XXVI Convegno Nazionale

XXVI CONVEGNO AIM

ASSOCIAZIONE ITALIANA di SCIENZA e TECNOLOGIA delle MACROMOLECOLE



Torino, 6-9 Settembre 2026



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Il PROGRAMMA

Plenary lecture
Keynote lecture

Polimeri da fonti rinnovabili e degradabili, riciclo
Materiali polimerici ibridi e (nano)compositi: sintesi, caratterizzazione e applicazioni
Processabilitá e stampa 3D di materiali polimerici
Chimica e fisica dei polimeri

DOMENICA 6 SETTEMBRE

Politecnico di Torino – Corso Duca degli Abruzzi 24

18:00		Registrazione
19:00		Welcome party

LUNEDÌ 7 SETTEMBRE

Polo Biotecnologico dell'Università di Torino (Via Nizza 52)

8:30		Registrazione
9:00		**Apertura lavori - Sala Keplero**
		Chairperson: R. Bongiovanni
9:10	**PL1**	**Y. Leterrier** (Ecole Polytechnique Fédérale de Lausanne) Robust superhydrophobic composite surfaces
10:00	**KN1**	**A. Dodero** (University of Fribourg) Block copolymer self-assembly in emulsions: from structural-color microparticles to multifunctional and reprogrammable photonics
10:30		*Coffee break*

PARALLEL SESSIONS

		Sala Keplero		**Sala Leonardo**
		Chairperson: M. Salzano de Luna		*Chairperson: R. Simonutti*
11:00	**O1.1**	**A. Barbato** (Università di Salerno) Development of active biodegradable PLA/PBSA films containing blueberry waste antioxidants extracted using nades as green solvents	**O3.1**	**A. Bardelli** (Università di Genova) From marine plastic litter to 3D printing: optimising blended polyolefin formulations for additive manufacturing
11:15	**O1.2**	**B. Brugnoli** (Università di Roma – La Sapienza) Multifunctional eugenol-based nanogels through copolymer design: antioxidant activity, intrinsic fluorescence, and drug encapsulation	**O3.2**	**R. Di Girolamo** (Università di Napoli Federico II) In situ stereocomplex formation during melt extrusion: an efficient nucleating strategy for crystallization of high-molecular weight PLA
11:30	**O1.3**	**A. D'Ilorio** (Università di Ferrara) Solvent-free grafting of pbs oligomers onto cellulose nanofibers for enhanced biocomposite compatibility	**O3.3**	**A. Sorze** (Università di Trento) Effect of natural fillers as substitutes for glass fibers in polyamide 6 composites for large-format additive manufacturing
11:45	**O1.4**	**M.R. Acocella** (Università di Salerno) Mechanochemical polymer-to-polymer recycling of polylactic acid	**O3.4**	**E. Togliatti** (Università di Parma) Influence of graphene on the electrical and mechanical properties of SLS-printed PA11
12:00	**O1.5**	**F. Bisio** (Università del Piemonte Orientale) (Meth)-acrylated tannic acid as a bio-based adhesion promoter for EB-curable coatings	**O3.5**	**D. Rigotti** (Università di Trento) Fused filament fabrication of TPU/PCM composites for thermally active wearable sport applications
12:15	**O1.6**	**G. Damonte** (Università di Genova) Environmentally friendly upcycling of PHA-based copolymers into branched multifunctional oligomers	**O3.6**	**A. Caccini** (Politecnico di Milano) Extending rubber fracture characterisation methods to layer adhesion assessment in 3D-printed TPU
12:30		Lunch time		

LUNEDÌ 7 SETTEMBRE (cont.)

		Sala Keplero		
		Chairperson: K. Sparnacci		
14:30	**KN2**	**V. Ambrogi** (Università di Napoli Federico II) Rethinking epoxy thermosets: from dynamic networks to circular materials		
		SESSIONI PARALLELE		
		Sala Keplero		**Sala Leonardo**
		Chairperson: P. Stagnaro		*Chairperson: C. Marano*
15:00	**O1.7**	**M. Calosi** (Università di Ferrara) Amorphous blends of PLA and PHA for waterborne coatings and foam applications	**O2.1**	**A. Bifulco** (Università di Napoli Federico II) Transparent and self-extinguishing silica-epoxy nanocomposites based on Novolac resin
15:15	**O1.8**	**R. Chiarcos** (Università del Piemonte Orientale) Investigation into the potential of poly(β-amino ester)-based vitrimers	**O2.2**	**L. Broggio** (Università di Trento) Solvent-free processing of high β-phase poly(vinylidene fluoride) films for energy conversion applications
15:30	**O1.9**	**S. Alfano** (Università di Roma – La Sapienza) Formulation and characterization of polyhydroxyalkanoate blends with waste protein fibers for packaging application	**O2.3**	**E. Buratti** (Università di Ferrara) Hybrid microgels based on PNIPAM and natural proteins: from molecular interactions to biomaterial applications
15:45	**O1.10**	**A. Giovagnoli** (Università di Bologna) Development and industrial processing of cellulose-based materials for rigid packaging applications	**O2.4**	**M.T. Letizia** (Istituto Universitario di Studi Superiori Pavia) Towards sustainable electrical cable insulation: design of a novel polyethylene-based composite system
16:00	**O1.11**	**D. Gaikwad** (Università Milano Bicocca) Use of fruit peels for the development of bio-based hydrogels	**O2.5**	**C. Ciarlantini** (Università di Roma – La Sapienza) Cyclodextrin-grafted chitosan scaffolds for enhanced curcumin delivery
16:15	**O1.12**	**G. Filippone** (Università di Napoli Federico II) Effect of processing pressure on the interfacial shear strength in short fiber biocomposites: implications for manufacturing	**O2.6**	**B. Bertoncini** (Università di Pisa) Long vs. short chain covalent functionalization in the preparation of mechanochromic polymers
16:30		*Coffee break*		
18:00		*Torino Tour – Ritrovo in Piazza San Carlo, di fronte al monumento*		

