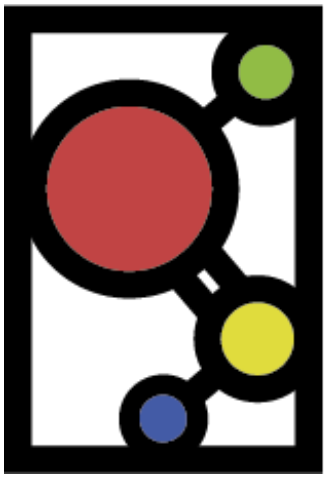

TOP

12TH INTERNATIONAL CONFERENCE

BOOK OF ABSTRACTS

12th conference on Times of Polymers and Composites, June 4th-8th 2025, Ischia Italy

Chaired by:

Domenico Acierno, Alberto D'Amore,
Luigi Grassia, Giuseppe Mensitieri

Thursday

Polymer brushes by “grafting to” reaction. Black-and-white or gray area?

Michele Laus

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Event: Top Conference 2025
Topic: polymer physics

The term *grafting to* indicates a specific class of chemical processes consisting in the attachment of telechelic polymers onto solid substrates to obtain ultrathin films of chemically anchored polymers, generally defined as polymer brushes.
Grafting to reactions are one of the most investigated approaches to producing polymer brushes due to their unique capability to control both the brush thickness and grafting density. Starting from the first studies on polymer brushes dating back to the 80s, the *grafting to* reaction was widely used to produce functional surfaces involved in applications ranging from biomedicine, to micro- and nano-electronics. Furthermore, in recent years, the investigation of the fundamental mechanisms underlying the *grafting to* processes has also gained renewed interest, especially for processes carried out in dry conditions.
Despite their widespread use, some aspects of the grafting to reactions remain not fully understood. The characteristics of the obtained brushes are mainly influenced by the molecular weight of the polymer, the mass distribution, the chemistry of the reactive end-group and the type of substrate.
In the present contribution, the effect of all of these parameters will be described to gain a more consistent understanding of the process.

Energy absorption in bamboo mimicking nanocomposite laminates

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Event: Top Conference 2025
Topic: nanocomposites

The energy absorption of bamboo mimicking flax fibre reinforced epoxy composite laminates is measured under impact conditions. Core-shell rubber nanoparticles are introduced and homogeneously distributed in the matrix for toughening purposes. Impact tests reveal that the absorbed energy and impact damage depend on the laminate lay-up, i.e. the local fibre concentration. The core-shell rubber nanoparticles greatly increase the absorbed impact energy while reducing the area of damage.

Fingerprinting the effect of functionalized polymers in filled compounds using large strain tests

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Versalis SpA (Eni)

Event: Top Conference 2025
Topic: nanocomposites

Tire rolling resistance is mainly related to energy dissipation in the tire tread elastomeric compound. Energy dissipation is influenced by polymer network defects, as well as by irreversibility related to filler network deformation and breakage caused by the cyclic strains occurring during service. A possible way of reducing negative effects related to filler network is to use functionalized polymers, i.e. polymers with a functional group able to react with filler surface. Functionalized polymers, in fact, can create a link between polymer matrix and fillers already during mixing. In such a way, they improve filler dispersion, and preserve the attained dispersion by reducing filler "flocculation" after mixing.
In this work, we applied large strain tests to assess filler network effects in filled compounds. A rejuvenation protocol was applied to get a fingerprint of the filled polymer when subjected to large strain stressing as well as after varying ageing times. Large Amplitude Oscillatory Shear (LAOS) was also used and applied to a set of filled compounds, based on distinct solution SBR polymers, having similar molar mass and architecture, with and without a specific chain-end functionalization. Experimental results were analyzed with two different protocols, i.e. Fourier Transform (FT) and Chebyshev decomposition. We show the effect of the functionalization through the analysis of a peak of the third-to-first harmonic ratio, occurring at mid-low strains in the range 5% to 10% ca. We checked that this peak is artifact-free and corresponds to a similar local maximum of the strain hardening parameter obtained by Chebyshev decomposition.

Multifunctional nanoclay-modified epoxy resin: a new tool against healthcare-associated infections

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Event: Top Conference 2025
Topic: nanocomposites

This research article reports the effort of the authors in identifying new materials with antibacterial and antiviral properties for structural applications in healthcare environments. The properties of a DGEBA resin reinforced with a natural montmorillonite modified with a quaternary ammonium salt are investigated in terms of antibacterial properties (against E. coli and S. aureus) and antiviral properties (against Herpes Simplex Virus type-1, AdenoVirus type-5, and Human CoronaVirus OC43). While nanomodification does not hamper the elastic and strength properties of the material, conflicting results appear in terms of anti-pathogen properties.

On the properties of extrusion blown films of polybutylene succinate copolymer composites with chitosan and nanoclay

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Event: Top Conference 2025
Topic: nanocomposites

Increment of biobased and biodegradable materials share in the polymer market is still a challenging issue. In the current research effect of different natural ingredients on the structure and properties of extrusion blown films of polybutylene succinate copolymer (PBSA) composites was analysed. High deacetylation degree chitosan (C98M) and chitosan oligosaccharide (C98) were compared for assigning antimicrobial properties to the developed PBSA composites, whereas organically modified nanoclay (NC) was used to improve mechanical and thermal properties of the developed hybrid composites. Minimum amount of the chitosan additive for assigning antimicrobial properties of PBSA composites was 7 wt.%, whereas C98 demonstrated better antimicrobial effect. The amount of nanoclay in the hybrid film compositions was changed in the range of 1 and 3 wt.%, ensuring effective stiffness and strength increase without excessive decrement of extensionability. Initially oscilliatory and rotation viscometry measurements were performed to find recommendable processing conditions of the developed hybrid composites. The obtained extrusion blown PBSA hybrid films were characterized in respects of it structural and exploitation properties using Fourier-transform infrared spectroscopy, differential scanning calorimetry, themogravimetric analysis, moisture vapour transmission rate, as well as tensile analysis. As a result of investigation it has been demonstrated that from the developed PBSA formulations with antimicrobial chitosan additive C98 and nanoclay NC hybrid films may be produced with yield strength ca 11 MPa and ultimate break of ca 550%.

Tailoring interfacial adhesion and self-healing in fiber reinforced composites for improved durability

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Event: Top Conference 2025
Topic: composites

Fiber-reinforced composites consist of a continuous phase, the matrix, whose purpose is to transfer the applied load to a reinforcing phase, the fibers. The efficiency of the load transfer significantly determines the final mechanical properties of the composite. Therefore, in recent decades, the possibility of tailoring the interfacial properties between fibers and matrix has been extensively studied in order to improve the mechanical performance and durability of composite structures. The aim of this work was to provide a contribution in this field by focusing on two primary research topics: the improvement of interfacial adhesion and the development of interfacial self-healing capability. Both topics involved the investigation of interfacial properties at the microscale through the fabrication of microcomposites subjected to microdebonding tests, in order to allow highly accurate estimates of the interfacial properties. Glass (GF) and basalt (BF) fiber were coated by thermoplastic poly(ϵ-caprolactone) (PCL) or poly(butylene adipate-co-terephthalate) (PBAT) in order to improve the interfacial adhesion with the matrix and to impart interfacial selfhealing capabilities. Furthermore, the experimental results were presented along with a finite element model (FEM) of the interfacial region to simulate the microdebonding and the self-healing mechanisms.

Exploring the potential of multifunctional thermoplastic polymer composites with self-healing capability

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Event: Top Conference 2025
Topic: composites

Self-healing is an inherent property of living organisms, which poses a significant challenge for materials science. In the field of composite materials, the concept of self-healing composites refers to the design of materials capable of autonomously restoring lost mechanical properties. The advantages of self-healing composites are numerous, including reduced maintenance and repair costs, and improved service life, leading to enhanced sustainability. This research focuses on investigating the intrinsic self-healing mechanism within polymer composites, which involves the ability of polymer matrices to heal microdamage, such as cracks, under external stimuli. More precisely, this work aims to develop a thermoplastic matrix possessing self-healing properties using polyamide 6 (PA6), which is the most commonly utilized thermoplastic polymer in the production of thermoplastic composites. As there is a lack of systematic investigation on this particular research topic in the scientific literature, various combinations of PA6 and different thermoplastic healing agents (i.e., polycaprolactone, cycloolefin copolymer), along with different types of compatibilizers, were employed. The optimized matrix has been then used for the manufacture of both short and long-carbon fiber composites. The results highlighted that the prepared self-healing laminates were capable of fully restoring the mechanical properties of the virgin materials. These composites, with their superior tensile properties and robust self-healing performance, have a promising potential for advanced applications in structural components with enhanced working life.

ENVIRONMENTAL EFFECTS ON CARBON FIBER-EPOXY DIMENSIONAL STABILITY

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Event: Top Conference 2025
Topic: composites

Thermal stresses in composite laminates are the consequence of different longitudinal and transversal coefficients of thermal expansion (CTE) in each ply, a phenomenon particularly significant when carbon fibers (CFs) are used. These frozen stress states in symmetric and balanced laminates do not produce any warpage, unless small asymmetry arises during the curing cycle. However, immediately after curing, a change of shape of CF reinforced composite laminates during storage at room temperature can be observed over a time span of days, even for symmetric laminates. Considering that the laminate is fully dried after vacuum bagging and autoclave curing at high temperature, usually above 100 °C, these changes were studied accounting for the effect of moisture absorption occurring when the laminate is exposed to standard environmental conditions, i.e. at selected relative humidity conditions. Shape changes, related to double and single side moisture absorption were measured on UD laminates in transversal direction assuming that CFs do not absorb water. The impact of moisture on the shape change of laminates was analysed introducing the effect of diffusion which was responsible for moisture concentration gradients through the thickness of the composite. Non-steady state behaviour was studied accounting either for the diffusion of moisture, a time-dependent process, either for the shape change of laminates related to the local moisture concentration and to the expansion of laminae in transverse direction. These characterizations enabled the measurement of a moisture expansion coefficient in the transverse direction and laminate distortions when moisture is absorbed only on one side of the laminate. Then, a multiphysics Finite Element Analysis, accounting for moisture absorption and capable of predicting the shape change of laminates depending on moisture absorption at room temperature, was developed.

Electrospinning of Natural Rubber/PLA/PEO blends: effect of solution and environmental parameters on the material's morphology

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Event: Top Conference 2025
Topic: composites

Nowadays, the widespread use of composite materials is limited in some applications by their low delamination resistance and low damping ability. Thermoplastic and elastomeric nano- and micro-fibers have recently been proposed to enhance the fracture toughness of Carbon Fiber Reinforced Polymer (CFRP) laminates, yielding promising results. In the present work, the morphology of microfibrous electrospun membranes based on natural rubber/poly(lactic acid)/poly(ethylene oxide) (NR/PLA/PEO) polymer blends is investigated. It is observed that environmental parameters play a key role in determining the morphology of the fibers, allowing smooth and defect-free ones to be obtained at low humidity values while porous ones at high humidity values.

Mechanical recycling of a short carbon-fiber reinforced polyamide-6 developed for 3D printing: rheological and mechanical investigation

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Event: Top Conference 2025
Topic: polymer physics

Besides household usage, Fused Deposition Modelling based 3D printing is expanding more and more also in an industrial setting, and this leads to the generation of a potentially large amount of waste, in terms of failed printed parts, supports or end of spool. It is thus imperative to find a convenient way to recover such a waste. Mechanical recycling is possible for this technology, since it is based only on thermoplastic materials. In this work, a polyamide 6 reinforced with short carbon fibre was recycled mechanically to investigate its re-use with the same technology, while maintaining its optimal mechanical properties. After grinding the 3D printed waste parts, the material was extruded to make a filament and was successfully 3D printed to obtain samples for mechanical and rheological testing. Tests were carried out both on virgin and recycled material for comparison purposes. Thermal and rheology analyses showed that the material degraded slightly due to thermo-mechanical reprocessing, but tensile tests ensured that the mechanical properties were not affected.

