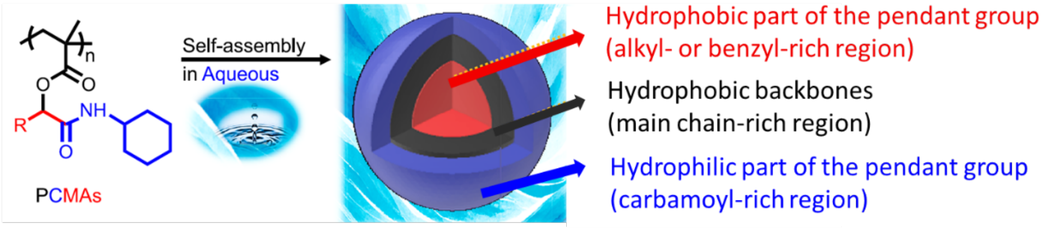

Figure 1: Schematic illustration of the proposed self-assembly behavior of PCMAs in aqueous solution.

Acknowledgment

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References

[1] Ejeta et al., *European Polymer Journal*, vol. 218, (2024) 113361.
[2] Sehlinger et al., *Macromolecules,* 46, (2013) 6031.

DESIGN AND CHARACTERISATION OF MXENE-BASED CONDUCTIVE NANOPAPERS FOR MULTIFUNCTIONAL COMPOSITE INTERLAYERS

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The development of multifunctional interlayers for fibre-reinforced polymer laminates requires materials that provide electrical conductivity, mechanical integrity, and compatibility with a broad variety of thermoset matrices. Two-dimensional (2D) nanoparticles, known as MXenes, exhibit excellent electrical properties but are offset by their limited mechanical robustness and environmental sensitivity [1]. Cellulose nanofibres (CNF), in contrast, offer mechanically resilient and structurally reinforcing films but are electrically insulating [2]. Therefore, the integration of MXene nanosheets with a CNF substrate allows coupling electrical functionality with structural reinforcement, enabling conductive nanopapers suitable for composite interlayer applications.

While MXene-based conductive films are widely reported, the role of flake lateral size in conductive network formation remains insufficiently clarified. In this study, MXene dispersions were probe-sonicated with controlled energy densities to generate different flake size distributions. These dispersions were deposited onto doctor-blade formed CNF nanopapers to systematically analyse how flake size influences electrical behaviour and structural integrity. Network development was monitored through layer-by-layer sheet resistance measurements and spatial resistance mapping to quantify electrical heterogeneity. Surface chemistry was analysed by X-ray photoelectron spectroscopy (XPS) to verify that observed electrical changes originate primarily from size-controlled network effects rather than chemical degradation. To further assess the influence of flake size on nanopaper characteristics, surface roughness was measured using contact profilometry and morphology was analysed via scanning electron microscopy (SEM).

The results showed a clear flake size-dependent transition in conductive network formation. Larger flakes promoted rapid establishment of conductive pathways and earlier spatial homogenisation, whereas reduced flake size delayed percolation and increased resistance variability at low layer counts. However, profilometry showed that films with smaller flakes exhibited lower surface roughness compared to specimens incorporating larger MXene flakes. Thus, MXene flake size tunes the conductivity-surface roughness trade-off in MXene-CNF interlayers.

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References

[1] Jia L., et al. Chem. Eng. J. 2023, 475, 146361. https://doi.org/10.1016/j.cej.2023.146361.
[2] Wang et al. Polymers 2023, 15, 4159. https://doi.org/10.3390/polym15204159.

ADVANCED NANOCOATINGS FOR STRUCTURAL HEALTH MONITORING OF WIND TURBINE BLADE LEADING EDGES

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Wind energy has become a crucial renewable energy source due to its cost-effectiveness and scalability. However, rain-induced leading edge erosion of wind turbine blades remains a significant challenge. Repeated raindrop impacts cause progressive material removal and surface roughening, degrading aerodynamic performance and reducing energy efficiency. Even minor erosion can result in 3–5% annual energy losses [1]. Structural health monitoring (SHM) is typically conducted through scheduled visual inspections using drones or robots, which are time-consuming and often detect damage only at advanced stages. Strain-based sensing technologies, such as strain gauges or fibre Bragg gratings, enable real-time monitoring but are costly, complex to integrate, and may lack sensitivity to early-stage matrix cracking [2].

In this work, two groups of glass fibre-reinforced polymer (GFRP) composites were manufactured: one group spray-coated with poly(3,4-ethylenedioxythiophene)-coated single-walled carbon nanotube (PEDOT-CNT) and the other with MXene aquaus solutions. Both coatings formed conductive surface networks for real-time leading edge damage monitoring. The sensing mechanism relies on piezoresistivity, whereby damage within the coating induces measurable resistance changes. Both specimen groups were subjected to cyclic thermal loading, low-energy impact, and controlled scratch testing. Thermal cycling between 5 °C and 70 °C for 100 cycles showed negligible resistance drift for PEDOT-CNT, while the MXene coating exhibited a 2.5% downward drift. After 250,000 impact cycles, PEDOT-CNT exhibited ~2% resistance change, compared with ~0.5% for the MXene coating, indicating good durability. Scratch testing revealed an exponential resistance increase with damage length for both coatings, in close agreement with numerical modelling. These results demonstrate that PEDOT-CNT and MXene nanocoatings detect damage initiation and progression, highlighting their potential as integrated sensors for structural health monitoring and predictive maintenance of wind turbine blades.

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References

[1] Oh S.Y., et al. Renew. Sustain. Energy Rev. 2024, 204, 114799.
[2] Sun B., Ooi K.T., Su M. Renew. Sustain. Energy Rev. 2026, 230, 116668.

MECHANO ATRP OF GLYCIDYL METHACRYLATE-EFFECT OF AIR ON THE POLYMERIZATION KINETICS

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Polymerization techniques utilized controlled mechanism are usually activated by temperature [1] or light [2]. However, in 2017 there was published new approach of activation of atom transfer radical polymerization (ATRP) by ultrasound and called mechano-ATRP [3]. Therefore, the presented study is dealing with polymerization of glycidyl methacrylate using ATRP upon stimulation of mechanical wave. The main drawback of such polymerization technique is sensitivity to air, specifically to oxygen. Therefore, this study is dealing with optimization of the polymerization conditions in the presence as well as in the absence of the air. The molecular weight during polymerization was monitored using gel permeation chromatography and polydispersity index was calculated based on this. It was found out that that air significantly suppress the polymerization rate, however is capable to proceed the polymerization at low temperature with high monomer conversion, which shows potential ways of this type of monomer to be effectively applied in various real-life applications.

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References

[1] CVEK, Martin, MRLIK, Miroslav, ILCIKOVA, Marketa, PLACHY, Tomas, SEDLACIK, Michal, MOSNACEK, Jaroslav, PAVLINEK, Vladimír, A Facile Controllable Coating of Carbonyl Iron Particles with Poly(glycidyl methacrylate): A Tool for Adjusting MR Response and Stability Properties, Journal of Materials Chemistry C, Volumer 3, Issue 18, Pages 4646-4656, 2015.
[2] MOSNÁČEK, Jaroslav,; ILČÍKOVÁ, Markéta; Photochemically Mediated Atom Transfer Radical Polymerization of Methyl Methacrylate Using ppm Amounts of Catalyst, Macromolecules, Volume 45, Issue 15, Pages 5859-5865, 2012.
[3] MOHAPATRA, Hemakesh, KLEIMAN, Maya, ESSER-KHAN, Aaron Palmer, Mechanically Controlled Radical Polymerization initiated by ultrasound, Nature Chemistry, Volume 9, Issue 2, Pages 135-139, 2017.

SYNERGISTIC EVALUATION OF MOISTURE CONTENT IN PETROLEUM-BASED POLYESTER MWCNT RECYCLED NANOCOMPOSITE

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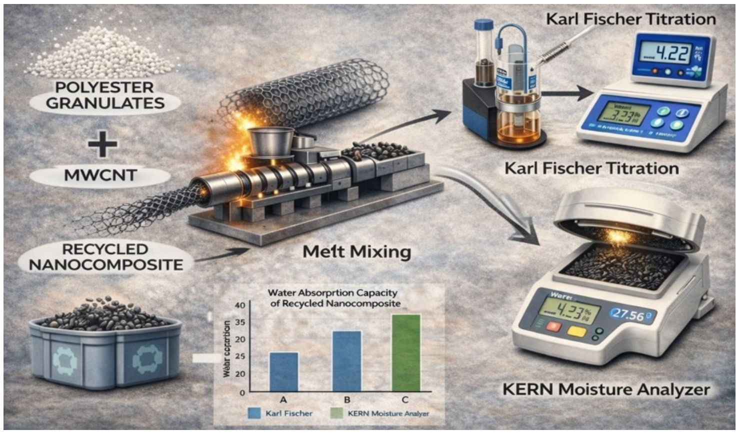
Moisture ingress significantly influences the durability, dimensional stability, and long-term performance of petroleum-based composite materials. The melt mixing method was used to prepare the nanocomposites using a twin-screw extruder [1,2]. This study presents a synergistic evaluation of moisture capacity in multi-walled carbon nanotube (MWCNTs) modified petroleum-based polyesters nanocomposites through Karl Fischer, and KERN moisture analyzer approaches [3]. MWCNTs were incorporated into a polyester matrix at 1 wt.% loadings to investigate their influence on moisture uptake capacity [1]. Furthermore, the moisture absorption capacity of recycled nanocomposites were assessed under controlled environmental conditions.

Graphical Abstract:



References

[1] Khan, K. U., & Ádámné Major, A. (2025). Morphological and Water Absorption Properties of Bio-Based Polyesters/MWCNT Nanocomposites. Engineering Proceedings, 113(1), 60.
[2] Khan, K. U., Weltsch, Z., & Adamne Major, A. (2026). Rheological and Thermal Properties of Recycled Petroleum-Based Polyesters MWCNT Nanocomposite: Sustainable Materials. Journal of Composites Science, 10(2), 88.
[3] Terjék, D & Kókai, Eszter. (2020). Measurement possibilities of water content in polyamide. IOP Conference Series: Materials Science and Engineering. 903. 012014.

MICROSTRUCTURAL EVOLUTION IN MICA-REINFORCED PA11 COMPOSITES

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This study investigates the microstructural evolution of polyamide 11 (PA11) composites reinforced with natural and surface-treated mica, with particular emphasis on filler–matrix interactions and their structural consequences [1,2].