MARTEDÌ 8 SETTEMBRE

Polo Biotecnologico dell'Università di Torino (Via Nizza 52)

Sala Keplero

Chairperson: G. Malucelli

9:00	**PL2**	**D. Beneventi** (University Grenoble Alpes) Cellulose fibres and derivatives: from traditional papermaking to advanced additive manufacturing
9:50	**KN3**	**S. Losio** (Istituto di Scienze e Tecnologie Chimiche) Cyclic olefin based copolymers via transition metal catalysis: bridging synthesis and functional application
10:20		*Coffee break*

SESSIONI PARALLELE

		Sala Keplero		**Sala Leonardo**
		Chairperson: A. Dorigato		*Chairperson: A. Pucci*
10:50	**O2.7**	**A. Bianucci** (Politecnico di Milano) Effect of silane coupling agent content on strain-induced cavitation in silica-filled SBR	**O4.1**	**C. Cecone** (Università di Torino) Electrospun membranes obtained from plant proteins and maltodextrins for the treatment of gadolinium-contaminated wastewater
11:05	**O2.8**	**S. Gabellini** (Università di Bologna) Synthesis and nanostructuration of DPP-based fluorescent polyesters for bioimaging	**O4.2**	**M. Turriani** (Università di Pisa) From amphiphilic random copolymers to functional nano-chelators: a new strategy for radionuclides sequestration
11:20	**O2.9**	**C. Imparato** (Università di Napoli Federico II) Silica-based nanostructured mixed oxides via sol-gel for the enhancement of fire resistance and recyclability of epoxy resins	**O4.3**	**L. Tosato** (Università di Bologna) A novel melamine-free waterborne intumescent coating for fire protection of wood
11:35	**O2.10**	**L. Gianoglio** (Università di Torino) Electrospun maltodextrin-derived carbon fibers: a sustainable platform for gold-based catalysts	**O4.4**	**J.A. Talamo Ruiz** (Politecnico di Torino) Electrospinning and solution blow spinning of water-based polymer solutions for the sustainable manufacturing of nanofibrous mats
11:50	**O2.11**	**A. Liguori** (Università di Bologna) Multifunctional and sustainable vitrimer systems	**O4.5**	**M. Scoti** (Università di Napoli Federico II) Tacticity-independent crystallization as a design strategy for chemically recyclable semicrystalline polymers
12:05	**O2.12**	**A. Nicosia** (Università di Catania) Functional polymers for the optical detection of amines: from bio-inspired to natural sensing units	**O4.6**	**G. Pignatiello** (Università di Napoli Federico II) Structure-property relationships in biopolymeric cryogels produced by freeze-casting
12:20	**O2.13**	**M. Righetti** (Università di Torino) Intercalated sodium bentonite in thermoplasticized corn starch: tuning oxygen barrier and mechanical performance for flexible food packaging applications	**O4.7**	**F. Olla** (Politecnico di Milano) Pressure-induced crystallization and polymorphic transitions of polybutene-1: high-pressure PVT study
12:35	**O2.14**	**F. Passoni** (Politecnico di Milano) Study of the high-pressure H_2 exposure effect on the mechanical behaviour of nbr based compounds	**O4.8**	**E. Guazzelli** (Università di Pisa) HEMIN-based amphiphilic random copolymers as biomimetic and recyclable catalysts for ARGET-ATRP in water
13:00		Lunch time		

MARTEDÌ 8 SETTEMBRE (cont.)