A Discussion of the Nature of Glass-forming Systems Or a brief history of time*, viscosity and temperature in glasses

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Event: Top Conference 2025
Topic: polymer physics

As early as 1914 Pochetinno recognized that organic materials such as pitch could potentially serve as models for the behavior of high temperature inorganics such as magmas because of their rapid increase in viscosity as temperature decreases. This observation is key to the present framework of glass-forming liquids in general. Thus, the VFT equation came from Vogel's work in 1921 followed by Fulcher in 1925 and Tammann (and Hesse) in 1926. Vogel worked on oils, Fulcher on silicate glasses and Tamman on a range of small molecule organics, including pharmaceuticals. The fact that the equilibrium data are extrapolated to a diverging viscosity at a finite temperature remains an important signature of glass formation. Kauzmann in 1948 published a work in which he showed that the liquidstate entropy, when extrapolated to below the glass transition apparently becomes zero near to the VFT temperature. Tammann and Hesse commented that the extrapolation to infinite viscosity was irrelevant, and the equation was only valid in the range of the observed data. In the case of the entropy, Kauzmann stated that "it is operationally meaningless to extrapolate curves below that temperature…". Thus, one can argue that the efforts to implicate the VFT diverging viscosity (or dynamics) at temperatures above absolute zero and the Kauzmann temperature as fundamental to the formulation of a theory of glasses is based on an incorrect interpretation of the writings of these foundational authors. From this history, I will segue to our own work that demonstrates the fallacy of these extrapolations.

Molecular Dynamics in Confined Amorphous Phases of Multilayered Polymer Systems: Impact of Compatibility

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Event: Top Conference 2025
Topic: polymer physics

During the past decade, numerous studies have been focused on understanding the glass transition (Tg) phenomena in thin polymer films and the interplay between the substrate and free surface effects. The confinement impact on macromolecular mobility has been shown to depend on the type of confinement: free standing films, supported thin films, thin films capped between two surfaces. Compared to those systems, layer-multiplying co-extrusion allows processing films containing thousands of alternating layers, with individual thicknesses that may reach the nanoscale, and displaying thin layers symmetrically confined between the walls of another confining polymer. In such systems, the existence of an interdiffusion zone, namely an interphase, at the interface between layers of two immiscible polymers must be considered. The interphase thickness may vary depending on the interactions between the two polymers, and its impact on the Tg variations and the molecular mobility of the amorphous phase is still an open question.
In this work, we study different coextruded multilayered films composed of two polymers with various compatibilities: from incompatible, like Polystyrene (PS) and Polymethyl Methacrylate (PMMA), to highly compatible, like Polycarbonate (PC) and Polyethylene Terephthalate glycol (PETg), with theoretical individual layer thicknesses down to 3 nm. The combination of different characterization techniques (modulated temperature scanning calorimetry (MT-DSC), dynamic mechanical thermal analysis (DMTA), dielectric relaxation spectroscopy (DRS)) is used to investigate the influence of the layer thickness reduction on the dynamic glass transition and the molecular mobility.

Biomimetic Behavior in Nonbiological Thermoresponsive Polymers

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Event: Top Conference 2025
Topic: polymer physics

Thermoresponsive polymer chains dispersed in water undergo a reversible transition, at a critical temperature Tc, from a coil to a globule conformation. PNIPAM is the simplest synthetic responsive homopolymer. Through crosslinking, it forms colloidal particles in which the coil-to-globule transition of the constituent chains triggers a drastic volume change in the particle itself. This conformational transition closely resembles the *folding/unfolding* transition in proteins, where slight temperature changes may result in sudden structural change and loss of biological activity (*denaturation*).
What else does this polymer share with typical protein behaviour? Recent experiments have revealed a low-temperature *dynamical transition* in PNIPAM, strikingly similar to the transition that enables biological functionality in proteins. Moreover, as in proteins, both conformational and dynamical transitions are highly sensitive to solvent additives. Here, I will discuss the protein-analogue behavior of PNIPAM, focusing on recent findings that shed light on its ability to mimic the dynamic properties of proteins and their sensitivity to interactions with biologically relevant additives (e.g., trehalose as a bioprotectant, glucose and glycerol as stabilizers). Altogether, PNIPAM emerges as a synthetic biomimetic material, that can be used as a simplified model to replicate and investigate isolated biological phenomena under controlled conditions.

Capillary instability of a stretched soft gel thread

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Event: Top Conference 2025
Topic: polymer physics

Thin liquid cylinders show Plateau-Rayleigh instability (PRI) leading to their breakup in drops. The breakup can be strongly delayed by adding a bit of high MW polymer, and totally suppressed in the case of cross-linked polymers (weak gels). Instead, a gel thread can show different undulation morphologies if capillary pressure is high enough (as compared to the elastic modulus of the gel). These structures may be used to fabricate undulated cylinders with controlled wavelength.
This talk summarizes theoretical predictions on PRI-related surface patterns of ultra-soft gels, their dynamics and possible routes to structure formation. Two main cases are considered: when a stretched gel thread is formed from a gel drop located between two surfaces, and when it is obtained by stretching of a gel cylinder. In the first case the thread can develop undulation patterns which then slowly disappear due to solvent flow out of the thread (into semi-drops at the ends). In the second case we predict that cylindrical gel threads can be stable in a range of pre-stretching degrees, but suffer from varicose instability at both higher and lower stretching parameters yielding pearling and beads-on-astring morphologies. The results can be applied also to reversible supramolecular gels with long relaxation times. The theory can be relevant for biological processes like generation of biofilaments.

Shear-Induced Supramolecular Organization of Calf-thymus DNA in Solution: Insights from SAXS Coupled with Rheology

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Event: Top Conference 2025
Topic: polymer physics

The investigation of DNA's dynamic and flow properties in solution is crucial for understanding its biological roles. DNA double helix strands interact and, at high concentrations, they form liquid crystalline phases, which are influenced by molecular weight and ionic strength. At rest, Small Angle X-ray Scattering (SAXS) shows that DNA double helix strands exhibit an electrostatic correlation peak whose intensity decreases in the presence of external salt. In this study, shear-induced liquid crystalline textures were observed in high molar mass calf-thymus DNA solutions (CT-DNA) at concentrations higher than
7 mg/mL using birefringence visualizations and rheology measurements. Then, SAXS, combined with rheology, was used to examine this supramolecular organization under flow, revealing orientations of CT-DNA with preferential inter-chain distances. Upon relaxation, a transition from anisotropic to isotropic behavior was observed in those DNA solutions. To summarize, it is shown that CT-DNA’s supramolecular organization at rest is progressively modified under flow and significantly influenced by DNA concentration, shear rate, and ionic strengt

Effect of fillers on the stability, miscibility and conductivity of selected polymer composites

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Event: Top Conference 2025
Topic: polymer physics

By making use of the developed multiscale theoretical approach, we study the effect of hard fillers on the thermodynamics, phase behaviour and electrical properties of polymer blends and diblock copolymer systems. The developed theory relies on the Sanchez-Lacombe equation of state of compressible filled polymer blends implemented in the calculation of the correlation functions between the polymer species and fillers. This approach makes it possible to calculate the excess thermodynamic functions caused by the presence of fillers, as well as the polymer-mediated potentials acting between these fillers. In particular, we prove that the correlations imposed by the variations of the composition of a polymer blend cause a significant non-osmotic contribution to the polymer mediated interaction between fillers immersed in this blend. The effect of fillers on the stability and miscibility of compressible polymer blends is studied in detail. In particular, we show that the presence of non-adsorbing fillers can be used to enhance the stability of a polymer blend that shows low critical solution temperature (LCST) behavior. The calculated osmotic effect of fillers explains the experimentally observed filler-induced increase of the LCST. Further, we study the electrical response of the polymer composite composed of conductive fillers and an insulating polymer matrix (polymer blend or diblock copolymers). By relying on the localization of fillers in a phase-separated composite determined by the developed method, we calculate the electrical conductivity of this composite.

Modification of thermoplastic starch to achieve a broad range of properties in mixture with biodegradable polymers

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Event: Top Conference 2025
Topic: polymer physics

Thermoplastic starch (TPS) is often a component of the mixtures with biodegradable plastics (BDP) aimed to a decrease of the price of biodegradable material. The acceptable ultimate properties are achieved only by addition of a compatibilizer able to make the mixture of usually hydrophobic apolar BDP with highly polar TPS compatible enough. Other physical properties are crucial, especially moisture uptake due to the effect on mechanical propeties, as well as barrier properties important due to the application of BDP as foils for food packagings. In both cases, the presence of TPS is the main reason considering the acceptable performance of the final mixture with BDP, therefore, the relevant properties of TPS may substantially affect the ultimaye properties of the BDP/TPS mixtures.

In the lecture, the key physical data on TPS are presented, especially the moisture uptake during storing as well as the permeation coefficients of gases. Finally a new effective compatibilizers is shown and its effect on mechanical properties of PBAT/ TPS mixtures is presented.

Acknowledgement Projects APVV 23-0224, APVV 20-0593 and VEGA 2/0109/2

Determination of Uniaxial and Planar Extensional Viscosity Using High-Pressure Capillary Rheometry

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Event: Top Conference 2025
Topic: polymer physics

Extensional viscosity (η_e) significantly influences the processability of polymer melts, the mechanical properties of final products, and manufacturing efficiency. Accurately determining η_e is essential for optimizing ecological, energy, and resource efficiency. Highpressure capillary rheometers, combined with orifice dies and the Cogswell method, enable the determination of η_e through entrance pressure drop (P_{en}) measurements. However, material adherence to the underside of orifice dies during these measurements can lead to overestimated P_{en} values and inaccurate η_e calculations.

Uniaxial and planar extensional viscosities are critical in material processing, particularly in controlling the neck-in phenomenon during film casting. While uniaxial η_e is relatively easy to measure, planar η_e remains challenging due to the difficulty of generating pure planar flow.

Recent advancements in the Rosand die design, inspired by Zatloukal ***et al.***, have introduced ***FreeFlow*** circular and rectangular orifice dies. These innovations eliminate P_{en} overestimation, enabling accurate determination of uniaxial and planar η_e. Additionally, these dies allow precise evaluation of extrudate swell (Barus effect), a parameter often inaccurately assessed with conventional dies due to material swelling into the die underside.

Using the Rosand high-pressure capillary rheometers and ***FreeFlow*** dies, researchers can now explore extrudate swell and extensional viscosity more comprehensively. This enhanced capability supports diverse simulations and process optimizations, advancing ecological, energy, and resource efficiency in polymer manufacturing.

Appropriate characterization of post-consumer recyclates as a prerequisite for their successful use

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For reasons of sustainability a circle economy is demanded and used plastics, in particular post- consumer recyclates (PCR), should be used in preference to virgin plastics for the production of new plastic molded parts in the future. The question arises as to what needs to be considered in this approach and what material characterisation tests should be concerned for the successful use of PCR in developing and manufacturing new products.
The authors examine two commercially available thermoplastic polymers, namely virgin material of copolymer polypropylene (PP), compared to rPP grades from post-consumer waste considered as a possible alternative. Injection molding processing tests, thermo-analytical and mechanical tests are carried out on the alternative materials, economic considerations are made and the test results obtained are evaluated comparatively.
The test results obtained suggest the introduction of material evaluation indicators that should be considered when selecting and specifying materials for product development and manufacturing.

Simulation of a real recycling scenario for a HDPE-based packaging

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Event: Top Conference 2025
Topic: polymer physics

Several factors still limit the achievement of effective mechanical recycling strategies for polyolefins. In particular, the thermo-mechanical degradation underwent during reprocessing, the different degradation forms experienced during the service life, as well as the cross-contaminations resulting from non-fully accurate sorting technologies, causes the obtainment of recyclates with heterogeneous microstructure, which significantly affect their final properties, often limiting their possible future applications. This study evaluates the combined effects of aging and cross-contamination for high-density polyethylene (HDPE) containing low amounts of polypropylene (PP) and polyethylene terephthalate (PET) as contaminants. HDPE systems were subjected to photo-oxidative or thermo-oxidative treatments and reprocessing to simulate real recycling scenarios. Results show that PP and PET contamination significantly reduce HDPE ductility under thermo-oxidative conditions, while exerting minimal impact on photo-oxidized materials.