Differential Scanning Calorimetry (DSC) revealed particle size–dependent modifications in crystallinity, while surface-treated mica promoted the formation of a mesophase structure, indicating altered nucleation and crystal growth mechanisms. Scanning Electron Microscopy (SEM) confirmed homogeneous dispersion and highlighted characteristic interfacial features on organo-modified mica surfaces. X-ray Diffraction (XRD) demonstrated an unusual reduction in the basal spacing of silanized mica, suggesting structural rearrangement during surface treatment, which partially reversed during compounding.

Dynamic Mechanical Analysis (DMA) indicated temperature-dependent changes in elastic response and increased internal damping, reflecting modified interfacial adhesion and constrained molecular mobility. Oscillatory rheometry revealed that surface-treated mica reduced complex viscosity and suppressed both energy storage and dissipation more effectively. The disappearance of the liquid–solid transition point and dominance of viscous behavior (tanδ) suggested the formation of a non-directly connected, physically interacting filler network rather than a percolated rigid structure. Amplitude sweep measurements confirmed irreversible breakdown of the three-dimensional filler structure at elevated strain.

References

[1] Varga, E., Palásti, F., Bata, A., Kis, D.I., Tajti, F. Polymers 2025, *17*, 2861.

[2] Varga, E., Nagy, D., Tóth, G. J. Compos. Mater. 2026, doi:10.1177/00219983261426551.

MXENE–WATER INTERACTIONS: WETTABILITY AND STABILITY OF TI$_3$C$_2$T$_x$

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MXenes are a rapidly expanding class of two-dimensional (2D) transition-metal carbides and nitrides with the general formula $M_{n+1}X_nT_x$. Among them, $Ti_3C_2T_x$ is the most widely studied due to its high electrical conductivity, large surface area, and hydrophilic character. These properties arise primarily from surface termination groups (T_x), such as –O, –OH, and –F, which are introduced during the chemical etching of MAX phases and strongly influence the interaction of MXenes with their environment [1].

In this contribution, the relationship between surface chemistry, wettability, and environmental stability of $Ti_3C_2T_x$ MXene is discussed. Wettability is typically characterized by contact angle measurements and reflects the interaction between the MXene surface and liquids. Due to the diversity of surface termination groups, MXene films often exhibit pronounced contact angle hysteresis, which is attributed to chemical heterogeneity and pinning of the triple-phase contact line [1].

At the same time, the surface chemistry governing wetting interactions also plays a key role in the stability of MXenes. Exposure to ambient conditions leads to gradual surface oxidation and hydrolysis, resulting in the formation of Ti^{4+} species and TiO_2 and ultimately causing degradation of the MXene structure [2].

These findings highlight the importance of surface chemistry in determining both the interfacial interactions and durability of MXene materials.

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References

[1] Machata P., Hofbauerová M., Soyka Y., Stepura A., Truchan D., Halahovets Y., Mičušík M., Šiffalovič P., Majková E., Omastová M. J. Colloid Interface Sci. 2022, 622, 759–768.
[2] Mičušík M., Slouf M., Stepura A., Soyka Y., Ovodok E., Procházka M., Omastová M. Appl. Surf. Sci. 2023, 610, 155351.

PREPARATION OF 2D MXENES, STUDY OF THEIR PROPERTIES AND APPLICATION IN POLYMERIC NANOCOMPOSITES

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High-performance fiber-reinforced plastic composites (FRPC) are increasingly required to provide applications beyond traditional materials and with improved performance, such as enhanced durability and high strength-to-weight ratios. Among emerging materials, MXenes — a family of two-dimensional transition metal carbides and/or nitrides — have demonstrated exceptional potential as multifunctional interlayers and nanofillers for composites due to their metallic conductivity, hydrophilic surface chemistry, and great mechanical properties [1].

This work includes the synthesis of MXenes from their precursor – MAX phases, with a particular emphasis on the minimally intensive layer delamination (MILD) method. Unlike conventional high-concentration hydrofluoric acid (HF) etching, the MILD approach utilizes *in-situ* HF generation, offering a safer, "greener," and more controlled pathway to produce high-quality, large-flake MXene nanosheets with optimized surface terminations (=O, -OH, and –F).

A series of nanocomposites using solvent casting were fabricated. $Ti_3C_2T_x$ MXenes were etched using MILD method and mixed with functionalized carbon nanotubes, following further addition into a polymer matrix. The structure and filler distribution were analyzed using scanning and transmission electron microscopies (SEM and TEM), electrical properties – using BDS (Broadband Dielectric Spectroscopy). Acrylate coating formulations by blending method of 2D $Ti_3C_2T_x$ MXene solutions with stable acrylate latexes were prepared. The structural and compositional properties of MXenes obtained by the new synthesis method were thoroughly characterised using XRD, XPS, TEM, Raman spectroscopy, SEM, UV-vis, AFM, Four-Probe, and mechanical techniques.

The results indicate that the inclusion of MXene layers significantly enhances the electrical and thermal conductivity of the polymer matrix without compromising its specific strength. Besides, we discuss the future possible applications of these materials, highlighting their application as multifunctional systems in aerospace and automotive sectors, where they can simultaneously provide de-icing capabilities and real-time strain sensing.

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References

[1] Gogotsi Yu. Chem. Mater. 2023, *35 (21)*, 8767-8770.

DEVELOPMENT OF A MULTIFUCTIONAL CALCIUM-BASED POLYMER COMPOSITE FOR LIGAMENT AND BONE HEALING APPLICATIONS

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Internal fixation devices are used to stabilize bones and soft tissues during recovery, but current bioabsorbable polymers have limitations in mechanical strength, degradation behaviour, and radiopacity. To address these issues, two bioactive filler systems, one based on a calcium nanoparticle and the other on bioactive glass, were developed and incorporated into resorbable PLA-based composites. A healing aid was used as a modifier to enhance matrix–filler interaction while simultaneously promoting tissue regeneration. Both materials aim to create multifunctional composites capable of providing fixation, promoting bone regeneration, and ensuring controlled degradation. Initial results show improved filler dispersion and demonstrates the potential of these tailored polymer systems for next-generation bioabsorbable fixation devices.

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PROCESSING OF PLA AND PLA/BIOACTIVE GLASS-COMPOSITES IN THE MEDICAL CONTEXT

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Many humans, especially at older ages, suffer from bone fracture at one point in their lives. To stabilise and heal these fractures, the osteosynthesis is utilised where both parts of the broken bone are fixed via a plate and screws. The gold standard remains metal implants which have numerous disadvantages like unmatched stiffness, low bioactivity and the need for a removal surgery. Resorbable implants made out of a biopolymer and an inorganic, bioactive filler could be a promising alternative. The M-ERA.NET project “BioIMplant” focuses on the development and processing of PL(G)A/bioactive glass-composites. Additive manufacturing as well as micro injection moulding (µIM) are used to shape the developed composite material into desired parts. This talk will focus on the qualification of these materials for Fused Filament Fabrication (FFF), Arburg Plastic Freeforming (APF) and µIM. Samples are produced and characterised with regard to their mechanical properties and morphology. Challenges and limits that arise around these technologies are shown and discussed. Furthermore, filling simulation is used to correlate observed experimental results with simulation data for µIM.

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FROM WASTE TO DURABLE MATERIALS – MODIFIED NATURAL FILLERS IN ENVIRONMENTALLY RESISTANT BIOCOMPOSITES

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In the era of a raw materials crisis and growing pressure for sustainable development, biocomposites based on renewable natural resources are becoming increasingly important. Of particular interest are combinations of biodegradable polymers, such as polylactide (PLA), with waste lignocellulosic fillers. However, due to significant differences in phase polarization, achieving good adhesion between PLA and natural fibers can be difficult. Known solutions, such as alkalization [1] or chemical surface modification [2], can improve the compatibility of these systems.

This study focused on the use of organosilicon compounds as modifiers to improve adhesion and enhance interfacial interactions in PLA composites with natural fillers. The study evaluated not only the method of preparing natural fillers for processing but also the effect of the type and content of organosilicon compounds on the mechanical properties of injection-molded samples - including tensile strength, flexural strength, and impact strength.

The results showed that appropriately selected organosilicon compounds enable a significant increase in the stiffness and strength of composites, which may contribute to the development of a new generation of materials with improved mechanical resistance and a favorable environmental profile [3].

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References

[1] Suárez L., Barczewski M., Kosmela P. *Journal of Natural Fibers*, 2023, 20, 1.
[2] Yao J., Shi J., Mao L. *Journal of Biobased Materials and Bioenergy*, 2018, 12, 303.
[3] Rudnik E. in: *Handbook of Biopolymers and Biodegradable Plastics*, p. 189. Elsevier, 2013.

A SUSTAINABLE APPROACH TO MANUFACTURING 3D-PRINTED COMPOSITE MOLDS FROM PLA WITH NATURAL FIBERS

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The manufacture of molds for composite part production remains associated with high material consumption, substantial energy demand, and limited end-of-life (EoL) recyclability [1]. These limitations become particularly significant in the case of large-scale and geometrically complex components, especially small-batch production, for which conventional tooling technologies entail considerable economic and environmental burdens.

To address these challenges, the present work proposes a sustainable approach to the fabrication of a hybrid plastic-metal mold. The proposed solution relies on a hybrid mold architecture that combines an additively manufactured structural body made of PLA–natural fiber biocomposites with a metallic working surface. The polymer body is produced by robotic large-scale additive manufacturing using direct pellet extrusion (Fused Granular Fabrication, FGF), enabling the rapid fabrication of large and geometrically complex structures.

A key aspect of this research is the identification of critical material parameters required to ensure both the durability of the 3D-printed mold body and the manufacturability of the process. In this study, polylactic acid (PLA) reinforced with natural fibers sourced from agri-food industry waste streams was used to support the valorization of secondary raw materials. To enhance filler-matrix interfacial interactions and the processability of the composites, selected organosilicon additives and natural waxes were incorporated into the material formulations [2]. Particular attention was given to the examination of composite properties, including impact resistance, durability, printability, rheological behavior, and thermal properties.

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References

[1] Armstrong K.O., Kamath D., Zhao X., Rencheck M. L., Tekinalp H., Korey M., Diana H., Ozcan S. Resour. Conserv. Recycl. 2023, *197*, 107117.
[2] Dobrosielska M., Dobrucka R., Pajewska-Szmyt M., Kozera P., Gabriel E., Głowacka J., Brząkalski D., Kurzydłowski K.J., Przekop R.E. Polymers. 2022, *14*, 5511.