	Sala Keplero			
	Chairperson: P. Bracco			
14:30	**KN4**	**C. Zagni** (Università di Catania) Functionalized polymeric materials: versatile macromolecular platforms for pharmaceutical and environmental applications		
	SESSIONI PARALLELE			
		Sala Keplero		**Sala Leonardo**
		Chairperson: P. Russo		*Chairperson: D. Caretti*
15:00	**O1.13**	**M. Colombo** (Politecnico di Milano) Structural control and amyloid reinforcement of waste-derived protein films	**O2.15**	**L. Simonini** (Università di Trento) Development and characterization of sandwich composites with thermal management and mechanical properties
15:15	**O1.14**	**V. La Matta** (Università di Napoli Federico II) Prospective life cycle assessment of tyre manufacturing: evaluating industrial decarbonisation pathways	**O2.16**	**R. Medri** (Università di Bologna) Eco-friendly dye–porphyrin copolymer for organic solar cells: from ternary donor to interfacial layer
15:30	**O1.15**	**N. Ferrentino** (Università di Salerno) From thiol-ene chemistry to bio-based polymeric networks: multifunctional limonene-derived materials	**O2.17**	**A. Riccioni** (Politecnico di Torino) Furanized cellulose nanocrystals for the preparation of diels-alder rubber composites
15:45	**O1.16**	**C. Di Bernardo** (Politecnico di Torino) Emerging concepts for sustainable biocomposites	**O2.18**	**R. Rossi** (Università di Firenze) Smart polymeric architectures based on photoswitches: from adhesives to responsive nanocarriers
16:00	**O1.17**	**A. Longo** (IPCB-CNR) Tuning PLLA Crystallization Kinetics via Reactive Extrusion Branching Strategies	**O2.19**	**P. Stagnaro** (SCITEC-CNR) Engineered polymer-based composites for radiative cooling systems
16:15		*Coffee break*		
16:30	**O1.18**	**M. Mollo** (Politecnico di Torino) Designing vanillin-based dynamic networks for the development of sustainable thermosets for future generation composites	**O2.20**	**L. Vitiello** (IPCB-CNR) Enhanced hydrolytic degradation of pla green composites by nanometric zno covalently bound on natural fibres via ALD
16:45	**O1.19**	**E. Pellegrino** (Politecnico di Torino) Melt-processing of dialcohol cellulose fibres/starch blends: processing strategies, structure and properties	**O2.21**	**V. Spinoso** (Università di Firenze) Capacitive sensor based on porous liquid crystalline gel
17:00	**O1.20**	**V. Giglio** (IPCB-CNR) Beyond biodegradability: comparative lc-ms profiling of plastic additive release from fossil-based and biodegradable agricultural mulch films into soil	**O2.22**	**A. Pucci** (Università di Pisa) Pyrolysis-derived telechelic polypropylene as a mechanochromic probe for visualizing stress redistribution and cavitation in polyolefin-based materials
17:15	**O1.21**	**C. Invigorito** (Anton Paar) Multiscale polymer analysis: correlating chemical structure, thermal behavior, and rheological response through complementary analytical techniques		
17:30		*Assemblea dei Soci*		
18:00		*Sessione Poster*		
20:30		Cena di gala @OGR Officine Grandi Riparazioni, Corso Castelfidardo, 22		

MERCOLEDÌ 9 SETTEMBRE

Polo Biotecnologico dell'Università di Torino (Via Nizza 52)

Sala Keplero

Chairperson: M. Zanetti

9:00	**PL3**	**A. Figoli** (Istituto per la Tecnologia delle Membrane - CNR) Innovative polymerised tailored membranes for gas and liquid applications
9:50	**KN5**	**D. Martella** (Università di Firenze) 3D printing meets liquid crystal polymers: responsive materials across different scales and applications
10:20		*Coffee break*

SESSIONI PARALLELE

		Sala Keplero		Sala Leonardo
		Chairperson: M. Messori		*Chairperson: M. Castellano*
10:50	**O1.21**	**D.H. Lamparelli** (Università di Salerno) When molecular imperfection works: sustainable polyester copolymers with industrial potential	**O2.23**	**P. Rizzo** (Università di Salerno) From hydrophobic to high-performance water filled polymeric films: a new paradigm in water purification materials
11:05	**O1.22**	**P. Russo** (IPCB-CNR) Natural antioxidant effect of hazelnut shell powder in PBS biocomposites under accelerated UV aging	**O2.24**	**S. Scurti** (Università di Bologna) Missive bottle-brush copolymers for soft opto-electronic via orthogonal polymerization
11:20	**O1.23**	**C. Noè** (Politecnico di Torino) Bio-based and antifungal by design: UV-cured eso/essential oil composites for next-generation active packaging	**O2.25**	**A. Dorigato** (Università di Trento) eEvaluation of the self-healing behaviour of multifunctional thermoplastic composite laminates
11:35	**O1.24**	**C. Pellecchia** (Università di Salerno) Engineering circular polyesters through molecular architecture: from thermoplastic elastomers to dynamic covalent networks	**O2.26**	**G. Proietto Salanitri** (Università di Bologna) Functional polymer hybrid hydrogels for multi-adsorption of oppositely charged emergent pollutants
11:50	**O1.25**	**R. Sergi** (Università di Roma – La Sapienza) Eugenol-derived polymeric networks as eco-friendly and circular wet-strength agents for high-performance paper products	**O2.27**	**C. Parmeggiani** (Università di Firenze) Shape-changing polymeric microparticles based on liquid crystal emulsions
12:05	**O1.26**	**F. Cano** (Università di Torino) Mechanical recycling of multi coupled material body seals based on thermoplastic elastomers in the automotive industry	**O2.28**	**R. Simonutti** (Università di Milano Bicocca) Fabrication of porous microparticles by RAFT polymerization
12:20			**O2.29**	**A. Fusari** (Politecnico di Milano) Investigating bacteria-driven alginate hydrogel matrix degradation: a rheological framework to discriminate between crosslinker depletion and backbone cleavage
13.00		Lunch time		