Exploring Sustainable Feedstocks, from Starch to Soldier Flies: Unlocking the Potential of Plant- and Insect-Derived Plastics

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Event: Top Conference 2025
Topic: polymer physics

This presentation highlights two research initiatives focused on the development of sustainable bioplastics through circular resource strategies and advanced material characterization.
The first study investigates the use of black soldier flies (BSF) as a novel feedstock for bioplastic production. BSF larvae efficiently convert organic waste into biomass, leaving behind chitin-rich exoskeletons. This chitin is extracted and processed into chitosan, a biodegradable polymer with promising applications in packaging, biomedical products (e.g., wound dressings), and water treatment, where it functions as a flocculant. The use of thermal analysis and rheology can characterize the BSF-derived materials, enabling process optimization and evaluation of industrial suitability.
The second study examines polymer blend systems composed of polybutylene succinate (PBS) and thermoplastic starch (TPS), focusing on their structure–process–property relationships. To enhance performance, the blends are reinforced with hemp fibers and talc particles and processed using injection molding and cast film extrusion. The influence of varying PBS/TPS ratios and different conditioning environments (humid vs. dry) is studied with respect to mechanical, thermal, and rheological properties. The results support targeted modifications to improve stability, functionality, and processability.
Together, these two research paths demonstrate how renewable and waste-derived resources can be transformed into bioplastics. By combining thermal and rheological characterization with sustainable design, the studies contribute to scalable, circular solutions for replacing petrochemical plastics.

Friday

Oxidation of Epoxies: Chemical Mechanisms and their Effect on Macromolecular Mobility and Physical Properties

E. Richaud

Arts et Métiers Sciences and Technologies

Event: Top Conference 2025
Topic: polymer chemistry

Epoxy diamine systems were thermally oxidized at 110°C under air. Ageing was monitored using DMA in multi-frequency multi-temperatures modes. The analysis lead to the conclusion the crosslinking predominates. Data were exploited using classical VTFH and WLF theories for estimating the changes of free volume related parameters with ageing.

Laboratory accelerated weathering of polymers: Current challenges and prediction of durability

Jean-Luc Gardette

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Event: Top Conference 2025
Topic: polymer chemistry

The problems caused by the degradation of polymers are at least as old as the use of synthetic polymeric materials. Sunlight is recognized as an important factor in the deteriorative aging of polymers. Since the pioneer work in the early 1950s[1] that established photochemistry and photophysics of polymers as an important and separate discipline in chemistry, much research started in the 1960s on the photodegradation of organic polymers has been directed towards an understanding of the chemical reactions involved[2-4]. Stemming from this research, studies on the stabilization against oxidative degradation have been further developed.
Lifetime prediction of polymers is based on accelerated weathering, but the representativeness of accelerated aging is still an issue. Some basic questions have not found a definitive answer. The prediction of the long-term properties durability and then the lifetime service of polymers from laboratory experiments performed in artificial accelerated aging conditions is indeed a difficult task and new rational approaches for quickly assessing the lifetime of commercial or new technologies are needed

Single-Step and Mask-Free Method for realizing Organic Electrochemical Transistors: a polypyrrole case study

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Event: Top Conference 2025
Topic: polymer chemistry

Organic electrochemical transistors (OECTs) are organic-based devices that have garnered increasing interest from the scientific community due to their potential for exploiting electron/ion transduction properties in various applications. Traditionally, OECTs are fabricated using commercial PEDOT:PSS dispersions and multistep photolithographic methods. However, limited examples of OECTs are developed through alternative methodologies and protocols utilizing diverse conductive polymers. This report presents a straightforward, reliable, and mask-less electrochemical approach for fabricating hybrid polypyrrole−polydopamine based OECTs. This strategy enables precise control over the conductive channel properties while ensuring cost-effective and low-waste fabrication. The proposed method facilitates the production of high-performance OECTs with a low operating voltage (<1 V), significant transconductance (gm = 0.26 mS), and excellent stability under pulse stimulation. The functional properties of the OECTs are evaluated using classical electrical characterizations (e.g., 2-point probe method), cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and structural analysis (e.g., Raman spectroscopy)1. The results convincingly demonstrate that this approach offers a simple yet effective route for leveraging PPy in OECT applications.

Development of Rigid Polyurethane Foams with Enhanced Flame Resistance and Biocidal Functionality

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Event: Top Conference 2025
Topic: polymer chemistry

As a result of the conducted research, rigid polyurethane-polyisocyanurate foams (PUR/PIR) with enhanced flame resistance and biocidal functionality were developed. The flame retardancy was achieved by incorporating a novel type of halogen-free flame retardants. Resistance to fungi and bacteria was conferred through the use of a proprietary hybrid biocidal additive (HBA). Such rigid polyurethane-polyisocyanurate foams are suitable for use as insulation materials in modular construction applications.

Photostability of recycled polyethylene films

S. Therias

ICCF

Event: Top Conference 2025
Topic: polymer changes

Recycled Plastic Materials (RPM) are used in a growing number of applications in order to reduce the environmental impact. Among the numerous issues arising from RPM, their durability in use conditions under environmental stress factors (light, heat...) is of great interest because of the variability of the sources in terms of chemical composition and stability.
To tackle these issues, Barbier Group (French leader in production of polyethylene films) and POPPI group are working in close collaboration in the frame of a Common Laboratory, on the durability of PE films including recycled polymers. The aim is to understand the photochemical behaviour of PE films containing RPM, especially the impact of contaminants and additives resulting from the first life of the materials, in order to develop innovative stabilization strategies that will allow an increase of their durability.
Various films (100 µm thick) were produced by Barbier group, either from recycled PE (rPE) or virgin PE (v-PE). Artificial accelerated photooxidation was performed in SEPAP MHE devices in High Energy (HE) mode.
Upon photooxidation, the infrared spectra of both recycled PE (r-PE) and virgin PE (v-PE) show growing bands in the carbonyl region (1900-1500 cm^{-1}), with a maximum at 1713 cm^{-1} (C=O stretching of carboxylic acids). IR characterization revealed that some r-PE degrades faster than v-PE. The efficiency of different HALS stabilizers commonly used for v-PE or specially designed for recycled materials were tested.
The ultimate goal is the proposal of stabilization strategies to prevent early degradation of RPM-containing films.

Long-Term Behavior of Polychloroprene: Linking Mechanical Properties to Network Evolution

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Event: Top Conference 2025

Topic: polymer chemistry

Polychloroprene (CR) is widely employed in marine environments for marine renewable energy due to its remarkable intrinsic properties, such as superior fatigue resistance resulting from its ability to crystallize under strain, and its suitability for processing largescale components. Compared to natural rubber, CR demonstrates enhanced durability; however, it is not immune to aging, as its mechanical properties evolve significantly over time. In marine conditions, CR is particularly sensitive to oxidative degradation, which affects its long-term performance. This study aims to elucidate the relationship between the macromolecular structure of CR and its mechanical behavior, particularly stiffness and fatigue life. The macromolecular structure is characterized through swelling experiments and solid-state nuclear magnetic resonance (DQ-NMR) to assess changes in the network architecture. During ageing it appears that the average crosslink density increases mainly due to radical reaction on the double bond. In the same time an increase in network heterogeneity also occurs, for high extend of degradation a double network exists. The origin of this behavior will be discussed. In the meantime, ageing leads to large changes in tensile behavior with an increase in stiffness, a decrease in both stress and strain at break as well as a decrease in fatigue life. Relationships between network modifications and tensile properties will be proposed and discussed. Additionally, the influence of carbon black content on the material's aging behavior and mechanical performance is evaluated. These investigations provide a comprehensive understanding of the mechanisms driving CR degradation in marine environments, with the goal of understanding its durability.

A New Approach to Producing Multiple-Shape Memory Polymers via Solid-State Mixing

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Event: Top Conference 2025

Topic: nanocomposites

Shape memory polymers (SMPs) can fix a temporary shape and return to a permanent one when exposed to external stimuli. Recently, multiple-SMPs, which store and recover multiple temporary shapes sequentially, have been developed. There are two main strategies for creating multiple-SMPs: (1) incorporating separate transitions into one material, such as copolymers or composites, and (2) mixing miscible polymers to achieve a broad thermal phase transition. The first strategy involves creating co-continuous phase morphology or multilayer structures to enhance SMP performance, while the second relies on nanoscale miscibility to form different Tg nanodomains, allowing fine-tuning of the shape memory effect without altering the composition. This approach offers advantages in robustness and recyclability.

The first strategy predominates, using immiscible polymers, but tailoring these blends into co-continuous structures is complex due to viscosity ratios and interfacial tensions. The second strategy is less popular due to limited polymer options but provides flexibility in adjusting shape memory behavior.

This work introduces a novel method to achieve homogeneous nanoscale mixing of immiscible polymers and form a broad glass transition using solid-state shear deformation under high pressure. High pressure torsion (HPT) is used, demonstrating successful tripleSMP formation in a polypropylene-polystyrene blend.

Accelerated alkaline hydrolysis of PET waste and nanocomposite materials

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Event: Top Conference 2025
Topic: nanocomposites

Global demand for polyethylene terephthalate (PET) is rapidly increasing as its use broadens beyond traditional sectors, driven by the developments of novel high-performance nanocomposites for applications in smart packaging, e-textiles or energy devices. To ensure the sustainability of these next-generation materials, advanced recycling procedures enabling the circular recovery of both the polymeric component and filler are essential. Chemical recycling, involving the breaking down of polymers into monomers, offers a promising route, though its industrial scalability remains constrained by high energy demands and reliance on toxic solvents. Here, we demonstrate that a green pre-treatment protocol, comprising dissolution and phase separation of PET in propylene carbonate followed by solvent substitution with water, significantly accelerates its alkaline hydrolysis. The treated material achieves complete depolymerization into monomers within 5 minutes at 90°C and in under two hours at room temperature, outperforming standard hydrolysis processes that require prolonged high-temperature and high-pressure conditions (T>200°C, P>1.5 MPa). Furthermore, this approach is effective for different post-consumer PET products, including PET-graphene nanocomposites, which are incompatible with traditional mechanical recycling. The graphene recovered through this process retains its structural and chemical integrity, and when reintegrated into PET-based nanocomposites, confers mechanical properties comparable to that of the pristine material.

Recycling Plastic Waste Through Solid-Phase Dissolution of Immiscible Polymer Phases under Ultra-High Plastic Deformation

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Event: Top Conference 2025

Topic: nanocomposites

Recycling plastics is critical for sustainable waste management, with mechanical recycling being the most common method. Depolymerization, which reverts polymers to their original monomers, is gaining attention as a strategy for a closed recycling loop, beneficial for the circular economy. Despite advances in reversible reactions and over 95% monomer recovery in polymers like polyethylenes and polyesters, recycling mixed plastic waste remains challenging due to risks of non-recoverable side reactions.

The solid-state shear pulverization technique has improved recycling by enabling compatibilization of incompatible polymers. This method bridges dry processing and chemical recycling via thermo-chemical conversion. Despite the challenge of mixing immiscible macromolecules, dynamic crosslinkers and pressure-driven alloying offer potential solutions.

A new strategy using high-pressure torsion (HPT) has been proposed to homogenize mixed plastic waste. By reducing polymer phases to the nanoscale, HPT increases the interphase area, blending phases into a uniform structure. Constitutive modeling highlights the key role of interphase formation in achieving homogeneous mixing of immiscible polymers. Solid-state mixing has shown success with common plastics like polyolefins, polystyrene, and polyesters, which make up 70% of mixed waste. Although scaling up remains a challenge, HPT provides an innovative, efficient, and scalable solution for recycling mixed plastic waste and holds promise for larger, more complex mixtures.