PROPERTIES OF THERMOPLASTIC STARCH MODIFIED WITH LIGNIN

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The increasing amount of plastic waste is a global problem which is possible to eliminate with the study of environmentally friendly materials that will be able to partially replace synthetic polymers. Currently, a large part of scientific studies is devoted to starch, which is a biodegradable and affordable material. Starch is a natural polysaccharide present in various plant species such as corn, wheat, rice, cassava or potatoes. Starch is the basic material for the preparation of many types of starch blends. The main use of starch blends is in packaging materials such as films or foams. The blends are also used in agriculture, such as mulch films. Some ideas for its use include controlled release of fertilizers, exact release of drugs in medicine, or its use for 3D printing. However, the goal is still to improve the preparation and final properties of starch blends. Starch is often modified to thermoplastic starch (TPS) using various plasticizers. The disadvantages of TPS are its poor mechanical properties and sensitivity to air humidity. For this reason, the properties of TPS are modified by adding different fillers. One of the potential fillers is lignin. Lignin is an aromatic and complex biopolymer composed of phenylpropanoid units. It´s present in the lignocellulosic biomass proceeds from softwood, hardwood or herbaceous species and it's obtained as a by-product in the pulp industry. The aim of the work was to analyze the effect of kraft lignin as a reinforcing and hydrophobic filler on the TPS. TPS consisted of corn starch, glycerol and water or starch with glycerol excluding water. The results of mechanical properties and dynamic-mechanical thermal properties pointed out to the reinforcing effect of lignin. Measurement of moisture content and water absorption demonstrated an increase of hydrophobicity due to the influence of increasing lignin concentration in TPS. All results were supplemented by Fourier-transform infrared spectroscopy.

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DESIGN OF A METAL-POLYMER INTERFACE FOR ADHESIVE BONDING BETWEEN STEEL SHEETS AND THERMOPLASTIC MATERIALS

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Bonding polymeric materials to metals, particularly steel, is an important challenge in materials engineering. The interface between a steel sheet and a polymer significantly influences the mechanical performance, durability, and environmental resistance of the entire structure. Achieving stable adhesion is challenging due to differences in physicochemical properties such as surface energy, elastic modulus and thermal expansion. Several strategies are used to create metal–polymer interfaces. Adhesive bonding with structural adhesives e.g., epoxy, polyurethane, or acrylic systems is commonly applied. Surface preparation of the metal, including mechanical or chemical treatment, is often necessary to increase surface roughness and surface energy and thus improve adhesion.

The mechanical strength of the interface can be evaluated using a pull-off test, in which a metal dolly is attached to the bonded surface and pulled perpendicular to it until breaking of the connection. The measured force or stress required for detachment provides a quantitative measure of adhesive strength, while analysis of the failure mode gives additional information about the adhesion mechanisms.

The aim of this work is to develop an effective bonding system between a steel sheet and a polymer structure produced by 3D printing for application in mold construction. The proposed interface integrates additively manufactured polymer structures with a thin metallic layer produced by incremental sheet forming. The study focuses on the selection of suitable thermoplastic materials, optimization of adhesive layer application methods and evaluation of bonding methods. An additional objective is the development of a controlled disassembly strategy enabling separation of the metal layer from the polymer base, supporting recycling and reuse of the materials within the manufacturing process.

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DETAILED CHARACTERIZATION OF THERMOPLASTIC STARCH FOR OPTIMAL PERFORMANCE IN BIODEGRADABLE MIXTURES WITH OTHER PLASTICS

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Thermoplastic starch (TPS) is a valuable polymeric additive especially for preparation of biodegradable plastics mixtures. TPS is formed by plasticization of native starches, almost entirely with glycerol, although number of other plasticizers are available. The primary aim of the addition of TPS to bioplastics is usually a decrease of the price of the final product while maintaining the biodegradability of the plastics blend.

However, modification of TPS, considering its physical and ultimate properties, is in many cases rather easy and straight forward process, and a number of different procedures are used for adjusting the ultimate properties of the TPS.

Certainly, the final effect of the addition of TPS consists not only in the price decrease but the mixture properties and possible applications depend significantly on the ultimate properties of both the matrix biopolymer as well as of the TPS.

In the lecture several options for TPS modification are briefly outlined and described, starting with the selection of native starch considering the origin of the starch. The effect of various plasticizers or even their mixtures are shown using the example of glycerol and urea.

The main concern is related to reinforcement of TPS using reinforcing fillers. Among these, especially precursors of nanoparticles are the most interesting since in that case usually a substantial reinforcement can be achieved with the fiber content well below 5 wt %, so that the final material maintains its classification as biodegradable compostable mixture according to relevant standards.

Few more advanced cases of TPS modifications will be presented, including the cases of deteriorating the properties during storage and options to maintainb the properties on acceptable level. The examples of the the effect of moisture uptake on mechanical and other physical properties of the TPS and the effect of long term storing resulting in so called retrogradation is shown, while chemical modification consisting in starch crosslinking with citric acid or dialdehydestarch is described.

Keywords: Biodegradable plastics, thermoplastic starch, physical ultimate properties, effect of storing and moisture absorption

Acknowledgement
This research was supported from the project APVV 23-0224 and VEGA 2/0109/23.

TAILORING THE MECHANICAL PERFORMANCE OF THERMOPLASTIC STARCH/PBAT BLENDS VIA A NOVEL COMPATIBILIZER

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Thermoplastic starch (TPS) is usually prepared by incorporating plasticizers into a starch matrix under heat and shear conditions. TPS-based bioplastics represent a promising alternative to conventional plastics due to their cost-effectiveness, renewability, abundance, and biodegradability [1]. Moreover, TPS has been widely considered as a partial replacement for synthetic polymers and expensive biodegradable plastics (BDPs) in many applications. However, its limited mechanical performance and poor compatibility with hydrophobic BDPs restrict its broader use. Among BDPs blended with TPS, the copolyester poly(butylene adipate–co–terephthalate) (PBAT) has attracted considerable attention, as its physical and mechanical properties are similar to those of polyethylene [2]. However, the poor compatibility between the hydrophilic TPS and hydrophobic PBAT makes the PBAT/TPS blends not so easy to prepare, and especially, their application properties are changing in many cases.

In this contribution, a novel compatibilizer was introduced to tailor the interfacial interactions in TPS/PBAT blends via melt processing. In particular, carboxylated liquid isoprene rubber (LIR-410) initially interacted with TPS via hydrogen bonding, whereas covalent bonding between the LIR double bonds and PBAT was induced through the thermal decomposition of dicumyl peroxide (DCP) during reactive melt processing and homogenization. Tensile tests showed a significant improvement in mechanical performance, indicating enhanced stress transfer between the TPS and PBAT phases. The compatibilized blends exhibited increased tensile strength from 12 MPa to around 22 MPa and elongation at break from 470 % to 666 % compared with the non-compatibilized blend. These improvements are attributed to enhanced interfacial adhesion and better phase dispersion promoted by the compatibilizer, as also confirmed by dynamic mechanical analysis (DMA).

Acknowledgment

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References

[1] Peidayesh, H., Heydari, A., Mosnáčková, K., Chodák, I. *Carbohydr. Poyml.* 2021, *269*, 118250.
[2] Wei, D.; Wang, H.; Xiao, H.; Zheng, A.; Yang, Y. *Carbohydr. Polym.* 2015, 123, 275–282.

STUDY ON THE EFFECT OF HYDROLYSIS ON BIOCOMPOSITES WITH PLA MATRIX

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Recently, there has been a high demand and pressure to use environmentally friendly biodegradable materials. Poly(lactic acid) (PLA) is a biodegradable thermoplastic polymer. Due to its combination of sustainability and biocompatibility, PLA finds applications in various fields, including packaging materials, disposable products, and medical applications [1]. PLA can be modified by combining it with natural fillers such as rice husks, flax, hemp, coffee waste, lignin, or eggshells. The resulting biocomposites exhibit improved mechanical, thermal, and biodegradable properties. The use of natural fillers also helps reduce PLA's manufacturing costs, optimize its physical properties, and support the development of more sustainable materials suitable for applications in the packaging industry, automotive sector, or 3D printing. [2].

The study focused on the impact of natural fillers (straw, sunflower shells, and reed) on the PLA matrix and on changes in the properties of the prepared materials before and after hydrolysis. Hydrolysis is an important factor to monitor when using biodegradable materials, as it helps predict their lifespan. From a material usability perspective, it is also necessary to study its thermal properties. The effects of fillers on PLA, as well as hydrolysis, were studied using differential scanning calorimetry, which revealed the glass transition temperature and crystallization. Thermogravimetry was used to monitor the impact of fillers and hydrolysis on the thermal stability of the materials. Clear changes were demonstrated in the glass transition temperatures and also in crystallization. Thermogravimetric analysis showed a slight stabilization after hydrolysis with sunflower shells.

Acknowledgment

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References

[1] Striani R., Fico D., Rizzo D., Ferrari F., Lionetto F., Corcione C. E.: Comprehensive Green Materials 3 (2025).
[2] Lage-Rivera S., Ares-Pernas A., Dopico-García M. S., Covas J., Abad M.-J.: Polymer Composites 45 (2024).

CHALLENGES IN PARAMETER DETERMINATION FOR MOLECULAR DYNAMICS SIMULATIONS

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There are several ways to describe the behavior of polymer chains. Polymer physics study deeply how the macroscopical properties of the chains can be described and the interactions between them, still there are several phenomena that can be hardly explain that way. This is where simulations can help scientists.

Molecular dynamics (MD) simulations are useful methods in the field of polymer science. They can ensure a femtosecond-scale resolution to study molecular movements over time while they solve Newton's equations of motion. There are many properties that can be described theoretically, like the radius of gyration or the mixing rule for blends, but these theorems fail if the result depends on the specific interactions of the different atomic groups, or the local chemical configuration. These are important circumstances in studying copolymers or blends. If someone wants to start an MD simulation it is required to set a representative chain length-distribution, a chemically right structure and a resolution for how many atoms and atomic groups are described by a single mass point. Nevertheless, these efforts are meaningless if not the right fitting parameters were added to the description of the different interactions that acts on these mass points, like bond strength, angle movements, or the Lennard-Jones interaction potential.

The main goal of this study is to share information about how these interaction parameters can be determined and what are the possible challenges that one face before starting such work. Representative results are presented through simulations carried out using the LAMMPS (Large-scale Atomic Molecular Massively Parallelized Simulator) program. The applied description for the particles was the united-atom (UA) model, where methyl- and methylene groups were united in two types of mass points and the Lennard-Jones parameters were fitted to the experimental densities and to the heats of formation. The main conclusions of the work are the ways, how the different fitting methods are affected the parameters on simple paraffin molecules.

References

[1] Kraus T., Zavada J. Carbohydr. Res. 1997, *304*, 81-88.
[2] Klan P., Cirkva V. in: *Microwaves in Organic Synthesis, Microwave Photochemistry*, Chap. 14, p. 463. John Wiley, NY, 2002.