MERCOLEDì 9 SETTEMBRE (cont)

	Sala Keplero	
	Chairperson: G. Filippone	
14:00	**KN6**	**M. Bertoldo** (Università di Ferrara) Polyesters in water: from dispersion strategies to functional applications
14:30	**KN7**	**D. Natali** (Ecole Polytechnique Fédérale de Lausanne) *Macrogiovani 2026 Winner* 4D-Printable shape morphing double network granular elastomers (DNGEs)
15:00		Conclusioni e saluti finali
15:30		Coffee break

LISTA DEI *la* POSTERS

POSTER

Polimeri da fonti rinnovabili e degradabili, riciclo	
P1.1	**B. Cavallo** (Università di Torino) Development of cellulose fibers recovery strategy from siliconized papers
P1.2	**M. Ceraulo (Università di Palermo)** PBAT/grape pomace biocomposite for film blowing applications
P1.3	**S. Coiai (ICCOM-CNR)** Antioxidant and UVv-blocking poly(butylene succinate) films via nitroxide radical coupling functionalization
P1.4	**E. Di Francesco (Università di Genova)** Thermal method to recover glass fibers from epoxy resin composites
P1.5	**M. Di Maro (STEMS-CNR)** Influence of fast pyrolysis bio-oil-derived phenolic-rich fraction on PLLA UV stability
P1.6	**G. Fredi (Università di Trento)** Polyethylene glycol-assisted film stacking of polylactide/bacterial cellulose nanocomposites for sustainable food packaging
P1.7	**L. Gianoglio (Università di Torino)** Biopol4Soil- Bioderived polymeric granules and non-woven fabrics for sustainable agriculture:biodegradability and phytotoxicity evaluation
P1.8	**C. Meo** (Università di Ferrara) Characterization of hydrolyzed polyesters from agro-waste: effect of extraction conditions on composition
P1.9	**M.C. Mistretta (Università di Palermo)** Influence of glochids and xompatibilizer on the rheological, mechanical and biodegradation behaviour of PBAT and PLA biocomposites
P1.10	**P. Scarfato** (Università di Salerno) Circular valorization of post-consumer polyurethane foams through mechanical recycling and sustainable composite design
P1.11	**R. Simonutti** (Università di Milano Bicocca) Itaconic Acid: a sustainable platform alternative to acrylic acid in radical polymerization
P1.12	**S: Zeynalova** (Politecnico di Torino) Biobased vitrimers using eutectic hardener systems

Materiali polimerici ibridi e (nano)compositi: sintesi, caratterizzazione e applicazioni	
P2.1	**E. Caianiello** (IPCB-CNR) Graphene oxide functionalization of bacterial cellulose: effects on the structure and adsorption performance
P2.2	**F. Cicogna** (ICCOM-CNR) Residual antioxidant activity of winery by-product biofillers in LDPE and HDPE composites
P2.3	**L. Conzatti** (SCITEC-CNR) Upcycling hazelnut by-Products into functional elastomeric composites for sustainable sports surfaces
P2.4	**R. D'Auria** (IPCB-CNR) Development of lignin-containing biodegradable polymer blends for fishing net applications
P2.5	**D. Errico** (Università di Ferrara) Preparation and characterization of thermoresponsive films obtained from hybrid PNIPAM/silk fibroin systems
P2.6	**T. Landovsaky** (Institute of Physics of the Czech Academy of Sciences) Stabilization of magnetic nanoparticles in liquid crystalline polymers via tailor-made ligands
P2.7	**V. Fiore** (Università di Palermo) Development of PBSA-based biocomposites reinforced with ceiba speciosa natural fibres
P2.8	**G. Malucelli** (Politecnico di Torino) Physics-informed machine learning for predicting optical transmittance and haze in transparent wood
P2.9	**G. Malucelli** (Politecnico di Torino) Preparation and characterization of UV-LED curable bio-based coatings containing polymeric carbon dots
P2.10	**G. Malucelli** (Politecnico di Torino) Sustainable transparent wood based on bio-based isobornyl acrylate/methacrylate matrices
P2.11	**M. Morreale** (Università di Enna "Kore") Microplastics release from pp-based blends and nanocomposites
P2.12	**P. Stagnaro** (SCITEC-CNR) Sustainable routes to lead-free flexible piezoelectric polymer-ceramic films for energy harvesting