ACKNOWLEDGMENTS

This research was funded by the National Science Centre (Poland) under Grant No. UMO-2023/51/D/ST8/01325.

Validation of industrially recycled carbon fiber upcycling: the reuse of ReCF in a car component as a proof of concept of circular economy

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Event: Top Conference 2025
Topic: composites

Carbon-fiber-reinforced polymers (CFRPs) are excellent candidates for lightweighting vehicles components. However, lack and cost of raw materials prevents their widespread application. Moreover, CFRPs are difficult to recycle. A recently started-up carbon fibers recycling plant (FIB3R, designed by HERAmbiente @Imola – BO - Italy, from a joined UniBo and Curti Costruzioni Meccaniche patent) produces now up tp 320tonn/year ReCF. Tailoring and optimizing the specific recycling process to boost the final ReCF properties, as well as the re-impregnation strategies to optimize composites production are at the basis of a successful result. The use of greener alternatives is still far from being a diffused practice in the mobility industry. This is mainly due to the lack of specifically suited industrial processing methods, material knowledge and design tools. Thus it requires the common effort of sustainable materials experts, green manufacturing technologists and a circular economy approach to support in this transition step the widespread use of ReCF withi the CFRP value chain.

The Stability of Co-Amorphous Molecular Glasses

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Event: Top Conference 2025
Topic: composites

The glass transition temperature (Tg) and stability of binary miscible mixture of molecular glasses, termed co-amorphous molecular glasses, is investigated as a function of composition. In such systems, a synergistic increase (or an antagonistic decrease) in the Tg over the value expected for the athermal mixture can occur due to strong (or weak) interactions between the two components. Such synergy, or the lack thereof, is anticipated to impact stability against crystallization, dissolution kinetics, and bioavailability. Here we discuss our current work modeling Tg and □Cp for binary systems, as well modeling the crystallization kinetics as a function of composition in the context of time-temperature-transformation (TTT) diagram. We find that the stability of the co-amorph is not directly related to fragility or to the ratio of Tg/Tm¬. Rather, there is a competition between the driving force for crystallization, which is related to the temperature-dependent solubility of the two components, and the molecular mobility which is related to the glass transition temperature of the co-amorphous glass.

Polymerization and degradation of bonding agent used in composite materials

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Event: Top Conference 2025

Aziridine additives were polymerized under several conditions. Polymerization kinetics were studied whether there is a catalyst. Resulting homopolymers were submitted to thermal and moisture ageing. The homopolymers show a good stability in temperature but a fast degradation in contact of moisture.

Enhanced Polymer Biocomposites via Chemically Treated Food Waste-Derived Calcium Carbonate

Michele Buono

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Event: Top Conference 2025
Topic: composites

This study highlights how calcium carbonate derived from food waste (FW-$CaCO_3$) from the processing industry represents a viable and sustainable alternative to mineral calcium carbonate. This type of filler has potential applications in polymer-based materials, as it effectively competes with mineral $CaCO_3$ in enhancing the mechanical properties of composites. In this work, the influence of chemical additives such as polymeric dispersants and fatty acids is investigated to improve powder dispersion within the polymer matrix and filler-matrix adhesion in the final composite. Additionally, the impact of FW-$CaCO_3$ particle size on the final composite properties is examined. The FW-$CaCO_3$ powders are produced using an industrial plant, where different chemical treatments are applied. The thermal stability of chemically treated FW-$CaCO_3$ is assessed before its incorporation as a filler into two different thermoplastic polymer matrices, Polylactic acid (PLA) and Polypropylene (PP). In conclusion, FW-$CaCO_3$ proves to be a viable substitute for mineral calcium carbonate in terms of enhancing the mechanical properties of the final biocomposite. Moreover, its use promotes a more sustainable approach by valorizing food waste and reducing reliance on non-renewable resources. These findings pave the way for further optimization and broader industrial applications in the field of polymer composites.

Three-dimensional printing of post-consumer HDPE/LLDPE blends

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Event: Top Conference 2025
Topic: polymer physics

Polyethylene is one of the most widely used and versatile polymers and recycling the large amount of waste generated each year is essential for achieving a circular economy. This study focuses on a high-density polyethylene (HDPE) obtained from a previous blow molding process. The material, neat and blended with linear low-density polyethylene (LLDPE), is reground and extruded into filament before being 3D printed through Fused Deposition Modeling (FDM) technology. The investigated blends are tested for tensile properties according to ASTM D3039 standard, showing an isotropic behaviour. Additionally, thermal analysis reveals that blending with LLDPE reduces the degree of crystallinity, which improves printability.

CO_2 Permeability in HNBR: Insights for CO_2 Transport Applications

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Event: Top Conference 2025
Topic: polymer physics

Carbon capture, utilisation and storage is a crucial short-term strategy to mitigate climate change. Once captured, CO_2 needs to be transported to storage sites, and to ensure efficient transport, it is typically compressed into a liquid or supercritical fluid. These conditions can alter the properties of materials used during the transport stage. HNBR, a commonly used elastomer in oil and gas applications, is investigated in this work in terms of its CO_2 permeation properties. The plasticization effect of CO_2 plays a key role, as it can shift the glass transition temperature, leading to peculiar permeability behavior at high-pressure.
Thermodynamic modelling is also effectively applied, describing the observed trends.

Elastocaloric performance of Natural Rubber in Solid State Cooling: evaluation of the effect of crosslinking density.

Marica Bianchi

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Event: Top Conference 2025
Topic: polymer physics

Elastocaloric cooling is recognized as a potentially viable alternative to conventional vapour compression cooling systems, which frequently utilize environmentally detrimental refrigerants.
Natural Rubber (NR), a well-known renewable resource, stands out among elastomers exhibiting elastocaloric behaviour due to a peculiar combination of nontoxicity, low cost, softness, long-life fatigue and high caloric power. Despite these properties, research on the refrigeration potential of NR is still in its early stages, and several aspects require attention. This work investigates the effect of crosslinking density on the elastocaloric properties of NR. Samples with three different crosslinking densities (2.9, 4.0 and 5.2 $mol \cdot 10^{-4}/cm^3$) were produced by internal compounding and hot pressing and thermo-mechanically characterized. Additionally, an energetic analysis of the elastocaloric effect was conducted. The assessment of the elastocaloric effect of the produced samples revealed that reducing the crosslinking degree significantly enhanced the elastocaloric performance, obtaining a coefficient of performance of the materials (COP_{mat}), evaluated as the ratio between extracted thermal energy and deformational work per unit volume, of 2.4 with the least cross-linked sample. These results underscore the significance of crosslinking density as one of the primary factors to be considered to enhance the refrigeration potential of NR.

Changes in mechanical behavior due to chain scission induced by chemical degradation in elastomer

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Event: Top Conference 2025
Topic: polymer chemistry

The oxidation of elastomers leads to modifications in the macromolecular network, which consequently affects the mechanical properties of the material. This degradation can be caused either by chain scission or by cross-linking that modify the macromolecular network. The latter has been extensively studied since many polymers contain double bonds (polydienes), and a decrease in elongation at break, λ break , along with an increase in the number of mechanically active chains, ν , has been observed. This is consistent with the rubber elasticity theory, where λ rupture is proportional to $\nu^{-1/2}$ [1]. However, in the case of a network undergoing predominantly chain scission, the relationship between these variables is not well understood, as most studies have primarily observed a decrease in elongation [2]. This study aims to investigate the evolution of fracture mechanical properties, particularly λ break , in model amorphous EPDM networks during their thermo-oxidative degradation. EPDMs undergo mainly chain scission under these degradation conditions. The network will be characterized through measurement through uniaxial tensile tests, swelling tests, and DQ NMR [3]. The fracture mechanical properties will be evaluated through uniaxial tensile tests and crack ropagation tests on notched specimens. Potential relationships between the macromolecular structure and these fracture properties will then be discussed.

Poly(Imide-Siloxane) Copolymer Materials for Lunar Dust Mitigation: Synthesis and Characterization of Surface Properties

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Event: Top Conference 2025

Topic: polymer chemistry

Dust poses a significant threat to any equipment operating on the Moon, particularly for long- term explorations. The development of efficient dust mitigation solutions is therefore critical for the success of lunar missions. In this work, fully aromatic and fluorinated polyimide (PI) and poly(imide-dimethylsiloxane) (PIDMS) copolymers are synthesized. The surface properties of the PIDMS materials are investigated using several techniques to evaluate their potential application as materials with lunar dust mitigation properties. In particular, the top and bottom surfaces are analyzed using Fourier transform infrared spectroscopy and wettability study to assess the preferential segregation of the siloxane chains towards one or the other side. Thermal analysis from differential scanning calorimetry suggests that the copolymer materials can withstand the harsh conditions of the Moon surface. Morphology analysis by scanning electron microscopy shows an increase in surface roughness upon addition of the siloxane segments.

Degradation of PBS, PET, and PEF under processing conditions

Nour Belgaied

École nationale supérieure d'Arts et Métiers

Event: Top Conference 2025
Topic: polymer chemistry

Polybutylene succinate (PBS, 51% bio-based), polyethylene terephthalate (PET, 20% bio-based), and polyethylene furanoate (PEF, 75% bio-based) were developed into films via thermocompression. Crystallinity was analyzed using Differential Scanning Calorimetry (DSC), while mechanical properties were evaluated through tensile tests. The influence of aging was studied by varying thermocompression conditions, such as compression times and temperatures, followed by re-evaluation of thermal and mechanical properties. This work provides insights into the relationship between microstructure and mechanical behavior, contributing to the optimization of PBS, PET, and PEF films for sustainable packaging applications.

Development of recycling strategies for medical HIPS toward a circular economy

Alessandro Funari

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Event: Top Conference 2025
Topic: polymer chemistry

This study explores the recycling potential of High-Impact Polystyrene (HIPS) used in medical packaging by examining its thermal, rheological, and mechanical properties. Recycled HIPS, derived from both post-industrial and post-consumer waste, shows performance comparable to virgin HIPS with only minor differences in thermal stability, glass transition temperature, and mechanical properties. Although post-consumer HIPS exhibits a lower melt flow rate, likely due to a higher molecular weight, its processing remains within acceptable limits. Overall, the results confirm the feasibility of mechanically recycling HIPS waste for healthcare packaging, while future research will address contamination risks and the effects of multiple recycling cycles.

Polypropylene-based 3D printed skin-core structures with thermal conductivity and balanced mechanical properties

Rossella Arrigo | Eleonora Lorenzi | Alberto Frache

Event: Top Conference 2025
Topic: polymer physics

In this work, polypropylene (PP)-based filaments for Fused Filament Fabrication (FFF) containing boron nitride (BN) or talc (T) were developed and used to formulate multifunctional 3D-printed parts with enhanced thermal conductivity and mechanical properties. More specifically, skin-core structures, with BN in surface layers and talc in the core, were optimized and characterized. Results show that confining BN to surface layers improves inplane thermal conductivity due to filler alignment during printing. Furthermore, the obtained structures maintain mechanical properties comparable to PP/T mono-material samples, despite reduced filler content and the presence of multi-materials interfaces, demonstrating the potential of the proposed strategy for creating high-performance multimaterial parts through FFF.