IN VITRO STUDIES OF ELECTROSPUN POLYCAPROLACTONE/CELLULOSE ACETATE CONTAINING GALLIC ACID/CINNAMIC ACID FOR BIOMEDICAL APPLICATION (ANTIBACTERIAL AND ANTICANCER)

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The challenges to human health posed by cancer and microbial infections are exacerbated by the limited selectivity of current chemotherapeutic drugs, which frequently fail to effectively differentiate between cancerous and healthy cells. Hence, a drug delivery system from polycaprolactone/cellulose acetate (PCL/CA) nanofiber were prepared that incorporated with cinnamic (C) and gallic (G) acid with different concentrations (CG@PCL/CA) for its potential an antibacterial and an anticancer application. The bead-free and smooth nanofibers with diameters between 425 ±149 nm to 504 ± 210 nm were obtained. The nanofiber diameters increased with an increase in CG content. Furthermore, the CG@PCL/CA nanofiber scaffold demonstrated potent in vitro antibacterial activity against both Gram-negative (Escherichia coli) and Gram-positive (Staphylococcus aureus) bacteria. It also exhibited concentration-dependent antioxidant activity, with DPPH scavenging rates that ranged from 22% to 85.6%. CG@PCL/CA nanofiber scaffold with high concentration of CG was effective against lung cancer cells (A549). These results indicate that the CG@PCL/CA nanofiber scaffold is a promising dual-function candidate with effective anticancer and antimicrobial properties.

Keywords: Anticancer; Nanofiber; Cinnamic acid; Gallic acid; Antibacterial

SUSTAINABLE PLA COMPOSITES REINFORCED WITH AGRICULTURAL WASTE FOR FDM 3D PRINTING

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This study focuses on developing sustainable composite filaments for Fused Deposition Modeling (FDM) 3D printing by modifying bio-based polylactic acid (PLA) with natural fibers derived from agricultural and food industry waste. PLA is among the most commonly used materials in FDM due to its ease of printing, glossy finish, and low shrinkage. Its renewable origin from sources like corn starch or sugarcane makes it a more eco-friendly alternative to petroleum-based polymers. However, PLA has relatively low impact resistance and limited durability, which motivates the search for composite solutions supporting sustainable production. In this research, waste-derived natural fillers are added to the PLA matrix to improve mechanical and thermal properties while reducing material costs and environmental impact. This approach addresses concerns about CO_2 emissions from conventional polymers and utilizes the low cost and wide availability of agricultural byproducts. The biocomposite filaments are produced via extrusion and are formulated to maintain printability while enhancing the performance of printed parts. The study includes optimizing filler content and dispersion, evaluating thermomechanical properties, print quality, and dimensional stability, and benchmarking against commercial petroleum-based filaments. Results show that PLA composites reinforced with natural waste fillers offer a viable and environmentally responsible alternative for additive manufacturing. These materials combine improved technical performance with a reduced ecological footprint, contributing to the advancement of sustainable solutions in 3D printing [1-3].

References

[1] Nguyen C.T., Pham D.T., Bui P.D., Tran H.C., Nguyen T.H. in: *Fabrication of potential environmentally friendly 3D printing biocomposite filament based on poly(lactic acid) and cellulose fibers from agricultural waste*, RSC Advances, Issue 12, 2026. Royal Society of Chemistry, London, 2026.

[2] Pereira D.F., Branco A.C., Claudio R., Marques A.C., Figueiredo-Pina C.G. in: *Development of Composites of PLA Filled with Different Amounts of Rice Husk Fibers for Fused Deposition Modeling*, Journal of Natural Fibers, Vol. 20, No. 1, p. 2162183. Taylor & Francis, 2023.

[3] Mian S.H., bin Jumah A., Saleh M., Mohammed J.A. in: *Fabrication of PLA–Date Fiber Biocomposite via Extrusion Filament Maker for 3D Printing and Its Characterization for Eco-Friendly and Sustainable Applications*, Polymers, Vol. 17, Issue 19, Article 2707. MDPI, Basel, 2025.

BER-LOADED CS-ZIF-8 @POLYDIMETHYLSILOXANE POROUS SPONGES FOR ANTIBACTERIAL AND TISSUE ENGINEERING APPLICATIONS

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Drug delivery systems (DDSs) are considered to be particularly important for controlling medication concentrations within the therapeutic range and enhancing the rate of drug release [1]. Berberine is a plant-derived alkaloid that combines chemical versatility, vigorous biological activity, and natural origin [2]. In hybrid polymer or MOF systems, it serves as both a functional agent (enhancing activity) and a sustainable component consistent with modern green material design. This study aimed to incorporate Berberine into porous sponges (CS-ZIF-8@PDMS) to improve their antibacterial and antioxidant properties. The proposed novel composite materials are designed to enable controlled drug release. The porous sponge CS-ZIF-8@PDMS-BER was synthesized by integrating chitosan and ZIF-8 into a PDMS sponge and subsequently loaded with the drug. Several characterization techniques were used to reveal the presence of chitosan and ZIF-8 NPs on PDMS sponges. The composites exhibited a two-stage berberine release profile, driven by chitosan's hydrophilicity, resulting in rapid initial release. Antioxidant testing (ABTS assay) confirmed significantly enhanced radical-scavenging performance, with CS-ZIF-8@PDMS reaching 99.6% inhibition and further improvement upon berberine incorporation due to synergistic redox interactions. Antibacterial evaluation (ISO 20743) demonstrated strong biological activity, with CS-ZIF-8@PDMS-BER achieving complete inhibition of E. coli and S. aureus after 24 h. Overall, the materials show robust multifunctionality, underscoring their potential for biomedical and antimicrobial applications.

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References

[1] Yin X., Tan P., Luo H., Lan J., Shi Y., Zhang Y., Fan H., Tan L. Mater. Sci. Eng. C. 2020, 109, 110541.
[2] Imanshahidi M., Hosseinzadeh H. Phyther. Res. 2008, 22, 999–1012.

DYE REMOVAL AND ANTIBACTERIAL PERFORMANCE OF NOVEL BIOBASED NANOFIBERS FROM POLY(TULIPALIN A)

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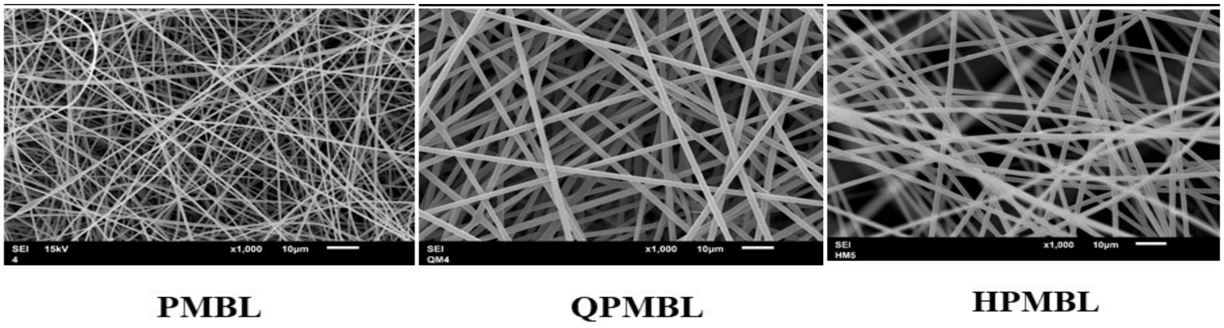
The development of polymers derived from renewable resources has gained significant attention in both academia and industry due to increasing sustainability demands. Tulipalin A, also known as α-methylene-γ-butyrolactone (MBL), is a fully renewable vinyl monomer naturally occurring in tulips and has been previously utilized in the synthesis of thermoplastic elastomers, hydrogels, and polyesters bearing pendant double bonds. In our previous work, the oxygen-tolerant photoinduced atom transfer radical polymerization (photoATRP) of MBL was successfully optimized. Here, we extend this work by demonstrating the fabrication of poly(MBL) (PMBL) nanofibers via electrospinning, thereby broadening its potential applications. Furthermore, chemically modified PMBL systems were prepared through hydrolysis and aminolysis, followed by their successful processing into nanofibrous structures (**Figure 1**). The resulting nanofibers were characterized using FTIR, SEM, and TGA. Their performance was evaluated in dye removal applications using various model dyes. Key parameters influencing adsorption behavior, including pH, temperature, and initial dye concentration, were systematically investigated. Additionally, quaternized nanofibers were assessed for antibacterial activity, further expanding the functional scope and application potential of these materials.



PMBL QPMBL HPMBL

Figure 1. PMBL based nanofibers.

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References

[1] Zain, G., Bondarev, D., Doháňošová, J. & Mosnáček, J. ChemPhotoChem. 2019, 3, 1138–1145.

FROM NANOMATERIAL TO FUNCTIONAL COATINGS: HYDROPHOBIC CARBON QUANTUM DOTS WITH PHOTODYNAMIC ANTIMICROBIAL ACTIVITY

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Quantum dots are still considered a relatively new class of nanomaterials, although their origins can be traced back to ancient times. They can be classified into several categories depending on the synthesis method, the precursors used, their final structure, and their intended application [1]. In our research, we focus specifically on hydrophobic carbon quantum dots, which have been extensively characterized using a wide range of analytical techniques.

These materials' function based on the principles of photodynamic therapy, utilizing a common low-intensity LED diode as the irradiation source. Upon irradiation, they generate reactive oxygen species (ROS), particularly singlet oxygen. Hydrophobic carbon quantum dots can be incorporated into various polymer matrices, textiles, and coating systems.

Their antimicrobial efficacy has been confirmed by several internationally recognized research groups. At the same time, ecotoxicological studies indicate that these materials do not adversely affect the viability of small organisms in different ecosystems. Current research is therefore increasingly focused on their application in antimicrobial coatings, particularly for frequently contaminated surfaces such as those found in public transport systems, the aviation industry, and other high-contact surfaces [2].

Acknowledgment

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References

[1] Kováčová M., et al. Part. Part. Syst. Charact. 2020, *37*, 1900348.
[2] Meier P., et al. Ecotoxicol. Environ. Saf. 2025, *300*, 118421.