Processabilitá e stampa 3D di materiali polimerici	
P3.1	**R. Arrigo** (Politecnico di Torino) Processing as a design tool for tailoring microstructure and properties in complex polymer systems

Chimica e fisica dei polimeri	
P4.1	**A. Bandini** (Università di Pisa) Fluorine-free proton exchange membranes: synthesis and characterization of sulfonated PPO-PBI networks for pemwes
P4.2	**A. Frache** (Politecnico di Torino) Towards circular flame-retarded polypropylene: fire performance after recycling and aging
P4.3	**S. Pragliola** (Università di Salerno) Design of carbazole-functionalized poly(triphenylamine)s for VISIBLE-driven water remediation

Il COMITATO SCIENTIFICO



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Maria Graziella Viola

Ecco i

PLENARY SPEAKERS



Ives Leterrier

EPFL Zurigo
Svizzera



Davide Beneventi

CNRS Grenoble
Francia



Alberto Figoli

ITM-CNR
Italia

PLENARY SPEAKERS

Plenary Lectures

ROBUST SUPERHYDROPHOBIC COMPOSITE SURFACES

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The presentation is an overview of the activities carried out at the EPFL to produce robust bioinspired polymer composite surfaces [1]. Focus is on integrative synthetic strategies based on photopolymerization to achieve superior property combination such as self-cleaning, antireflectivity and wear-resistance. Hybrid organic-inorganic nanocomposites are produced using acrylate, epoxy and organosilane precursors with surface-treated silica nanoparticles and microfibrillated cellulose via a dual cure photopolymerization and thermal condensation process [2]. The dynamics of network formation are investigated using photo-hyphenated methods such as photo-rheology and photo-calorimetry. The optimization of the dual cure sequence, with the right timing of the photo-exposure vs. condensation leads to an improved printability and nanoscale shape fidelity owing to a reduced viscosity, and a superior hardness, up to several 100 MPa with a high loading of preformed particles. The addition of a reactive surfactant into the hybrid formulation further enables to control the surface energy of the composite via an enthalpy gradient migration from the bulk to the composite-air interface [3]. The subsequent replication of the surface of lotus leaves and rose petals with hierarchical roughness leads to superhydrophobic surfaces that are wear-resistant [4,5]. Ongoing work investigates photo-reversible chemistries to add self-repair and reshaping performance to the property portfolio.

1. González Lazo M.A., Katrantzis I., Dalle Vacche S., Karasu F., Leterrier Y., A Facile in Situ and UV Printing Process for Bioinspired Self-Cleaning Surfaces, Materials, 9, 738 (2016). DOI 10.3390/ ma9090738.
2. Poothanari M.A., Schreier A., Missoum K., Bras J., Leterrier Y., Photo-Cured Nanocellulose Composites: Recent Advances, ACS Sustainable Chem. Eng. 10, 3131−3149 (2022). DOI 10.1021/ acssuschemeng.1c07631.
3. Wasser L., Dalle Vacche S., Karasu F., Müller L., Castellino M., Vitale A., Bongiovanni R., Leterrier Y., Bio-Inspired Fluorine Free Self-Cleaning Polymer Coatings, Coatings, 8, 436 (2018). DOI 10.3390/coatings8120436.
4. Cully P., Karasu F., Müller L., Jauzein T., Leterrier Y., Self-Cleaning and Wear-Resistant Polymer Nanocomposite Surfaces, Surf. Coat. Technol., 348, 111–120 (2018). DOI 10.1016/j.surfcoat.2018.05.040.
5. Balkan A., Sola E., Karasu F., Leterrier Y., Photo-Curable Thiol-Ene / Nanocellulose Elastomeric Composites for Bio-Inspired and Fluorine-Free Superhydrophobic Surfaces, ACS Appl. Mater. Interfaces, 16, 61144−61156 (2024). DOI 10.1021/acsami.4c16445.

CELLULOSE FIBRES AND DERIVATIVES: FROM TRADITIONAL PAPERMAKING TO ADVANCED ADDITIVE MANUFACTURING

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Cellulose and its derivatives have long been base raw materials in the paper, board, and textile industries, with more limited but well-established roles as functional additives in battery manufacturing, coatings, and food processing.

Over the past fifteen years, the emergence of cellulose nanofibers (CNFs) and cellulose nanocrystals (CNCs) has substantially broadened the accessible propertyies space of these materials. Namely, from high-strength natural fibres to film-forming soluble derivatives, with microfibrillated cellulose and nanocelluloses occupying an intermediate space of tunable mechanical and physicochemical characteristics.

A key enabler for additive manufacturing has been the specific rheological behaviour of nanocellulose-based hydrogels: shear-thinning under nozzle flow and rapid structural recovery upon deposition. This has overcome the historically poor processability of native cellulosic fibres, paving the way to cold-extrusion 3D printing of cellulose pastes, hydrogels, and composite inks.