Saturday

Molecular Modelling of Graphene-Paraffin Nanocomposites for Heat Storage

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Event: Top Conference 2025
Topic: nanocomposites

Paraffin waxes, which consist of low molecular weight alkanes, are a promising material for use in heat buffers, but, unfortunately, they have very poor thermal conduction. We boost the effective thermal conductivity (TC) of paraffin wax making their nanocomposites with a very fine, highly thermally-conducting embedded network of graphene nanofillers. It is shown that increased branching leads to decreased TC, especially in the solid state. A strong relation between crystallinity and TC is found. Secondly, polydisperse samples of paraffin wax are studied. Molecular mass distribution has an effect on TC, but not as strong as branching. Next, graphene is introduced in the form of a single layer with infinite area, and the properties of the paraffin in wax-graphene composites are modelled. Adjacent to a single-layer sheet of graphene with infinite area, paraffin molecules are found to align themselves parallel to the graphene sheet. When slowly cooled, the wax crystallises into distinct layers. Given that these are oriented parallel to the graphene, the TC component perpendicular to the graphene sheet is lowered as compared to bulk paraffin.
The special attention was paid to simulate the so-called Kapitza, or Interfacial Thermal Resistance (ITR). With increasing graphene area density of octyl functional groups, high reduction of ITR of up to 95% is found. Using Direct Numerical Simulations (DNS) on system scales, the effective conductivity as function of network and paraffin properties can be predicted, and model parameters for coarsened system-scale descriptions are extracted from MD simulations, thereby creating a coherent multiscale approach.

Nanofibres for sound absorption – a preliminary investigation

Emanuele Manzi

University of Bologna

Event: Top Conference 2025
Topic: nanocomposites

Noise reduction is included in the main tasks to deal with when working in the field of automotive and aerospace industries. When trying to improve comfort, it is crucial to research and enhance acoustic properties. Nanofibres can be a viable solution to address sustainability and noise absorption while ensuring material savings through lightweight nonwoven mats. They are also very intriguing for potentially improving the acoustic properties of conventional materials even in combination with them. The process and connection between improved noise absorption and nanofibrous membranes are still not fully known or confirmed. For this reason, in this preliminary study different nanofibrous morphologies are obtained via electrospinning, leading to the possibility to correlate acoustic absorption with nanoscale morphologies, mainly focusing nanofibres' diameter, which is easily tailorable. For this reason, an impedance tube was used to draw a first measurement method approach.

Block Copolymer Toughening of Epoxy – Effect of vitrification temperature on morphology and fracture toughness

Claudius Pirro

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Event: Top Conference 2025
Topic: nanocomposites

The influence of the vitrification temperature on the phase separation of block copolymer modified epoxy systems and the resulting fracture mechanical properties is investigated. It is found that the temperature-driven demixing process causes dominantely phase separations in the nanoscale when polymerised at 23 °C, whereas microscale phase separations occur during polymerisation at 80 °C. The nanoscale phase separations result hereby in higher values of fracture toughness K_{1c} and fracture energy G_{1c}. With increasing block copolymer concentration, fracture toughness and fracture energy further increase.

Bacterial Cellulose as Reinforcement in Nanocomposites Prepared via Film Stacking of Thermoplastic Biopolymers

Edoardo Zonta

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Event: Top Conference 2025
Topic: nanocomposites

The widespread use of plastic materials, particularly in the food packaging industry, poses environmental challenges due to both the sourcing of these materials and their nonbiodegradable nature. Cellulose, the most abundant renewable biopolymer, is gaining traction as a replacement for traditional non-biodegradable synthetic plastics, with bacterial cellulose (BC) offering numerous advantages across various industries. Bacterial cellulose (BC), constituted by an interwoven network of nanometric cellulose fibers, possesses a unique structure and properties, including high mechanical strength, biocompatibility, and sustainability. However, to fully leverage these properties in various applications, enhancing its functionality through composite materials is imperative. One promising approach is film stacking, wherein BC films are combined with thermoplastic polymers to create advanced composite materials with tailored properties. This study, performed in collaboration with Bioniks srl (Verona, Italy), aims to explore the feasibility and potential of film stacking techniques for creating BC-based composite materials with enhanced mechanical, thermal, and functional properties. Specifically, the research focuses on identifying the most promising thermoplastic polymers for film stacking with BC (e.g., polylactic acid) and optimizing the processing parameters to achieve desirable composite characteristics. A possible pre-treatment of BC, involving a pre-impregnation step with a water-soluble polymer (e.g., polyethylene glycol), was evaluated to enhance the quality of the prepared composite. This approach aims to fully exploit the unique BC microstructure, facilitating better penetration of the matrix polymer and promoting strong bonding with the cellulose reinforcement. Experimental testing covered various properties, including chemical, thermal, morphological, mechanical, and optical characteristics of the prepared composites.

Electrospun materials for contrasting delamination in composites

Emanuele Maccaferri | Laura Mazzocchetti | Tiziana Benelli | Giulia Lucarini | Pietro Braga | Tommaso Maria Brugo | Andrea Zucchelli | Loris Giorgini

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Event: Top Conference 2025
Topic: nanocomposites

Carbon fiber reinforced polymer (CFRP) laminates experimented a considerable diffusion in several application fields, especially where high specific mechanical properties are requested. While such materials are very versatile and contribute to obtaining lightweight and more “sustainable” structures, they potentially suffer from delamination, which poses an important limitation to their even more extensive widespread use. The integration of electrospun materials, especially nanofibers, is a smart solution to reduce such phenomenon. The present work aims to compare different fibrous and nanofibrous systems that are able to contrast delamination by increasing interlaminar fracture toughness. In particular, the reinforcing effect delivered by electrospun veils made of Nylon 66, Nylon 66 coated with nitrile butadiene rubber (NBR), rubber-containing blends (NBR with polycaprolactone, PCL, or with Nomex), and a commercial thermosetting polymer is disclosed.

Multifunctional xanthan/wood fibers based composites for the production of topsoil covers

Alessandro Sorze | Francesco Valentini | Alessandro Pegoretti | Andrea Dorigato

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Event: Top Conference 2025
Topic: composites

Topsoil covers (TSCs) are bio-based mulching films that support reforestation and agriculture in arid conditions, by inhibiting weed growth and reducing soil moisture losses after transplantation. This study focused on the development of bio-based composites as TSCs using xanthan gum (XG) as matrix and wood fibers as reinforcement to find an alternative to commercial plastic mulching films. Different formulations of TSC were produced by first mixing XG and wood fibres in aqueous solution and then by cross-linking the produced composites with different cross-linking agents, such as citric acid (CA), sodium trimetaphosphate (STMP) or tannic acid (TA) at different concentrations and under specific heat treatment conditions. TSCs cross-linked with CA exhibited the highest stability and exceptional water absorption capability (up to 1500 % increase over the original weight), retaining their shape even after multiple absorption and drying cycles. Additionally, TSCs with CA displayed water vapor permeance values of 9.5·10−6 g/(Pa·s·m2), comparable to a commercial woven fabric polypropylene (PP) mulching film. The average penetration resistance of the composites, which simulates the resistance of TSCs to weed perforation, was statistically higher than that of the commercial PP material. Flame tests demonstrated the non-flammable behaviour of the produced topsoil covers, despite the presence of wood fibers. Field trials conducted to assess the effect of TSCs on tree growth demonstrated that the TSCs maintained excellent plant health. This research showed the potential of xanthanbased composites as TSCs when cross-linked with citric acid, offering a simple and scalable technology for forestry and agriculture applications.

Processing and mechanical characterisation of a continuous flax fibre reinforced unidirectional lamina

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Event: Top Conference 2025

Topic: composites

Ecosustainable composites can be obtained by replacing traditional reinforcements with fibres of vegetable origin and employing a biodegradable thermoplastic polymer as the matrix. The resulting material is often named “green composite”. Since mechanical properties of natural fibre reinforced composites are usually low, a possibility of obtaining structural green composites is to keep fibres aligned in a single direction. This results in high properties in the longitudinal direction, albeit transverse properties remain low. In this work, unidirectional flax fibre reinforced poly-(lactic acid) green composite laminae are obtained by a filament winding procedure followed by hot pressing. Filament winding is chosen because it allows a certain degree of fibre pre-tensioning, and this ensures a good degree of fibre alignment even after the hot pressing phase. Tensile testing is finally performed according to ASTM D3039 to measure the mechanical properties. As expected, the green composite has a significant anisotropic behaviour, with transverse strength that is lower than the neat matrix, while the longitudinal properties have a substantial enhancement.

Machine Learning System for Frailty Detection and Monitoring in Smart Homes using Heterogeneous Sensors

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Event: Top Conference 2025
Topic: composites

The cINnAMON project aims to develop a cost-effective, non-intrusive home surveillance system to assist elderly individuals at risk of frailty. It integrates wearables to detect behavioral and physiological changes. A hybrid machine learning approach, combining Convolutional Neural Networks (CNNs), Long Short-Term Memory (LSTM) networks, and Transformer models, analyzes data like weight loss, BMI, and exhaustion to predict frailty. The classification performance is evaluated using multiple traditional machine learning algorithms, such as Random Forest, Support Vector Machines (SVM), and Gradient Boosting, along with a deep learning model, with metrics like accuracy, precision, recall, F1score, and ROC-AUC. This study contributes an adaptable AI-driven framework for proactive frailty detection, offering real-time monitoring and automated alerts for caregivers and healthcare professionals.

Synthesis of hybrid materials prepared via sol-gel route: Chemical and physical characterization

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Event: Top Conference 2025
Topic: composites

This study investigates the synthesis of a silica-based (SiO_2) glassy material incorporating a polyphenol-rich grape extract (G) to develop a bioactive glass-like system for food and beverage packaging. Using the sol-gel method, grape extract is incorporated into the silica matrix at 5% (SiO_2-G5) and 15% (SiO_2-G15). Structural and thermal stability analyses (FTIR and TGA/DTG) show that SiO_2-G5 exhibits greater stability than SiO_2-G15. Encapsulation rate analysis reveals that, in SiO_2-G15, part of the extract remains surface-bound rather than fully entrapped, making it more vulnerable to degradation. Furthermore, in vitro release studies evaluate whether the material can release polyphenolic compounds into a liquid medium, potentially providing antioxidant activity. The results indicate that SiO_2-G5 releases nearly 100% of the bioactive molecules, while SiO_2-G15 shows limited release due to molecular aggregation within the silica matrix. These findings highlight SiO_2-G5 as a promising bioactive material for glass-based food and beverage packaging, ensuring both enhanced stability and controlled antioxidant release.

Theoretical Modeling and Numerical Simulation of Residual Stresses in Polymers and Polymer-based Composites during the Curing Process

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Event: Top Conference 2025
Topic: composites

A mathematical formulation to model the evolution of epoxy's viscoelastic properties during the curing process is proposed. The model assumes a linear viscoelastic behavior of the resin and is based on the hypothesis of thermo-rheological and chemo-rheological simplicities. A modified version of the well-validated TNM (Tool–Narayanaswamy–Mohynian) model is used to model the concurrent effects of curing and structural relaxation on epoxy's relaxation times The formulation is implemented in Ansys to predict the residual stresses developing during the cure in both a neat epoxy component and in a carbon-epoxy composite at the micromechanical level. The numerical procedure comprises two moduli: at first, the thermal-kinetical problem is solved using the thermal module of Ansys and a homemade routine written in APDL language, then the resulting temperature and degree of conversion profiles are used to evaluate the viscoelastic functions, allowing the calculation of residual stresses through the structural module.
The results show that residual stresses arise especially during the cooling to room temperature. These stresses constitute a significant portion of the resin's nominal strength and scale with the Biot number. It was also found that residual stresses significantly affect the mechanical properties of the composite, especially under transverse compressive loads.

Poster Session

Lightweight and Impact-Resistant Photovoltaic Modules for Vehicle Integration Using Glass Fiber-Reinforced Polymers

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Event: Top Conference 2025
Topic: composites

The integration of photovoltaic (PV) technology into vehicles demands the development of lightweight PV module concepts. This research introduces and assesses an innovative lightweight PV module design, where PV cells are embedded into glass fiber-reinforced polymer (GFRP) composites through the vacuum-assisted infusion process. Utilizing GFRP as both the front and back material achieves a substantial weight reduction of 45–55% compared to traditional glass-based PV modules.