ADVANCED MATERIALS AND DESIGN STRATEGIES FOR HIGH-PERFORMANCE PEM FUEL CELLS

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Proton exchange membrane fuel cells (PEMFCs) are among the most promising electrochemical energy conversion technologies for clean and efficient power generation. However, their large-scale commercialization remains constrained by challenges related to membrane cost, durability, performance under harsh operating conditions, and sustainability. Conventional perfluorosulfonic acid membranes, such as Nafion, are critically evaluated for their limitations, including high cost, fuel crossover, and performance degradation at elevated temperatures and low humidity. In this context, biopolymer-based PEMs, including cellulose, chitosan, alginate, gelatin, and their functionalized derivatives, are highlighted as sustainable, low-cost, and tunable alternatives, offering promising proton conductivity, mechanical integrity, and environmental compatibility. In parallel, 3D printing and additive manufacturing are introduced as transformative design strategies for PEMFCs, enabling precise control over membrane architecture, thickness, porosity, and functional gradients that are difficult to achieve using conventional casting techniques. The integration of advanced materials with 3D printing opens new avenues for the fabrication of tailor-made PEMs with enhanced proton transport pathways, improved water management, and superior durability. Finally, current challenges, knowledge gaps, and future perspectives for combining biopolymer chemistry with additive manufacturing in PEMFC applications are discussed, providing guidance for next-generation fuel cell membrane development.

Keywords: PEMFC; Nafion; Biopolymers, 3D printing; **Additive manufacturing**

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POLY(2-ISOPROPENYL-2-OXAZOLINE) AS DRUG DELIVERY PLATFORM

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Poly(2-isopropenyl-2-oxazoline) (PIPOx) represents a universal polymer platform suitable for various applications in the biomedical field due to its non-cytotoxic nature, immunomodulatory properties, and the possibility of post-polymerization modifications with drugs or formation of hydrogels [1,2]. A combination of these properties creates a platform for the formation of various biomaterials, including polymeric drug carriers [3] and hydrogels that can serve as delivery platforms for enzymes, as depicted in Fig. 1.

In this contribution, we show the preparation of PIPOx-based drug carriers that fulfill not only the function of a carrier, but also, thanks to immunomodulation properties, may enhance the therapeutic effect of the polymer-drug construct. Moreover, we demonstrate the versatility of PIPOx in the formation of hydrogels, their physicochemical properties, and the immobilization of enzymes for antibacterial applications.

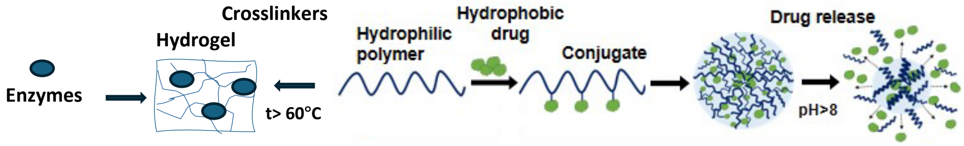

Fig.1: Schematic illustration of PIPOX/based platform for sustainable drug release.

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References

[1] Kronek J., Minarčíková A., Kroneková Z., Majerčíková M., Strasser P., Teasdale I. Polymers, 2024, 16, 1708-1730.
[2] Jerca F.A., Muntean C., Remaut K., Jerca V. V., Raemdonck K., Hoogenboom R. J Contrl Rel.2023, 364, 687-699.
[3] Kronekova Z., Majerčíková M., Paulovičová E., Minarčíková A., Danko M., Markus J., Letasiova S., Kronek J. Biomacromolecules, 2024, 25, 3288-3301.

HIGH TRANSPARENT FLUORINATED POLYIMIDES FOR SPACE APPLICATION

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Polyimides (PI) are an important class of high-performance polymers used in many applications. They exhibit excellent properties such as high thermo-oxidative stability, strong resistance to radiation and solvents, and good mechanical strength. Because of these properties, polyimides are widely used as advanced materials in aerospace, biomedical technologies, sensors, and optical devices. Their high stability under extreme environmental conditions also makes them promising materials for space applications. The aim of this work was the preparation of a series of fluorinated polyimides designed for potential space applications. The monomers were selected to ensure high optical transparency of the resulting polymers. In addition to their potential use in space technologies, these materials are also investigated as substrates for the preparation of flexible perovskite-based solar cells, where high transparency and stability are essential requirements. The prepared polyimides were studied in terms of their basic properties, including thermomechanical and optical properties, as well as properties important for their potential use in space. These included outgassing and resistance to ultraviolet radiation, as well as irradiation by protons and electrons. These tests are crucial for evaluating the suitability of these materials for use in the harsh conditions of the space environment.

VALORIZATION OF SPENT COFFEE GROUNDS AS A BIO-BASED NUCLEATING AGENT FOR POLYPROPYLENE

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In recent years, the demand for sustainable solutions in polymer engineering has been growing. One pathway is the use of bio-based additives, preferably by-products or waste products from other industries, e.g. food and agriculture. As a potential by-product, spent coffee grounds (SCG) were employed. SCG were characterized by means of elemental analysis (EA), moisture content, ash content, and thermogravimetric analysis (TGA). For this work, a polypropylene (PP) matrix was selected because it is one of the most commonly used plastics. The main limitation of PP is its low crystallization rate. For this purpose, blends of PP with 2–8 wt. % of SCG were prepared and their crystallization behavior was investigated. The results show that SCG can act as a nucleating agent for PP. The crystallization curves (Fig. 1) show that even a low addition of 2 wt. % shifts the crystallization peak to higher temperatures, specifically from 114 °C to 118–119 °C. In the melting endotherms (Fig. 2), a change in the morphology of PP can be observed, predominantly with the addition of 4 wt. % SCG. The melting curve of this blend shows two significant peaks at 149 and 164 °C, which are attributed to the β-phase and the α-phase of PP, respectively. These results suggest that SCG can serve as an efficient, specific, bio-based nucleating agent for PP, enabling control of its polymorphic composition and thus the resulting physical properties. Overall, these findings are promising, and the effect of processing conditions and other factors (distribution, dispersion) on the nucleating function of SCG will be further investigated.

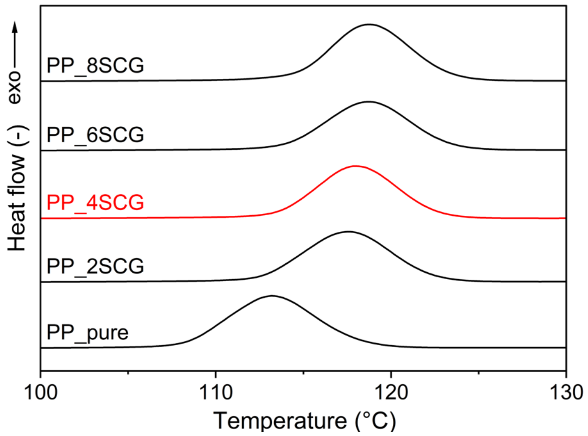

Fig. 1 Crystallization exotherms of PP/SCG blends

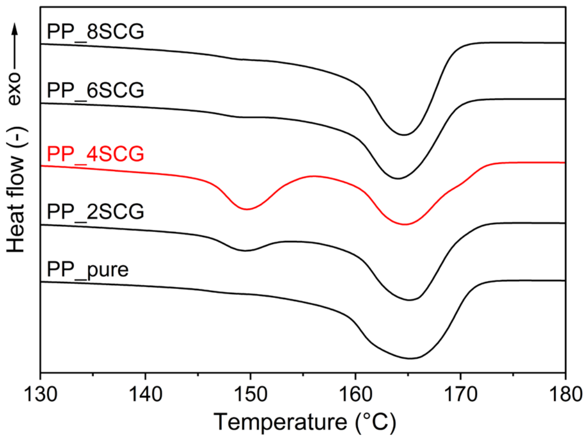

Fig. 2 Melting endotherms of PP/SCG blends

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INTEGRATED BIOREFINERY OF AFRICAN CATFISH (*CLARIAS GARIEPINUS*) BY-PRODUCTS: MULTI-PRODUCT VALORIZATION AND LIFE CYCLE ASSESSMENT

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African catfish (*Clarias gariepinus*, AC), a warm-water fish species extensively farmed in Central Europe, generates substantial by-products (BPs) comprising up to 60% of total biomass weight. Rich in proteins, lipids, and minerals, these BPs represent valuable raw materials for biorefinery applications [1,2]. This study presents an integrated valorization process to recover gelatin, protein hydrolysate, fish oil, and natural pigments from ACBPs, coupled with life cycle assessment (LCA) to evaluate environmental sustainability at the laboratory scale. The extraction protocol employed sequential washing, defatting, demineralization, and enzymatic treatment to disrupt collagen quaternary structure, followed by a four-step gelatin extraction under controlled temperature and time conditions: 45 °C for 20 min, 50 °C for 25 min, 70 °C for 20 min, and 90 °C for 30 min. This integrated approach yielded 18.2 ± 1.2 % fish oil, 9.8 ± 2.1 % protein hydrolysate, 1.7 ± 0.7 % pigment extract, and 33.2 ± 2.3 % gelatin. The fourth gelatin fraction exhibited superior functional properties, including gel strength of 121.9 ± 11.9 Bloom, dynamic viscosity of 3.23 ± 0.04 mPa·s, melting point of 25.6 ± 0.6 °C, gelling point of 11.0 ± 0.6 °C with the yield of 2.28 ± 0.29 %. The extracted oil demonstrated favorable nutritional composition with 16.6% essential fatty acids and an SFA:MUFA:PUFA ratio of 11:14:10. Notably, amino acid analysis revealed elevated hydroxyproline and proline content (196 mol%) in both gelatin and hydrolysate compared to cold-water fish species, conferring superior thermal stability characteristic of warm-water species [3]. LCA identified water consumption and energy demand as primary environmental hotspots requiring optimization. Overall, this near-zero-waste biorefinery approach demonstrates the technical and environmental feasibility of comprehensive aquaculture by-product valorization, contributing to circular economy principles at the aquaculture-polymer processing interface.

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References

[1] FAO. *Clarias gariepinus* Burchell, 1822. In: Fisheries and Aquaculture. FAO, Rome, 2025. [Cited: 17.02.2026]. https://www.fao.org/fishery/en/aqspecies/2982/en.
[2] Adejumo A. L., Azeez L., Ajayi E. I., Atere T. G., Aderibigbe F. A., Adetoro R. O. *West Indian J. Eng.* 2022, 44, 2. doi:10.47412/OYMI4758.
[3] Alves A., Marques A., Martins E., Silva T., Reis R. *Cosmetics* 2017, 4, 39. doi:10.3390/cosmetics4040039.