Application domains span a surprisingly broad range. Indeed, beyond the most cited example of tissue engineering scaffolds, the literature reports CNF hydrogels for stimuli-responsive drug delivery, conductive nanocellulose composites for flexible pressure sensors and wearable electronics, electrodes for enzymatic biofuel cells and electrochemical biosensors, as well as structural components with high thermomechanical performance from thermoset biocomposite pastes. The biodegradability, non-toxicity, and renewability of nanocelluloses make them particularly attractive across all these contexts.

This contribution provides an overview of how cellulose, in its various forms, has been formulated into hydrogels and composite pastes for the additive manufacturing of functional devices and structural objects, and of where this rapidly evolving field currently stands.

INNOVATIVE POLYMERISED TAILORED MEMBRANES FOR GAS AND LIQUID APPLICATIONS

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Membrane technology is applied with success in many industrial fields and in some of them, as desalination and wastewater treatment, it can be considered a dominant technology.
Recently, innovative polymerizable functionalized membranes have been developed and the possibility of tailoring them allowed to use for a wider number applications.
Three case studies on innovative polymerized membranes in water treatment, gas separation and water electrolysis for producing green hydrogen will be reported and discussed in details, showing the potentiality and the versatility of this innovative approach [1-4]. Moreover, several factors, as the operating parameters and the membrane functionalities materials, influencing the performance of the membrane process will be discussed and future prospects will be also highlighted.

References

1. F. Galiano, A step forward to a more efficient wastewater treatment by membrane surface modification via polymerizable bicontinuous microemulsion, Journal of Membrane Science, 482 (2015) 103
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I
KEYNOTES

BLOCK COPOLYMER SELF-ASSEMBLY IN EMULSIONS: FROM STRUCTURAL-COLOR MICROPARTICLES TO MULTIFUNCTIONAL AND REPROGRAMMABLE PHOTONICS

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Controlling structural color through scalable, precise, and multifunctional materials design remains a central challenge in the development of next-generation photonic materials. Here, we present a versatile approach based on the confined self-assembly of block copolymers (BCPs) within emulsion droplets, enabling the fabrication of photonic microparticles with highly ordered internal nanostructures and vivid structural colors. By exploiting supramolecular additives and low-molecular-weight swelling agents, the photonic bandgap can be tuned across the visible spectrum through controlled variations in domain periodicity and refractive-index contrast. This strategy enables broad spectral control while preserving the structural integrity of the particles and their compatibility with scalable emulsification processes. Building on this materials platform, the photonic microparticles can be translated into practical water-based structural-color coatings by dispersing them in polymeric binders and combining them with broadband absorbers. The resulting formulations generate vivid structural colors and can be deposited on a variety of substrates relevant to packaging, textiles, cosmetics, and other coating technologies.

Beyond coloration, the nanostructured BCP framework provides a programmable host matrix for the selective incorporation of functional nanomaterials. Quantum dots, plasmonic nanoparticles, and magnetic nanoparticles can be localized within specific polymer domains, producing hybrid microparticles that combine Bragg reflection with photoluminescent, plasmonic, or magnetic functionalities. In this way, optical properties arising from the periodic BCP structure can be coupled with additional responses originating from the incorporated nanomaterials. The emulsion-based processing strategy also allows the construction of more complex hierarchical particle architectures. In particular, double-emulsion templates can be used to generate core-shell microparticles in which a structurally colored BCP shell surrounds a functional liquid or solid core.

Control over droplet deformation and particle morphology further enables the fabrication of anisotropic rod-like photonic microparticles with orientation-dependent optical properties. When magnetic nanoparticles are incorporated, these anisotropic particles can be aligned by external magnetic fields, enabling control of their optical response through particle orientation. Their incorporation into thermoresponsive polymer gels provides an additional route towards reprogrammable photonic materials. In the gel state, the particles are immobilized within the polymer network, preserving their orientation and the corresponding optical state. Upon transition to the sol state, particle mobility is restored, allowing the microparticles to be reoriented under an applied magnetic field. Subsequent gelation fixes the newly programmed orientation, enabling repeated switching between mobile and immobilized states and the reconfiguration of the material's macroscopic optical response.

Overall, confined BCP self-assembly provides a scalable, modular route to structurally colored, multifunctional microparticles. The ability to control internal periodicity, refractive-index contrast, nanoparticle localization, particle shape, hierarchical compartmentalization, and field-induced orientation enables the development of static, responsive, and reprogrammable photonic materials. These capabilities offer opportunities for applications in sensing, optical tagging, anti-counterfeiting, adaptive coatings, display technologies, and wearable photonic devices.