Our results indicate that the proposed GFRP-supported module stack significantly enhances resistance to hail impact, ensuring that both small- and large-scale modules remain intact without cell cracks following impact. The special epoxy resin used in the GFRP structure provides complete transparency when combined with glass fiber, allowing sunlight to reach the PV cells without obstruction. This ensures that the efficiency of the solar cells is maintained. Additionally, the integration of a GFRP sandwich back layer further strengthens impact resistance, effectively preventing cell damage.

These findings underscore the advantages of GFRP-based PV modules in enhancing durability and reducing weight, making them highly suitable for vehicle-integrated photovoltaics and other lightweight energy applications. Furthermore, GFRP materials offer design flexibility in component manufacturing, facilitating seamless PV integration onto surfaces of various vehicle shapes.

EVALUATION OF MATERIAL PROPERTIES AND DEGRADATION BEHAVIOR OF ECO-FRIENDLY LIGHT IRRIGATION DRIPLINES MADE FROM BIODEGRADABLE POLYMER BLENDS

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Event: Top Conference 2025

Topic: polymer chemistry

Keywords. Biodegradable polymers; irrigation light driplines; soil and compost burial test; photo-oxidation.

Irrigation light driplines (ILD), made up of two ad hoc designed components (pipe and continuous dripper), based on a blend of commercial biodegradable polymers were prepared by Irritec via a proprietary process. An evaluation of the material properties, as well as soil and compost burial degradation behavior, was carried out. Moreover, rheological and mechanical properties were assessed to determine the suitability for processing in an industrial apparatus for pipe production. Carbon black (2%) was added and ILD were subjected to photo-aging by UV exposure up to 198 h. The degradability in soil (30 °C) and compost (58 °C) was monitored by weight loss. The impact of UV irradiation on the degradation behavior of biodegradable ILD was also investigated under soil burial conditions. Moreover, ILD samples were analyzed by FT-IR ATR before and after UV and soil/compost burial degradation. The rheological properties of the biodegradable systems, in both shear flow and non-isothermal elongational flow, closely resembled those of conventional polymeric matrices employed in irrigation pipe manufacturing. The highest ILD degradation rate was observed in compost at 58 °C. However, UV aging encouraged the disintegration of ILD in soil as previously observed (Rapisarda, 2019).

Synthesis of colored beetroot/silica-hybrid by sol-gel route: chemical and colorimetric study

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Event: Top Conference 2025
Topic: composites

This work aims to synthesize silica-based hybrid materials incorporating beetroot extract (Br) via the sol-gel method at different concentrations (4 wt%, 8 wt%, and 24 wt%). The hybrids are analyzed using colorimetric and Fourier-transform infrared (FTIR) spectroscopy to assess their structural and functional properties. Colorimetric analysis confirms a significant color change compared to the transparent SiO_2 reference, with increasing extract content leading to darker and more saturated materials. This is further supported by the ΔE parameter, which reach a value of 50.0 in SiO_2+24Br%. FTIR spectroscopy reveals the successful incorporation of Br within the silica network and the formation of hydrogen bonding interactions between SiO_2 and Br, as evidenced by shifts in the OH bending and SiO-Si stretching bands. Additionally, characteristic beetroot peaks confirm the integration of polyphenolic compounds within the silica matrix. The persistence of these functional groups suggests that the bioactive molecules remain embedded in the hybrid material, potentially preserving their functionality.

DESIGN OF TAILOR-MADE POLYHYDROXYALKANOATES: FROM BIOSYNTHESIS TO BIODEGRADATION

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Event: Top Conference 2025
Topic: polymer chemistry

The conference will present different examples of PHA production in order to show how the choice of substrates integrated at the start of the biosynthesis process makes it possible to influence the chemical structure and the morphology of the PHA produced and thus to adjust the physico-chemical characteristics and the functional properties (rheological behavior, thermal stability, mechanical behavior, viscosity, barrier properties, etc.). PHAbased blends can be also formulated with other biopolymers or different fibers or fillers in order to produce bio- or nanocomposites.
Some results that we have recently obtained by different approaches illustrate the ability of certain PHA to biodegrade in a very spectacular way in the marine environment. However, significant differences in behavior are observed with regard to the composition and morphology of PHA. The main factors intrinsic to PHA (chemical structure, molar mass, free volume, glass transition, mobility, crystallinity, solubility, hydrophilic/hydrophobic balance, etc.) play a determining role in their degradation.
All of this work provides original data and new insights into the colonization of PHA by marine microorganisms and their associated marine biodegradation. The promising results already obtained and those to come aim to develop models to help design tailor-made (bio)degradable polymers. Their (bio)degradation could be controlled, or even programmed, by acting on the physical and chemical factors previously identified and intrinsic to the PHA, as well as on the extrinsic factors, relating to the environment.

Influence of Biological Medium pH on the Stability and Gene Delivery Efficiency of Chitosan/peGFP-C3 Polyelectrolyte Complexes

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Event: Top Conference 2025
Topic: polymer chemistry

Natural and synthetic polycations are commonly used in nucleic acid-based therapies for their ability to condense and protect nucleic acids, enhancing cellular uptake. While the formation of these complexes is well-documented, fewer studies have examined their stability under both extracellular and intracellular conditions. Chitosan, a biodegradable natural polysaccharide, has shown promise for gene delivery; however, its pKa of ~6.5 makes its ionization state highly sensitive to pH fluctuations around this value. In this study, we investigated the pH-induced changes in the stability of chitosan/peGFP-C3 complexes, along with their effects on cell viability, proliferation, and transfection efficiency in HEK293T cells. The experiments were conducted in DMEM-MES (pH 6.5) and DMEMHEPES (pH 7.1) buffers. The highest transfection efficiencies were observed in DMEM-MES (pH 6.5), followed by replacement DMEM-HEPES (pH 7.1), mainly with high molecular weight chitosans. Cell viability was higher in DMEM-HEPES, whereas acidic pH (6.5) led to an accumulation of cells in the S phase, suggesting that low pH may interfere with cell cycle progression. These findings highlight the critical role of pH in optimizing gene delivery and cell growth conditions.

SUSTAINABLE AND BIODEGRADABLE BIOCOMPOSITES BASED ON PBSA AND SPENT ARTEMISIA ARBORESCENS: PERFORMANCE AND INCREASED DEGRADABILITY IN COMPOST

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Event: Top Conference 2025
Topic: composites

The use of biodegradable polymers is limited by their mechanical properties and higher production costs compared to conventional plastics. One valuable approach to develop costeffective systems and enhance their performance is focused on the incorporation of plantbased wastes and by-products. These fillers not only can improve the material performance but also introduce functional properties, reducing costs. Bio-fillers from renewable resources are a sustainable alternative to the traditional ones, providing a contribution to the circular economy. Spent biomass from industrial processes appears a particularly attractive choice, as it utilizes materials that would otherwise be discarded. *Artemisia arborescens*, widely used in various applications, generates significant amounts of spent biomass after extraction processes, including distillation. This spent *A. arborescens* represents a valuable resource for biocomposite development. In this work, biocomposites based on poly(butylene succinate-co-adipate) (PBSA75/25) and spent *Artemisia arborescens* were prepared using two concentrations of filler (10% and 20%). The influence of *A. arborescens* incorporation on the rheological, mechanical, and thermal properties, as well as the degradation behaviour in compost, was investigated and compared to neat PBSA75/25. The inclusion of the filler led to increased stiffness but significantly reduced ductility. Noteworthy, the presence of spent *A. arborescens* accelerated the degradation process in compost.

Acknowledgement: Funded by the Next Generation EU - PNRR M4 - C2 - investimento 1.1: Fondo per il Programma Nazionale di Ricerca e Progetti di Rilevante Interesse Nazionale (PRIN) - PRIN 2022PNRR cod. P2022M3FTM, titled “SUstainable routes to high PErformance and Recycling of BIOdegradable plastics for a circular economy – SuperBio” CUP B53D23027640001.

Using Rheology to Evaluate Agri-Food Waste Fillers in Biocomposites

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Event: Top Conference 2025

Topic: composites

Today, various food and agricultural wastes are being incorporated into biodegradable polymers in order to improve the mechanical performance while maintaining the advantage of biodegradability with a view to a circular economy. However, the addition of these fillers causes a different effect on the polymer matrix, acting as a possible reinforcement or as a catalyzing agent for degradation phenomena. Infact, food and agricultural waste often contains a large variety of chemical components in its composition. These components can interact with polymeric matrices during the preparation of the biocomposites. In this work we can observe how through measurements of flow curves it is possible to have information about the effect of the addition of these different fillers. Infact, viscosity can provide information on the variation of molecular weight and therefore on the possible degradation mechanisms of the matrix.

Acknowledgement : Funded by the European Union – Next Generation EU - PNRR M4 - C2 -investimento 1.1: Fondo per il Programma Nazionale di Ricerca e Progetti di Rilevante Interesse Nazionale (PRIN) - PRIN 2022PNRR cod. P2022M3FTM_002 dal titolo " SUstainable routes to high PErformance and Recycling of BIOdegradable plastics for a circular economy - SuperBio"
CUP B53D23027630001

Evaluation of carbon fibres from composite recycling and waste glass powder as admixtures to improve geopolymer mortars properties

Manuela Ceraulo | Marco Beccali | Fabio Cardona | Alessandro Biondi | Massimiliano Di Liberto | Bartolomeo Megna |

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Event: Top Conference 2025
Topic: composites

Sensible Heat Thermal Energy Storage or SHTES is a technology of growing importance in industrial energy saving strategies as it allows the recovery a fraction of energy that can be used when necessary. The most common storage unit is made of a high-performance concrete, which uses Portland cement (OPC) as a binder, a material that has a huge carbon footprint. In the civil engineering there is a line of research aimed at developing alternative binders to cement with a lower environmental impact. Among the alternative binders, geopolymers are the most promising in the industrial field of SHTES as they are characterized by ceramic structure with eventual high resistance to thermal stress and high chemical inertia. Unfortunately, the thermal properties, e.g. thermal conductivity, of geopolymers are not satisfying and improving these properties is essential to be able to propose alternative systems to the reference ones currently in use. In this works several type of geopolymers composite are studied to improve thermal properties and long-term durability. Additive such as carbon fibres (0.5%, 1% and 1.5%), coming from composite recycling, river sand and waste glass powder are tested.
This study was developed in the framework of the research activities carried out within the Project “Network 4 Energy Sustainable Transition—NEST”, Spoke 8, Project code PE0000021, funded under the National Recovery and Resilience Plan (NRRP), Mission 4, Component 2, Investment 1.3— Call for tender No. 1561 of 11.10.2022 of Ministero dell’Università e della Ricerca (MUR); funded by the European Union—NextGenerationEU.

Segmentation of a Three-Dimensional X-ray Computed Tomography Images for characterization and analysis of natural fibers reinforced composites

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Event: Top Conference 2025
Topic: composites

Because of numerous advantages of natural fiber, biobased composites have attracted a great deal of interest from both academia and industry worlds. Due to its excellent physical and mechanical characteristics, among natural fibers, flax fiber is revolutionizing the world of composites materials. The present work explores the use of X-ray computed tomography (CT) technique on flax fibers reinforced composites. The later were manufactured using vacuum bag and an autoclave. The CT technique was performed using a Phoenix Nanotom and the target material used in the tube was tungsten. From the recorded two-dimensional (2D) X-ray projection images, the three-dimensional (3D) image of the sample is then computationally reconstructed. Afterwards, the CT technique was extended with 3D image analysis, to characterize pores/voids in the overall volume of the material. The image analysis was based mainly on three steps: i) Image denoising, ii) Image segmentation and features extractions iii) Visualization of the results. The obtained images highlight the location, the size, the shape and the content of pores within the overall volume of the material. As the voids/pores act as stress concentrations and crack initiators in the composite. their impact on the mechanical properties of the material is very important. Hence, the results may enrich and lead to better understanding the damage observed on similar laminates in previous study.