CHITOSAN-BASED PACKAGING WITH BIOACTIVE COMPOUNDS

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Plastic packaging plays a crucial role in the food industry. However, its extensive production and limited recyclability significantly contribute to environmental pollution. Biopolymers such as chitosan and zein represent environmentally friendly alternatives due to their biodegradability, renewability, and functional properties [1]. When combined with natural active compounds, these materials can inhibit microbial growth and extend shelf life of food products.
The aim of this study was to develop innovative biodegradable packaging materials that can replace conventional synthetic plastics while simultaneously enhancing food safety and quality. Chitosan-based films were prepared by blending chitosan with polyethylene glycol and glycerol to improve mechanical properties and incorporating selected natural active compounds thymol and eugenol. The film-forming solutions were cast onto Petri dishes and dried for 24 hours. The obtained films were characterized in terms of antioxidant activity, release behavior of active compounds under acidic and neutral conditions, and antimicrobial properties evaluated using the disk diffusion method. The prepared films were also tested on real food samples – minced meat which was natural or deliberately inoculated by *Escherichia coli* or *Listeria monocytogenes* and microbial growth was monitored over time.
The results demonstrated controlled release of natural antioxidants and antimicrobial agents over a seven-day period in both acidic and neutral environments. There was a reduction in total viable counts measured after 7 days in the meat model using film containing thymol and eugenol. This effect was also proved especially on the amount of *E. coli.* In addition, all prepared films showed measurable antioxidant activity. Biodegradation studies are currently in progress. Overall, the findings indicate that the developed materials have strong potential for application as active biodegradable food packaging systems.

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References

[1] QU, Tengfei; WANG, Xiaowen and ZHANG, Fengchun. *Antibacterial Food Packaging with Chitosan and Cellulose Blends for Food Preservation*. Polymers, 2025, vol. 17, issue 13. ISSN 2073-4360.

MECHANICAL PROPERTIES OF NEW BIODEGRADABLE POLYMER COMPOSITES WITH BIOGLASS

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Biodegradable polymer-based composite materials are getting significant attention due to their bioactivity and biocompatibility in tissue engineering and biomedical applications [1]. This study investigates the mechanical properties of a newly developed biodegradable polymer composite with varying concentrations of two different types of bioglass particles: laboratory-synthesized bioglass produced in Taiwan at National Taiwan University of Science and Technology, Taipei (TBG) and commercially available bioglass from Matexcel (BG). The composites based on polyhydroxyalkanoates (PHA) and polylactic acid (PLA) blends with triethyl citrate (TEC) as plasticizer were fabricated using melt-blending and compression molding for the uniform distribution of bioglass into the polymer matrix. Mechanical characteristics were assessed using tensile testing to determine the influence of bioglass type on composite strength and stiffness. TBG showed more uniform particle size distribution and homogeneous morphology when compared to commercial BG. PLA/PHB/TEC blends with 5 wt.% TBG shows higher Youngs modulus when compared to composites with 5 wt.% of commercial BG. These results highlight the potential of novel synthesized bioglass as a cost-effective alternative to the commercially available one, and it can be intended to use in biomedical and tissue engineering applications. This study provides significant insights into the design of mechanically robust and bioactive scaffolds for regenerative medicine.

Keywords- Biodegradable polymer; Bioglass; tensile testing; Tissue engineering; Bioscaffold; Regenerative medicine

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References

[1] Khan, T., Vadivel, G., Ramasamy, B., Murugesan, G., & Sebaey, T. A. (2024). Biodegradable Conducting Polymer-Based Composites for Biomedical Applications—A Review. *Polymers*, *16*(11), 1533. https://doi.org/10.3390/polym16111533

SYNTHETIC POLYMER MATERIALS AS REPLACEMENT FOR HUMAN ORGANS IN A NEONATAL SIMULATOR

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The classical surgical approach involves open surgery, characterised by large operative wounds. Open procedures in the abdominal or thoracic cavity are associated with numerous complications. Numerous studies highlight the severe and often long-term complications of these invasive procedures, which can significantly impact the child's quality of life. The most common complications include chest and abdominal deformities, scoliosis, chronic pain, keloid scars, and psychological issues.

The use of minimally invasive surgery (MIS) in paediatric patients has increased rapidly over the past two decades. MIS offers several well-established advantages over open surgery, such as faster recovery time, lower complication rates, reduced health care costs, and better cosmesis. Training simulators for MIS in newborns and infants must possess several essential characteristics: they should be easily reproducible, cost-effective, readily accessible, highly realistic, and capable of undergoing validation.

Rabbits were selected as the most suitable animal model for analysing the mechanical properties of organs and tissues due to their close resemblance to newborns. Additionally, rabbits were the most commonly used animals in training courses utilising animal models for MIS training in neonatal surgery Our team prepared biological tissues and organs as follows: rabbit organ specimens (kidney, liver, lungs, spleen, pancreas, diaphragm, large intestine, oesophagus, small intestine, and stomach) were procured from a local supplier and while adhering to all ethical rules. Mechanical measurements were conducted using compression methods for solid organs and tensile methods for hollow and membranous tissues. Specifically, mechanical properties were assessed by compression testing (kidney, liver, lungs, spleen, and pancreas) and by tensile testing (diaphragm, large intestine, oesophagus, small intestine, and stomach).

Based on mechanical property evaluations, our team subsequently identified polymers with similar elastic properties from a range of silicones and hydrogels.

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DIFFERENTIAL PHOTODYNAMIC EFFECTS OF HYDROPHILIC AND HYDROPHOBIC CARBON QUANTUM DOTS AGAINST *RICKETTSIA SLOVACA* STRAIN 13-B

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Background

Photodynamic therapy (PDT) represents a resistance-safe antimicrobial strategy. However, the impact of different photosensitizer platforms on intracellular bacterial kinetics remains insufficiently characterized. We compared hydrophobic carbon quantum dots (CQDs) in a silicone polymer matrix (hCQD/PDMS nanocomposite) and hydrophilic CQDs synthesized from citric acid (CA-CQDs) against *Rickettsia slovaca* 13-B in Vero cells and evaluated genomic stability using whole-genome sequencing.

Methods

Replication kinetics were quantified over 48 h using copy number analysis of *ompB* gene. Growth rates (μ), doubling times, and fold-changes were calculated. WGS was performed to detect potential treatment-induced mutations.

Results

PDT using hCQD/PDMS did not induce early bactericidal activity. Growth rates remained positive during 0–24 h ($\mu \approx 0.11\ h^{-1}$), with moderate slowing in later phases.

In contrast, PDT using CA-CQDs caused a significant early decline in the bacterial growth rate (μ down to $-0.060\ h^{-1}$), corresponding to halving times of 11–19 h. Surviving populations exhibited partial rebound growth between 24–48 h, though at reduced rates compared to controls.

Whole-genome sequencing revealed no reproducible patterns of PDT-specific mutations or resistance-associated variants across conditions.

Conclusions

CA-CQDs exhibit a markedly stronger early bactericidal effect than hCQD/PDMS, indicating distinct oxidative photodynamic efficiencies. Importantly, neither platform induced genomic adaptation, consistent with the established principle that PDT does not promote antimicrobial resistance. These findings highlight that photosensitizer formulation critically determines intracellular antimicrobial potency while maintaining genomic safety.

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MECHANICAL PROPERTIES OF ORGANIC FILLER PLA-BASED COMPOSITES

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This article investigates the application potential of incorporation of various waste organics fibers as a renewable reinforcement on different kind of PLA composite properties. Such fibers us: sunflower husks, grass, straw, bushwhack husks, reed, alfalfa were tested. In this study, 5 wt.% of fiber with intended length up to 1000 µm was incorporated into PLA matrix and the obtained composites by an injection molding were characterized through morphological, mechanical and thermal analyses. Tensile testing revealed that all kind of fibers significantly reduced elongation to fracture (from 25 to 50%), as well as tensile strength (up to 20%), promoting a brittle fracture mode of the composites. Porosity and weak interfacial adhesion between fillers and PLA matrix that limits stress transfer were confirmed by SEM. Among the used additives to the PLA composite with sunflower husks has the most acceptable mechanical properties. DSC analysis revealed that the maximum degradation temperature of the tested composite material is unchanged (Tm≈168°C). After first heating, the neat PLA 3251 is almost in 88% amorphous. Adding modifiers to the polymer increases of the amorphous phase of the composites was observed, with the exception of the straw where 20% of crystalline structure were calculated. During the second heating up to 210°C, an increase in crystallinity was observed in all tested PLA-based composites in the range of 26% to 34%. This means that at least two phenomena can be expected during the processing of this type of composites: the first, resulting from the injection process and related to the plasticization temperature and its local increases caused by friction in the plasticizing system, and the second, degradation of the fillers. The second phenomenon may be a deliberate action related to lowering the injection temperature, provided that such a situation may be technologically difficult. Another aspect is the influence of a potential compatibilizer, which may act synergistically or antagonistically on the described phenomena.

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References

[1] N. Kubiak, B. Sztorch, M. Kustosz, M. Frydrych, M. Jałbrzykowski, T. Hartmann, D. Pakuła, C. Zopp, L. Kroll, R. E. Przekop, Sustainable PLA Composites Filled with Pomace Fibers: Thermal, Structural, and Mechanical Properties, Materials 2025, 18, 3952.
[2] NatureWorks LLC. Available online: https://www.natureworksllc.com/ (accessed on 15 January 2026).

THE EFFECT OF MULTIPLE MECHANICAL RECYCLING STEPS ON FIBRE LENGTH DISTRIBUTION IN RELATION TO MECHANICAL PROPERTIES FOR NATURAL FIBER REINFORCED PLA

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The characteristics of fiber length distribution, fiber dispersion, and fiber orientation play a crucial role in determining the mechanical properties of fiber-reinforced polymers, such as tensile strength, elastic modulus, and elongation at break. During processing by extrusion and injection molding, mechanical stresses cause progressive fiber shortening. This effect becomes more pronounced with an increasing number of processing cycles, as typically encountered in mechanical recycling. [1]

The present study investigates this phenomenon in natural fiber–reinforced polylactide (PLA) composites containing straw, alkalized reed, and sunflower husk fibers. Fiber treatment and processing methods are shown in [2].

The results show that the average fiber length decreases with an increasing number of mechanical recycling cycles (shredding, compounding, injection moulding). This reduction in fiber length correlates with the observed decrease in elastic modulus of the composites. At the same time, the combination of shorter fibers and repeated processing cycles leads to a more homogeneous fiber distribution within the polymer matrix, which together with other effects results in an increase in tensile strength. Further effects were observed.

Designation	PLA type	Fibre type
2.1R	PLA Ingeo 4043D	Straw (250-1000µm)
2.1SH	PLA Ingeo 4043D	Straw (250-1000µm)
2.2R	PLA Ingeo 4043D	Alkal. Reed (250-1000µm)
2.2SH	PLA Ingeo 4043D	Alkal. Reed (250-1000µm)
2.3R	PLA Ingeo 4043D	Sunflower husk (250-1000µm)
2.3SH	PLA Ingeo 4043D	Sunflower husk (250-1000µm)

Table 1: List of composites used during recycling trials (up to three recycling steps)

References

[1] Bauer, B., Weber, M., Phan, P.A., Kliger, S., Fassbender, N., Heimann, T., Kollbach, P.,Drechsler, K., Tallawi, M. (2026). Influence of multiple mechanical recycling on short fiber reinforced thermoplastic for additive manufacturing, Composites Part A: Applied Science and Manufacturing, 204. https://doi.org/10.1016/j.compositesa.2026.109603.