RETHINKING EPOXY THERMOSETS: FROM DYNAMIC NETWORKS TO CIRCULAR MATERIALS

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Epoxy thermosets are crucial in high-performance applications owing to their outstanding mechanical properties, thermal stability, and chemical resistance. However, their permanently crosslinked networks poses significant challenges for repair, recycling, and end-of-life management, making them one of the most critical materials in the transition toward a circular economy.
I will discuss the different strategies currently being explored to improve the sustainability of epoxy thermosets. These include the development of vitrimeric epoxy networks as a sustainable-by-design approach, the conversion of conventional thermosets into vitrimer-like ones through mechanochemistry, and the use of solvolysis to recover valuable chemicals by upcycling end-of-life materials. The fundamental principles behind these strategies will be highlighted by discussing representative examples from recent research, and addressing the opportunities and environmental challenges associated with their implementation. Together, they demonstrate how advances in polymer chemistry and technology are opening new perspectives for enhancing the sustainability of epoxy thermosets without compromising the performance that makes these materials essential in demanding applications.

CYCLIC OLEFIN BASED COPOLYMERS VIA TRANSITION METAL CATALYSIS: BRIDGING SYNTHESIS AND FUNCTIONAL APPLICATION

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Cyclic olefin copolymers (COCs) are thermoplastic materials composed of a cyclic olefin - typically norbornene - and ethylene, generally synthesized via metallocene catalysts [1]. COC exhibit low water absorption, excellent electrical insulation, biological inertness, and UV transparency, making them suitable for advanced biomedical, membrane, and optical applications.
Several commercial COC families exist, differing in monomer structures and polymerization methods. In general, COCs are produced by chain copolymerization of cyclic monomers such norbornene or tetracyclododecane with ethylene. For instance, TOPAS Advanced Polymers (formerly Ticona) manufactures TOPAS COCs from norbornene and ethylene, whereas Mitsui Chemicals utilizes tetracyclododecane to produce APEL COCs. Notably, norbornene monomer synthesis is complex and poses significant engineering safety challenges, which historically led to market monopolies and high manufacturing costs.
While early commercial developments relied on Ziegler–Natta systems, the advent of metallocene and half-sandwich complexes - such as constrained geometry type or non-bridged titanocene-, activated by methylaluminoxane (MAO), revolutionized the field by enabling precise control over polymer microstructure, composition, and transparency [2]. Recent research has expanded beyond traditional formulations to focus on the copolymerization or terpolymerizations of cyclic olefins with propylene, higher α-olefins, functionalized cyclic olefins, reactive dienes to tailor thermal, chemical, and mechanical performances [3].
Understanding the relationships between catalyst design and polymer properties provides key insights into both academic research and industrial applications, facilitating the development and commercialization of advanced COCs with tailored properties [4].

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FUNCTIONALIZED POLYMERIC MATERIALS: VERSATILE MACROMOLECULAR PLATFORMS FOR PHARMACEUTICAL AND ENVIRONMENTAL APPLICATIONS

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The design of functionalized polymeric materials provides versatile macromolecular platforms capable of addressing critical challenges in both the pharmaceutical and environmental sectors. In pharmaceutical applications, three-dimensional porous networks serve as biocompatible containers for controlled drug delivery and as active heterogeneous supports for metal catalysts (e.g., Pd complexes) in the catalytic synthesis of Active Pharmaceutical Ingredients (APIs). Concurrently, for environmental mitigation, amino acid-functionalized hydrogels enable selective CO_2 capture, while surface-charge and hydrophobicity modulation drive the efficient removal of organic contaminants and heavy metals during water remediation, highlighting the immense structural potential of these customizable architectures.

3D PRINTING MEETS LIQUID CRYSTAL POLYMERS: RESPONSIVE MATERIALS ACROSS DIFFERENT SCALES AND APPLICATIONS

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The use of light in polymer science offers unique opportunities, spanning from fabrication of smart materials by photopolymerization, to their actuation for different applications. By combining shape-changing liquid crystalline networks (LCNs) with advanced 3D printing technologies, complex architectures with stimuli-responsive properties can be produced. LCNs are crosslinked polymer networks prepared from reactive mesogens that efficiently convert external stimuli, such as light, into mechanical motion. Their chemical composition can be tailored to tune mechanical properties and optimize force generation during actuation. In this contribution, we demonstrate their integration with additive manufacturing techniques to fabricate a variety of functional devices, including light-driven actuators, structurally colored responsive structures, and photonic components.

Polyesters in Water: From Dispersion Strategies to Functional Applications

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Aqueous dispersions of biopolyesters have long been used in drug delivery, typically in highly diluted formulations. At higher solid contents, however, they open new opportunities as sustainable waterborne materials for films, coatings, and functional composites. Our group has developed stable biopolyester dispersions with solid contents up to 40%, suitable for paper coatings that provide water and oil resistance while preserving biodegradability and recyclability. These systems can also be blended with water-soluble polymers such as polyvinyl alcohol, combined with fillers such as graphene oxide for sensor applications, or used to incorporate thermolabile bioactive molecules, including osteogenic peptides in PLA films. Beyond PLA, our work explores different polyesters, including PLGA obtained from CO_2-derived building blocks, PHA as a biodegradable polymer in diverse environments, and mixed PHA/PLA emulsions to tailor properties and expand applications.