In-plane mechanical behavior and anisotropic response of 3D printed continuous basalt fiber composites

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Event: Top Conference 2025
Topic: composites

3D printing of continuous fiber-reinforced composites has a strong potential to improve mechanical performance beyond prototyping or non-structural uses. Basalt is a natural material with excellent mechanical properties, high impact strength and good thermal resistance, which has received limited attention in 3D printing. This study focuses on a continuous basalt fiber composite fabricated via Fused Filament Fabrication (FFF) and the comprehensive characterization includes thermal analysis and in-plane tensile testing. The final composite shows a longitudinal strength that is remarkably higher than the neat matrix, demonstrating its suitability for structural applications. However, the transverse and shear properties are significantly lower, showing pronounced anisotropy. Anisotropy impacts component design, so optimized continuous fiber deposition is the key to unlock the full structural potential of 3D-printed basalt fiber composites.

Estimation of the aging of breast prostheses materials by accelerated tests

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Event: Top Conference 2025
Topic: polymer physics

Breast prostheses are extensively employed for either aesthetical augmentation or medical aims. Clinical or subjective reasons may sometimes induce early removal; however, it is not uncommon for them to remain implanted for extended periods, often exceeding 20 years. Understanding the expected materials changes over time is crucial for deciding on their potential removal or replacement. This study examines the aging of silicone prostheses materials, measuring the changes in the mechanical properties of the elastomeric shell and the viscosity of the inner gel after accelerated aging tests at various temperatures over a period exceeding two years. Predictive models based on the time-temperature superposition principle enable the estimation of mechanical performance over extended timeframes, providing valuable insights into the expected durability and lifespan of implants.

ELECTROSPUN PA12 NANOFIBERS: EFFECT OF SOLUTION PARAMETERS ON FIBER MORPHOLOGY

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Event: Top Conference 2025
Topic: nanocomposites

Carbon fiber-reinforced polymers (CFRPs) are widely used in different industries due to their exceptional mechanical properties and low density. However, delamination and poor vibration damping capacity pose significant challenges to their application. This study focuses on the production of nanofibrous polyamide 12 (Nylon 12) mats obtained through electrospinning, to improve the structural properties of epoxy CFRP laminates. Three different Nylon 12 solutions have been prepared using various solvents, and the process parameters for electrospinning have been optimized. The nanofibers produced by the solution with a mixture of formic acid and anisole solvent showed different morphologies depending on the solution concentration. An increase in Nylon 12 concentration leads to thicker, porous fibers. Thermal analysis has demonstrated that the electrospinning process does not alter the thermal properties of the polyamide. The results suggest that the use of PA12 nanofibrous membranes could represent a promising strategy for improving interlaminar fracture toughness in laminated CFRPs.

Design and Verification through Kinematic Coupled Static Analysis (FEM) of the DeltaPod Robot Load-Bearing Structure

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Event: Top Conference 2025
Topic: composites

This study explores the design and verification process for the load-bearing structure of the DeltaPod robot ABB IRB 390. By integrating kinematic analysis with static analysis using Finite Element Modeling, the structural integrity and operational precision of the robot are validated. The modular framework design prioritizes compactness, rigidity, and adaptability, enabling integration into industrial environments. Advanced simulation techniques, including rigid body dynamics and von Mises stress analysis, were employed to assess and optimize the framework's performance under operational loads. The findings confirm that the designed structure ensures precision, minimal displacement, and reliable performance, making it suitable for diverse industrial applications and the polymer science community.

Polymers with Dynamic (Reversible) Bonds: Advanced Materials for Sustainable Future

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Event: Top Conference 2025
Topic: polymer physics

It is well-known that the enormous volume of polymers produced in recent decades and their low recyclability creates enormous ecological problems. One of the potential solutions to improve their recyclability is a substitution of some covalent bonds in these materials by dynamic (reversible) bonds, such as hydrogen, ionic or dynamic covalent bonds (e.g., vitrimers). This makes polymer-based materials not only recyclable, but also enables unique properties such as self-healing, shape memory, time programmable behavior and extreme toughness [1-3]. The talk will overview studies of dynamics and viscoelastic properties of model polymers with dynamic bonds, emphasizing many current misconceptions [4,5] that should be avoided in analysis of these materials. Our studies revealed the important role of the so-called steric factor in the viscoelastic properties of systems with associative dynamic bonds (vitrimers). This factor is completely neglected in the vitrimers literature and can slow down the bond rearrangements by many decades. Based on a broad range of experimental data, we reveal the major mechanisms controlling viscoelastic properties of polymers with dynamic bonds and propose a general model describing their unique properties. At the end, we describe a way to sustainable polymers based on bio-derived chemicals with dynamic bonds that provide materials recyclable by design.

3D printing of shape stabilized Phase Change Material in HDPE and Expanded Graphite with enhanced thermal conductivity

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Event: Top Conference 2025
Topic: composites

Organic phase change materials (PCMs) have been widely exploited in passive cooling applications due to their ability to store latent heat in melting. Several studies were conducted on shape stabilization of PCMs, however, very few research was conducted in fused deposition of thermoplastic polymers loaded with PCMs. 3D printing offers advantages in the realization of complex geometries, making easier the realization of thermal management systems with high exchanging surface area with both device to be cooled and environment for heat dissipation. In this work, high density polyethylene is selecting as printable supporting matrix, because of its relatively low melting point which permits to process the blend without PCM degradation. A fatty acid mixture is selected as PCM for thermal management of electronic devices like batteries or photovoltaic cells. Expanded graphite (EG) is preliminary vacuum impregnated with the PCM to realize a first stabilization and enhance thermal conductivity, necessary for high charging/discharging rates. Subsequently, HDPE is melt compounded with the impregnated graphite, the blend is extruded and finally the obtained filament is printed. The result is a high PCM content composite with enhanced thermal conductivity, which does not present leakage issues upon PCM melting. HDPE plays a fundamental role for the shape stabilization, giving good mechanical properties to the final product, which demonstrate suitable for thermal management of electronic devices.

Nanofibrous Coatings of Poly(Lactic Acid) and NanoHydroxyapatite for Enhanced Biocompatibility of Titanium Implants

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Event: Top Conference 2025
Topic: nanocomposites

Electrospun nanofibrous coatings based on poly(lactic acid) (PLA) and bioactive nanohydroxyapatite (nHAp) are developed to enhance the biocompatibility and corrosion resistance of titanium implants for medical applications. The electrospinning process parameters are optimized to achieve uniform morphology of PLA nanofibers and PLA/nHAp composite fibers. The morphology and porosity of the fiber coatings were investigated by scanning electron microscopy. FTIR spectroscopy confirms the successful incorporation of nHAp into the PLA fibers, while electrochemical impedance spectroscopy demonstrates a significant improvement in corrosion resistance for the nanocomposite-coated titanium. Results show that the PLA/nHAp composite coatings prepared by electrospinning have promising features for applications in orthopedic and dental implantology.

Advanced characterizations of Gas-Polymer Interactions: Pioneering CCUS Research into ECCSELLENT Project

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Alma Mater - Università di Bologna

Event: Top Conference 2025
Topic: polymer physics

Human activities, mainly through greenhouse gas emissions, have unequivocally caused global warming, with global surface temperature reaching in the 2011-2020 decade 1.1°C above pre-industrial levels. Among the greenhouse gases, CO_2 emissions are the most significant, exceeding than 36 billion tons per year, with an increase of the atmospheric concentration of 1.5-2 parts per million (ppm) per year. Carbon Dioxide Capture, Utilization, and Storage (CCUS) has emerged as a key strategy to reduce atmospheric CO2 concentrations to 450 ppm by 2100, making it instrumental in achieving net-zero emissions.
As part of ECCSELLENT project the Department of Civil, Chemical, Environmental and Material Engineering (DICAM) of University of Bologna is committed to improve Italian research infrastructures in the CCUS field. The new research center focuses on preparation and characterization of innovative polymeric materials through physical, chemical and mechanical analysis. Novel polymers are developed and manufactured in various forms, such as thin coating, hollow fibers and self-standing films. The membranes separation efficiency, permeability and gas-polymer interactions are assessed through single and mixed gas permeation experiments. Physical properties are investigated using AFM to evaluate morphology, surface topography and thickness of active layer, while QCMD-D technique allow the determination of nanoscale properties through mechanical analysis.
To evaluate properties and performance of polymeric materials in CO_2 transportation (high pressure and low temperature), BET apparatus is used to characterize samples at cryogenic conditions. The effect of dense-phase CO_2 on polymer structural, mechanical and chemical properties are investigated through the use of FT-IR Spectroscopy and Broadband Dielectric spectroscopy (BDS).

Acknowledgement: This research was funded by the National Science Centre (Poland) under Grant No. UMO-2023/51/D/ST8/01325.

Physical Gelation of Poly(Vinyl Alcohol) Solutions by Freeze-Thawing: Role of Process Parameters on Chemical and Mechanical Properties of Hydrogels

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Event: Top Conference 2025

Topic: polymer chemistry

Hydrogels are hydrophilic polymer networks dispersed in water and reinforced by physical or chemical interactions. Their exceptional ability to absorb and retain large amounts of water supports their use in the medical and pharmaceutical sectors, where biocompatibility is an essential requirement. This property also makes them promising for space applications, especially for radiation protection, where their high hydrogen content plays a key role in mitigating the effects of ionizing radiation on astronauts and electronic equipment. In this work, physically cross-linked hydrogels are prepared using a poly(vinyl alcohol) (PVA) matrix, varying the freeze-thaw cycles and sonication times of the polymer solution. Analyses performed included chemical composition determined by Fourier transform infrared spectroscopy (FTIR), thermo-mechanical properties evaluated by dynamic mechanical analysis (DMA), water content, density and degree of crystallinity. The results obtained were used to study how the mechanical and chemical properties of the hydrogel vary with different preparation conditions.

Electrically Conductive Polyimide/Graphene Nanocomposites for Advanced Space Applications

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Event: Top Conference 2025

Topic: nanocomposites

Aromatic polyimides (PI) with high resistance to radiation combined with functional graphene-based fillers are promising materials for a wide range of space applications, such as those involving sensors, antibacterial coatings and external spacecraft or satellite components. In this work, nanocomposites made of a fluorinated and aromatic polyimide filled with graphene nanoplatelets (GNP) (different concentration from 5 to 20 wt%) are prepared following an eco-friendly approach with a bio-based solvent, dimethyl isosorbide (DMI), used for the polymer synthesis and the composite processing. Several experimental techniques are used to investigate the morphology and surface properties of the PI/GNP nanocomposites, assessing their potential application in space environments, in particular for low Earth orbit (LEO).

The effect of nanoclay on the rheological and mechanical properties of polybutylene succinate-based composites with different antimicrobial chitosan additives

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Event: Top Conference 2025

Topic: nanocomposites

Biobased plastics have great future growth potential by considering limited availability of fossil resources. Hence, polybutylene succinate (PBS)-based plastics are considered as important constituents for future biobased and biodegradable polymer composite materials market. Consequently, current research is devoted to elaboration of PBS based plastic formulation with improved processability, increased stiffness and strength, better barrier properties as well as antimicrobial effect. To reach the aim PBS homopolymer and copolymer are evaluated as potential matrices for thermoplastic composites. Organically modified nanoclay in the range of 0.5-8 wt.% is used as functional additive for improved stiffness, strength and rheological behaviour of the developed nanocomposites. For extended applicability different antimicrobial additives (including, chitosan and chitosan oligosaccharides with different molecular weights, deacetylation degrees and origins) are used in the concentration range from 3 to 10 wt. %. The composition of the developed PBS hybrid composites is designed with a projection not to exceed the total filler content of 20 wt%, thus maintaining it processability by a number of thermoplastics processing methods. Laboratory scale melt compounding technology of the designed PBS hybrid composites has been developed and optimal processing conditions have been determined based on rheological investigations. Particular attention has been addressed to evaluation of the addition on the antimicrobial chitosan additive to melt processing behaviour and mechanical performance of the developed hybrid composites. It has been determined that although processability window of the developed PBS hybrid composites is decreased by the chitosan additive, it demonstrated certain synergetic reinforcing effect together with nanoclay.