[2] Kubiak, N., Bogna, S., Magdalena, K., Frydrych Miłosz, Pakuła Daria, Jałbrzykowski Marek, Przekop, R. E. (2025). Sustainable PLA composites filled with poaceae fibers: Thermal, structural, and mechanical properties. Materials, 18(17), 3952. https://doi.org/10.3390/ma18173952.

CARBON PASTE ELECTRODE FOR SELECTIVE ELECTROCHEMICAL DETERMINATION OF INSULIN UNDER INTERFERENCE CONDITIONS

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Reliable determination of insulin is essential for monitoring metabolic disorders and for applications in biomedical and pharmaceutical analysis. Electrochemical detection of insulin in complex biological environments may be significantly affected by the presence of electroactive species that generate overlapping signals. Therefore, the development of analytical systems exhibiting high selectivity toward insulin in the presence of common interferents represents an important challenge. At the same time, increasing attention is being devoted to the development of environmentally sustainable sensing platforms based on low-cost and renewable materials. In this study, an eco-friendly electrochemical sensor based on a carbon paste electrode (CPE) was developed for the selective determination of insulin. The electrode was fabricated from recycled carbon powder as the conductive component and coconut oil serving as a biodegradable binder, while a graphite pencil lead was used as the electrode substrate. To enhance the electrocatalytic activity toward insulin oxidation, copper particles were electrodeposited onto the carbon paste surface using cyclic voltammetry. The electrochemical response of insulin was investigated by cyclic voltammetry within the potential range from −1.0 to +1.0 V at a scan rate of 100 mV s^{-1}. The analytical performance of the copper-modified carbon paste electrode (Cu/CPE) was evaluated in phosphate buffer solution within the concentration interval of 0.66–3.3 µM. The recorded voltammograms exhibited a well-defined irreversible anodic peak attributed to the oxidation of insulin molecules, predominantly associated with tyrosine residues in the peptide structure. A linear relationship between the anodic peak current and insulin concentration was obtained, yielding a sensitivity of 170 µA μM^{-1} and a limit of detection of 0.7 µM.

To assess the selectivity of the developed sensor, electrochemical measurements were performed in phosphate buffer solution in the presence of common interfering species typically occurring in biological systems, including glucose, uric acid, and selected amino acids. The presence of these compounds did not significantly influence the oxidation signal of insulin, demonstrating the ability of the Cu/CPE sensor to discriminate insulin from coexisting electroactive species.

These findings indicate that the proposed environmentally sustainable Cu/CPE platform provides a simple, cost-effective, and selective approach for electrochemical insulin determination under interference conditions, highlighting its potential for future applications in biochemical and pharmaceutical analysis.

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FROM 2D SURFACES TO FINITE SIZE QUANTUM DOTS: COMPUTATIONAL STUDY OF GRAPHENE-, BOROPHENE-, AND SILICENE-BASED MATERIALS

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Since its experimental discovery in 2004, graphene and its derivatives found utilization in many industrial applications [1]. It also inspired a search for novel “beyond graphene” two-dimensional (2D) materials, such as phosphorene, borophene, silicene, or germanene [2]. Besides huge experimental efforts to prepare and characterize novel 2D materials, theoretical calculations also play an important role in the design of these materials or prediction of their properties. In our studies, we turn our attention to graphene- and borophene-based nanomaterials doped or decorated with transition metal (TM) atoms and their hydrogen storage properties [3–5]. We found that the finite-size graphene quantum dots (coronene and circumcoronene) doped with TM atoms show similar H_2 binding performance as their 2D analogs [4] which makes them suitable materials for H_2 storage technologies. Similar analogy can be found for borophene or silicene surfaces [5].

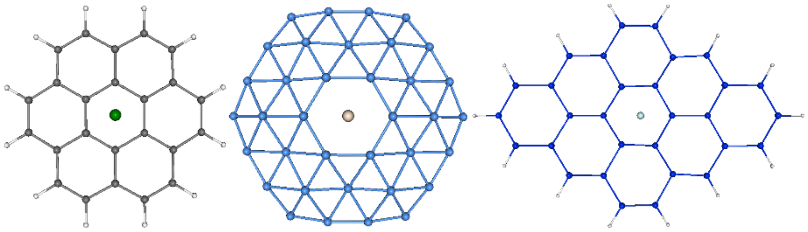

Fig. 1. Finite-size graphene-, borophene-, and silicene-based quantum dots decorated with TM atoms.

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References

[1] Geim A.K., Novoselov K.S. Nat. Mater. 2007, *6*,183–191.
[2] Vishnoi P., Pramoda K., Rao C.N.R. ChemNanoMat 2019, *5*, 1062-1091.
[3] Malček M., Müllerová S., Bučinský L. Phys. E 2022, *139*, 115144.
[4] Malček M., Sredojević D.N., Tkáč O., Bucinsky L. Diam. Rel. Mat. 2023, *139*, 110335.
[5] Tančárová K., Voroshylova I.V., Bucinsky L. Malček M. Flatchem 2025, *49*, 100799.

PA6/GC$_3$N$_4$ NANOFIBRES COMPOSITE FOR ROS GENERATION IN ADVANCE OXIDATION PROCESSES

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Polymer-based photocatalytic materials capable of generating reactive oxygen species (ROS) are of growing interest for environmental and antimicrobial applications, particularly within advanced oxidation processes (AOPs) for water treatment [1]. In this study, we developed composite nanofibrous mats based on polyamide 6 *(Ultramid B24 N03*, BASF) incorporating graphitic carbon nitride (g-C$_3$N$_4$), a visible-light-active photocatalyst. PA6 was dissolved in a mixed organic acid system and blended with dispersed g-C$_3$N$_4$, followed by homogenization and ultrasonication. The resulting suspension was processed into nanofibrous layers using needleless electrospinning (Nanospider™ technology) under controlled temperature and humidity conditions. This approach enabled uniform incorporation of the photocatalyst into a high-surface-area fibrous structure, combining the mechanical stability and permeability of PA6 with the photocatalytic functionality of g-C$_3$N$_4$. Such composite fibrous materials are promising for heterogeneous photocatalysis in liquid media, where photoinduced charge carriers generate ROS capable of degrading organic micropollutants, microplastics and inactivating microorganisms. Since many ROS are short-lived, the oxidative performance of the materials was evaluated using indirect EPR technique: spin-trapping. These methods allow in situ irradiation directly in the EPR cavity and real-time monitoring of transient radical species. EPR confirmed efficient production of highly reactive radicals. Additionally, eco-friendly fiber production approaches inspired by *Brachypelma* spiders were also explored as a sustainable alternative fabrication route and production of ROS was confirmed as well. The results confirm that electro-spun PA6/g-C$_3$N$_4$ composites act as efficient photoactive platforms for ROS generation. This work highlights the potential of polymer-based nanofibrous architectures as multifunctional materials for next-generation environmental remediation technologies.

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References

[1] Zažímal F. et al. in *Journal of Water Process Engineering,* 109545, 2026 (In Press).
[2] Dvoranová D. et al. In *Catalysts*, *8*(2), 47, 2018.

SURFACE FUNCTIONALIZATION OF POLYMERS BY NON-THERMAL PLASMA: FROM SYNTHETIC POLYMERS TO NATURAL MACROMOLECULES FOUND IN THE SEED COAT

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Non-thermal plasma (NTP) is an effective tool for improving the surface properties (surface free energy, adhesion, etc.) of various substrates, including polymers widely used in everyday products. Its non-equilibrium nature and low gas temperature allow nanometer-scale surface modification of thermo-sensitive targets, such as polymers or biological samples, without altering their bulk properties. For this reason, NTP is considered a promising tool in agriculture, particularly for enhancing seed germination and plant growth, as it provides gentle treatment conditions. However, the active species and mechanisms responsible for these effects remain insufficiently understood. Therefore, analyzing chemical changes in the thin plasma-treated surface layer is crucial for understanding the processes occurring after plasma treatment.

The present contribution provides a comprehensive study of the effects of two NTP sources, namely, Diffuse Coplanar Surface Barrier Discharge (DCSBD) [1] and Piezobrush PZ3 [2] on the surface chemistry of selected synthetic polymers (polyamide (PA), polypropylene (PP), and polycarbonate (PC)) and natural macromolecules (polysaccharides, peptides, etc.) in the seed coats of selected seeds (pea, broccoli) analyzed using X-ray Photoelectron Spectroscopy (XPS).

XPS results revealed significant changes in elemental composition and chemical states, particularly an increase in oxygen-containing functional groups such as C–O, C=O, and O–C=O species. These modifications indicate oxidative activation and enhanced surface polarity. The findings demonstrate that low-temperature plasma enables controlled surface functionalization, providing a versatile approach for advanced surface engineering applications in polymer science and seed technology.

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References

[1] Černák, M., Hudec, I., Kováčik, D., & Zahoranová, A. *The European Physical Journal-Applied Physics*, *47*(2), 22806, 2009.
[2] Korzec, D., Hoppenthaler, F., & Nettesheim, S. *Plasma*, *4*(1), 1-41, 2020.

STUDY OF ADHESIVES BASED ON METALLOCENE COPOLYMERS

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Hot-melt adhesives (HMAs) are thermoplastic adhesives designed for applications at temperatures above the polymer melt temperature. Currently, metallocene polyolefin polymers and copolymers are frequently used as a base that endows the HMAs with excellent performance. In many cases, the nonpolar HMAs adhesion strength to cellulose-based materials such as paper, cardboard, or cotton is satisfactory. The simplest approach to obtain higher adhesion is to increase their polarity by applying controlled oxidation to a certain extent. In addition, an increase in the metallocene polyolefin-based HMAs polarity is frequently achieved by adding polar components to the adhesive polymer composition [1 - 3]. An increase of HMAs polarity has been frequently achieved by addition of polar components to an adhesive polymer composition. An easy way of modification of polyolefin macromolecules by free radical grafting is treating the polymer powder, foils or fabrics by means of polymerizing vinyl monomer along with free radical initiator. Such approach to initiate polymer grafting is used mainly for surface modification of powders, foils and fibres. The metallocene ethylene-octene random copolymer Resinex PE RXP 1502 was used for HMAs preparation in virgin form as basic component as well as the adhesive additive after modification by grafting of acrylic acid. RXP powder was treated in the flow of $O_2 + O_3$ gas produced at RT in an atmospheric plasma generator, power = 300 W, input O_2 flow 5L/min. The modification of the activated RXP powder proceeded in Brabender Plasticorder at 110 °C for 30 minutes. The most effective way of activated RXP powder grafting with acrylic acid (RXP-g-PAA) is kneading molten RXP with reaction components in Brabender Plasticoder at 110 °C for 30 minutes. The determined grafting efficiency is high and varies between 0.77 and 0.97. The polar component of the surface energy increased 1.7 times The temperature resistance in peel of RXP-g-PAA increased 1.3 times, and the values of temperature resistance of adhesive joints in shear are similar.

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References

[1] Pavlinec J., Novák I., Rychlý J., Kleinová A., Nógellová Z., Preťo J., Vanko V. Žigo O., Chodák, I. J. Plastic Film and Sheeting 2019, *35*, 239-259.
[2] Rychlý J., Rychlá L., Novák I., Vanko V., Preťo J., Janigová I., Chodák I. Polymer Testing 2020, *85*, art. no. 106422.
[3] Novák I., Preťo J., Vanko V., Rychlý J., Pavlinec J., Chodák I. Polymers 2022, *14*, art. no. 1253.

MECHANICAL PROPERTIES OF BIODEGRADABLE PLA/PHB/ATBC BLENDS FILLED WITH CELLULOSE

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Novel composites based on the ternary biodegradable blends consisting of poly(lactic acid) (PLA), poly(3-hydroxybutyrate) (PHB) plasticized by acetyltributyl citrate (ATBC), and filled with various loading of the cellulose were prepared and their properties were investigated. PLA/PHB/ATBC ternary blend as well as cellulose composites were prepared by melt mixing at 190 °C. Content of cellulose filler ranged between 0 and 10 wt.%. The mechanical and viscoelastic properties were characterized by tensile tests, dynamic-mechanical analysis and rheological measurements. The addition of ATBC plasticizer significantly effected the mechanical properties of materials. It was found that the filled PLA/PHB/ATBC composite at the highest cellulose loading exhibited significantly lower values of the tensile strenght and elongation at break due to reduced free volume resulted in limited relaxation processes during tension.

The differences in dynamic moduli for PLA/PHB/ATBC ternary blend and composites containing the cellulose filler depended extensively on the cellulose loading while loss factor values progressively decreased with increasing cellulose content. Softening interactions between the cellulose and multiphase polymer system resulted in lower glass transition temperature and reduced polymer chain mobility.

It is important to note that the PLA/PHB/ATBC blend filled with the 10 wt.% of the cellulose is still showing extraordinary mechanical properties of approximately 200 % elongation at break and slighty lower tensile strength value compared to original PLA/PHB/ATBC ternary blend as a result of more flexible structure.

The presented results of mechanical properties clearly enable the possibility to partially replace the commonly used biodegradable polymers such as PHB and PLA by natural materials such as cellulose filler, while enhanced mechanical properties can be achieved by using ATBC as plasticizer [1].

Acknowledgment

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References

[1] Mosnáčková K., Šišková Opálková A, Kleinová A., Danko M., Mosnáček J., *Int. J. Mol. Sci.* 2020, 21, 9678; doi:10.3390/ijms21249678.

THE USE OF BASIC SOLID-STATE NMR TECHNIQUES IN THE STUDY OF TPS AND PBAT COMPATIBILITY IN THEIR BLENDS

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Solid-state nuclear magnetic resonance (NMR) spectroscopy is a powerful nondestructive tool for obtaining information on the structure and molecular mobility of various materials, including polymers. The arrangement of investigated nuclei and interactions between them are reflected in the shape of the NMR spectrum. In liquids, these interactions are averaged by molecular motion, resulting in narrow, resolved NMR signals, unlike the broad, unresolved signals observed in solid-state NMR spectra. Magic angle spinning (MAS) and cross-polarisation (CP) techniques, together with heteronuclear decoupling, are among the most important basic solid-state NMR techniques which have overcome this drawback in the last few decades [1].

Solid-state NMR preserves the three-dimensional structure of the analysed polymers, and the resulting resonances observed in the ^{13}C NMR spectra provide valuable insight into their conformation. The CP MAS ^{13}C NMR spectra recorded for poly(butylene adipate-*co*-terephthalate) (PBAT), thermoplastic starch and their compatibilized and non-compatibilized blends elucidate the short-range ordering in these materials. Deconvolution of the signal related to protonated aromatic carbons in the butylene-terephthalate units (BT) revealed a peak at ~129.5 ppm, corresponding to amorphous BT segments, and a peak at ~131 ppm, attributed to the α-form of crystalline BT regions [2]. The methylene resonance at 34 ppm, assigned to BA units in the amorphous phase, indicates that these units lack regular conformational order. The lineshape of TPS resonance at ~103 ppm reflects the arrangement of starch chains and allows identification of the presence of amorphous and crystalline domains [3]. At 30% and higher TPS content in blends, changes in molecular mobility of some functional groups in the PBAT component and glycerol used for TPS plasticization brought about by compatibilisation can be inferred from the shape of the ^{1}H MAS NMR spectra. The values of the spin-lattice relaxation time T_1 (^{1}H) indicate that the local molecular dynamics within the starch chains is also affected by compatibilisation.

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References
[1] Laws D.D. et al., Angewandte Chemie 2002, *41*, 3096-3129.
[2] Kuwabara K. et al., Biomacromolecules 2002, *3*, 390-396.
[3] Mutungi C. et al., Carbohydr. Polym. 2012, *87*, 598-606.

INSTITUTE OF POLYMER SCIENCE AND TECHNOLOGY (ICTP-CSIC)

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The Institute of Polymer Science and Technology of the Spanish National Research Council (ICTP-CSIC) is a research center devoted to the study and development of polymers and advanced materials. Located in Madrid (Spain), it was founded in 1947 with the aim of promoting innovation and knowledge in this field, ICTP has established itself as a reference both nationally and internationally.
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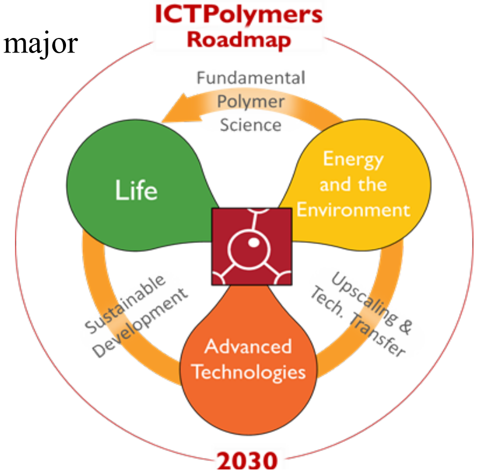

Figure 1: *Main research lines and trasnversal axes.*

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This activity has been supported by the MaX-CSIC Excellence Award DEEP-MaX-2024_ICTP and REDIN23005.

PROCESSING CHALLENGES IN PHYSICAL FOAM INJECTION MOULDING OF PLA-NATURAL FIBRE COMPOSITES

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The increasing demand for sustainable and lightweight polymer solutions has accelerated the development of biobased composite systems, particularly polylactic acid (PLA) reinforced with natural fibres (NF). While these materials offer significant ecological and economic potential, their processing via physical foam injection moulding remains challenging. In this context, technologies such as the Cellmould® process, utilizing supercritical gas as a physical blowing agent, represent a promising approach for the design of lightweight structures.

This work addresses key process engineering challenges in the Cellmould® processing of PLA-NF composites. Emphasis is placed on the interaction between material properties, especially fibre content, and process parameters that influence gas dissolution, nucleation, and cell growth. The natural fibres used in this study were processed and fractionated following the methodology described in our previous work [1].

The results indicate that natural fibres fundamentally influence melt rheology and flow behaviour, affecting the stability of the polymer-gas solution and the reproducibility of the foaming process. In addition, moisture and interfacial compatibility are identified as key factors governing foam formation and structural integrity.

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References

[1] Kubiak, N., et. al. (2025). Sustainable PLA composites filled with poaceae fibers: Thermal, structural, and mechanical properties. Materials, 18(17), 3952. https://doi.org/10.3390/ma18173952.

PVA/PVP/POLOXAMER HYDROGEL SYNTHESIS, WITH INCORPORATED MOO$_X$ NANOPARTICLES: RETENTION AND MORPHOLOGICAL STUDIES

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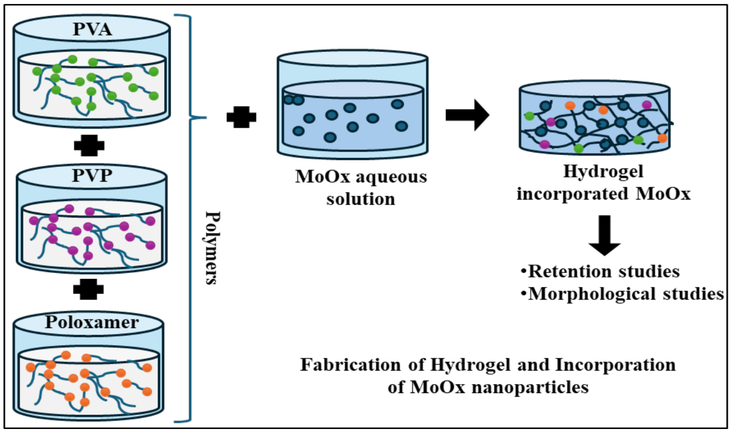
Hydrogels belong to a group of biomimetic materials composed of hydrophilic cross-linked networks, predominantly formed from polymer and water molecules. They provide adequate biocompatibility, adhesion, and permeability while maintaining a moist environment. This work presents the preparation and characterization of PVA/PVP/poloxamer hydrogels embedded with molybdenum oxide (MoO$_x$) as a soft-material system for photothermal therapy (PTT), focusing on refining mechanical properties, optimizing MoO$_x$ loading and assessing biocompatibility. Molds are used to cast hydrogels through the freeze-thaw and polymer-blending method, enabling reproducible gelation and uniform nanoparticle incorporation. The performance of the synthetic PVA/PVP/Poloxamer hydrogel will be compared with that of hydrogels based on renewable polymers (2-isopropenyl-oxazoline and α-methylene-γ-butyrolactone). MoO$_x$ nanoparticles are dispersed uniformly within the hydrogel matrices, resulting in consistent optical and thermal behavior. Retention and morphology analysis confirm that MoO$_x$-loaded hydrogels form a promising platform for PTT with tunable mechanical properties, stable nanoparticle integration and high photothermal efficiency, supporting their potential for tissue sparing and targeted cancer treatment strategies.



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References

[1] Annusova A, Labudová M, Truchan D, et al. ACS Omega. 2023 14 8(47) 44497-513.
[2] Taheri A, Atyabi F, Dinarvnd R. J Pediatr Endocrinol Metab. 2011 24(3-4) 175–179.

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