Slow liquid dynamics releases mechanical stress in polymers

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Event: Top Conference 2025
Topic: polymer physics

Stress in polymers relaxes on timescales often decoupled from the segmental motions and characterized by a constant activation barrier [1,2]. This talk will discuss the connection between this anomalous equilibration of mechanical stress and the recently identified slow Arrhenius process (SAP). The SAP is active both in the liquid and in the glassy state, and while slower than the α-process in the melt, it becomes faster than it, below the glass transition temperature [3,4]. The SAP is also intimately connected with the high-temperature flow (which shares the same activation barrier) and has been associated with several equilibration kinetics [3]. By combining rheology, dielectric spectroscopy, and fluorimetry and reviewing data from the literature, we discuss the possible role of the SAP in equilibrating stresses in nanoconfined polymers and show that it provides an additional source of mobility in the glassy state.

Degradation of Environmentally-friendly Stabilized HDPE Under Accelerated Weathering Conditions

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Event: Top Conference 2025
Topic: polymer physics

High Density Polyethylene (HDPE) is a very popular material of choice for multiple applications spanning from packaging to pipe. Due to its excellent properties, mainly low cost, ease of fabrication, and being modifiable for the enhancement of mechanical properties. Despite all of the advantageous properties of HDPE, it is still prone to degradation. One prominent choice for HDPE stabilization is Irganox 1010. Irganox 1010 has posed some concerns to be used in food-contact and medical applications as it may leach out as a toxic chemical throughout the lifetime of the product. This work is aimed to evaluate the degradation of HDPE using widely-used stabilizer that is posing environmental concerns against a more environmentally-friendly stabilizer. Accelerated UV weathering technique were utilized to test the performance of each additive. FT-IR analysis showed that overall carbonyl index calculation can be used as an effective method to measure degradation of HDPE samples. It is noted that Irganox 1010 and Vitamin E performed similarly in stabilizing HDPE samples enduring 2 weeks of UV weathering, or 1.7 months of Arizona sun equivalent. This is an important finding as Vitamin E proves to be an adequate alternative to Irganox 1010.

Harnessing Black Soldier Flies for Sustainable Bioplastic Production: Advancing Circular Economy through Chitin Extraction and Material Characterization

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Event: Top Conference 2025
Topic: polymer physics

The utilisation of black soldier flies (BSF) as a sustainable resource for bioplastic production presents a transformative opportunity to advance circular economy principles. BSF larvae efficiently convert organic waste into valuable biomass, leaving behind chitin-rich exoskeletons during their life cycle. This chitin can be extracted and chemically processed into chitosan, serving as a biodegradable and renewable precursor for bioplastics. By repurposing BSF waste, this approach addresses two critical environmental challenges: reducing plastic pollution and managing organic waste.

Thermal analysis plays a pivotal role in characterizing the thermal stability and degradation behaviour of BSF-derived bioplastics. This data ensures the optimisation of processing conditions and end-use performance. Additionally, rheological measurements assess flow behaviour and molecular weight indications, providing insights into its processability and suitability for diverse applications. Targeted applications are packaging, wound healing gauzes and diversely water treatment and aquaculture where chitosan is a flocculant removing bacteria and heavy metals.

The integration of thermal analysis and rheology facilitates the fine-tuning of material properties, ensuring that BSF-based bioplastics meet industrial standards and functional requirements. This novel material stream not only reduces reliance on petroleum-based plastics but also utilises organic waste, fostering a circular economy. By closing the loop between waste generation and material production, BSF-derived bioplastics represent a sustainable innovation with significant environmental and economic benefits. Ongoing research continues to optimize chitin extraction, paving the way for broader commercial adoption and scalable production. This presentation will give an introduction to the research of BSF bioplastic creation and characterisation.

Micro & Nanoplastics in the Environment: Detection, Occurrence, Fate, and Impact

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Event: Top Conference 2025
Topic: polymer chemistry

Plastics can be quite complex materials, as they combine the intrinsic variability of the macromolecular structure with the additional properties from additives and chemical modifications possibly occurring during production and processing. Ageing causes a multiplicity of chemical and physical transformations, which can drastically modify their physical properties and chemical reactivity. Finally, the exposure and interactions with the different environmental compartments, that is facilitated by the transport of lightweight plastic items and fragments through waterways, soil, and the atmosphere, may result in further increase of complexity due to adsorption of organic and inorganic pollutants, along with biofouling. Therefore, addressing the issue of micro- or even nano-plastic detection, characterization and interaction with living organisms is extremely challenging. Nonetheless, this is only a part of the whole picture, as the actual harm to the environment is not limited to the consequences of the interaction with increasingly small particulate (down to the nanometer) capable of entering the organisms and even the cells, or the contact of the polymer particle surface with sensitive biological tissues and membranes. A more deceptive but possibly even more serious threat is represented by the molecular degradation products continuously released by ageing plastic particles. The results of our multifocal approach will be outlined, encompassing the development of accurate mass-based quantification protocols for plastic particles in complex environmental matrices (P.I.S.A., Polymer Identification and Specific Analysis), the study of the degradation products and of their interactions with living organism (from micro to plants and humans), and potential for environmental self-remediation.

Innovative Approaches to Sustainable Materials and Surface Treatments for Household Appliances

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Event: Top Conference 2025
Topic: polymer physics

Thermoset plastics, commonly used in household appliance components, are experiencing an annual growth rate exceeding 4% due to their exceptional heat and solvent resistance. Recycling thermosets presents significant challenges due to their cross-linked structures, which traditionally hinder reprocessing and reintegration into production cycles.
Addressing this, this project aims to redefine the production processes of the industrial partner through a circular economy lens. The project investigates innovative methods for recycling production and post-consumer waste, replacing current thermoset polymers with recyclable thermoplastics, including biopolymers. Furthermore, it explores advanced surface finishing technologies with reduced environmental impact.
This study focuses on developing eco-friendly chromium plating processes for phenolic resins. Traditional electroplating of thermoset polymers relies on chemically intensive pretreatments, hindering sustainability goals. By incorporating conductive fillers—carbon black, graphene, and carbon nanotubes—into the resin matrix, pre-treatment steps such as acid washing and electroless nickel plating can be eliminated. Among the fillers, carbon nanotubes achieved the highest conductivity, enabling a simplified plating cycle that retained comparable coating quality to the conventional method.
The results highlight the potential of conductive fillers to streamline electroplating while aligning with the broader goals of this project: reducing resource consumption, improving recyclability, and advancing green technologies. This integration fosters the development of sustainable, high-performance components, offering significant market opportunities for eco-friendly solutions in household appliance production.
This research activity has been financed by the Fondazione Cassa di Risparmio di Trento e Rovereto (CARITRO, Grant number 2022.0489) within the project “Sviluppo di componenti per elettrodomestici eco-sostenibili tramite materiali plastici innovativi (ELETTROPLAST)”.

Shape Memory Composites from Bio-based Benzoxazine/Urethane Copolymers Filled with Graphene Having Multi-actuation Capability

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Event: Top Conference 2025
Topic: nanocomposites

In this work, shape memory polymers (SMPs) were developed from a combination of benzoxazine (BZ) monomer and polyurethane prepolymer (PU-prepolymer), both derived from bio-based raw materials. The bio-based BZ monomer (V-fa monomer) was synthesized through a Mannich condensation reaction using vanillin, paraformaldehyde, and furfurylamine. The bio-based PU-prepolymer was obtained by reacting palm oil polyol (MW = 1400 Da) and toluene diisocyanate (TDI). To investigate the curing behavior of the poly(Vfa/Urethane), with a mass ratio of 50/50, differential scanning calorimetry was employed. The structure of the resulting poly(V-fa/Urethane) was confirmed using Fourier transform infrared spectroscopy. Furthermore, the synthesized V-fa/Urethane copolymers with weight ratios of 70/30, 60/40, 50/50 and 40/60 were observed to exhibit shape memory behaviors induced by Near-inferred irradiation (808 nm). The poly(V-fa/Urethane), specifically with a mass ratio of 50/50, demonstrated superior shape memory performance. It exhibited a remarkable capacity to retain the temporary shape up to 90%, achieve 99% shape recovery, and exhibit a recovery time of 25 s. The shape memory properties were further improved with the addition of 3wt% graphene nanoplatelets (GNPs), ex-hibiting an improvement in shape fixity value to 94%, and shape recovery time value to 16 s. Moreover, our findings suggest that the 60/40 poly(V-fa/Urethane) reinforced with 3wt% GNPs possess favorable characteristics for applications as multiple SMPs, with shape fixity values of 97% and 94%, and shape recovery values of 96% and 89% for the first and second shapes, respectively.

Hydrogel patches modified with an active substance for use in alleviating migraine symptoms

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Event: Top Conference 2025

Topic: polymer chemistry

Migraine is a chronic neurological disorder of unknown etiology affecting approximately 148 million people worldwide. Modern medicine provides numerous pain-relieving solutions for soothing headaches and migraines, but none of them are entirely free of drawbacks. The most commonly used menthol-based hydrogel patches provide a cooling effect, however menthol's intense odor may limit the effectiveness of the therapy or even worsen symptoms. An alternative could be plant extracts such as butterbur (Petasites) and feverfew (Tanacetum parthenium), which are known for their anti-migraine properties but have not yet been used in hydrogel formulations. This solution may contribute to the development of more effective and long-lasting treatments. The aim of this research was to design, synthesize, and in situ modify hydrogel materials using natural active substances, as well as to investigate the physicochemical properties of the obtained patches intended for alleviating migraine symptoms.

Hydrogels were synthesized from agar and poly(vinyl alcohol) in different ratios. The cross-linking process was carried out using sodium tetraborate as a cross-linking agent and a single cycle of freeze-thawing. The next step involved the in situ modification of hydrogel compositions with active substances derived from plants: butterbur and feverfew extracts.

In order to analyze the properties of hydrogel materials, measurements of swelling, density, and contact angle were performed, along with optical microscopy observations. Average molecular weight between cross-links and crosslinking density were calculated based on the results. Lastly, release of active substances from hydrogel matrix were assessed with UV-Vis spectrophotometry.

The obtained safe, natural-based hydrogel materials were found to be highly absorbing, reaching up to 1700% swelling in 24 hours and capable of being combined with fabric to form a prototype migraine patch. Furthermore, the release of active substances from the hydrogels was confirmed.

Characterization of the crystallization susceptibility of biodegradable thermoplastic starch-based compositions during injection molding

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Topic: polymer physics

The development of biodegradable polymer compositions is a response to the problem of increasing amounts of plastic waste. Thermoplastic starch is produced from renewable sources, and its production costs are significantly lower than plastics of petrochemical origin. Biodegradable materials based on thermoplastic starch offer a promising solution, although their composition has limited applicability at elevated temperatures, which hinders its use in areas like the food industry.

The aim of this study was to develop biodegradable cutlery from compositions based on thermoplastic starch with increased resistance to high temperature and further examining the effect of the commercially available additive, used as a nucleation initiator, on thermal and mechanical properties of obtained compositions.

Firstly, biocompositions were prepared with the commercial additive in different ratios, injected into molds heated to 95, 100, and 105°C. Differential scanning calorimetry was performed to determine the optimal amount of the additive for obtaining thermal resistance above 60°C. Thermoplastic starch-based compositions were then processed to obtain cutlery, paddles, and beams samples. Basic properties of obtained materials were characterized including density, melt flow rate, melt volume rate, tensile strength, flexural strength, and impact strength according to Izod and Charpy methods. Selected cutlery samples were tested under home composting conditions according to DIN EN 17428 standard. Results of the research confirmed that the commercially-available additive enhances the thermal resistance of the obtained biodegradable compositions, while maintaining satisfactory mechanical properties, making them suitable for the production of everyday use products, contributing to sustainable development and the reduction of plastic waste.

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