4D-Printable Shape Morphing Double Network Granular Elastomers (DNGEs)

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The growing relevance of soft robotics within materials science has, in the recent years, driven increasing interest in the development of soft, yet load-bearing and responsive materials that can be processed into customized shapes. Double network granular elastomers (DNGEs), composed of crosslinked microparticles interconnected through a second interpenetrated elastomeric network combine toughness with load-bearing properties and extrudability.[1] To prepare DNGEs, the microparticles are swollen in the precursors' solution of the second network before being centrifuged to increase packing densiy of the microparticles to a point where they are named jamming (*Figure 1a*). In the jammed state, the swollen microparticles are shear-thinning, exhibit a low yield point and fast shape recovery, assets ideal for (DIW)-based 3D printing (*Figure 1b*). The mechanical properties of DNGEs can be tuned with the composition of the DNGE. In this talk, I will introduce smart DNGEs that exhibit a thermo-sensitive shape-morphing behaviour. This is achieved by formulating DNGEs from crystallizable monomers that are crosslinked through a photo-induced thiol-ene reaction. The crystallization of polymeric domains are exploited for the fixation of different temporary shapes, while the original shape of samples is recovered by heating above the material's melting transition (*Figure 1c*). Semicrystalline domains thus consent to combine the enhancement of the mechanical properties with the obtainment of thermo-sensitive shape-memory properties, introducing a novel elastomeric material suitable for load-bearing applications and capable to generate active force upon heating (*Figure 1d*). Mechanical properties of the DNGEs are optimized by regulating the amount of crosslinker in the microparticles and in the second network. Leveraging multi-material DIW printing, I will showcase DNGEs with locally varying compositions that deform in pre-defined ways. I foresee shape-memory DNGEs, to open up new possibilities in 4D-printing load-bearing smart materials well-suited, for example for soft robotics.

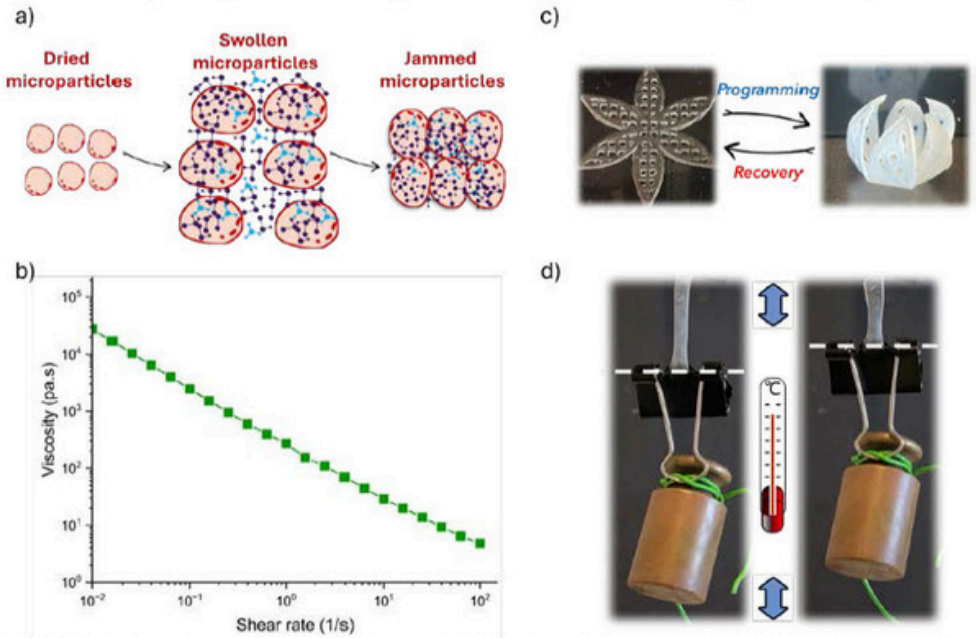


Figure 1. a) steps for the preparation of the shear-thinning ink: first the microparticles are swelled in the solution of second network precursors before being jammed; b) flow curve of the ink showing shear-thinning behavior; c) shape-memory properties of 3D-printed DNGEs; d) load-bearing and active force demonstration of shape-morphing DNGEs: the materials can be programmed to bear and lift loads when activated through heating.

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DEVELOPMENT OF ACTIVE BIODEGRADABLE PLA/PBSA FILMS CONTAINING BLUEBERRY WASTE ANTIOXIDANTS EXTRACTED USING NADES AS GREEN SOLVENTS

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Biodegradable active packaging represents a promising strategy to improve food preservation while reducing environmental impact. In this work, antioxidant compounds recovered from blueberry peels using Natural Deep Eutectic Solvents (NADES) were incorporated into PLA-based coatings applied onto biodegradable PBSA/PLA films. The extracts and resulting films were characterized for antioxidant activity, physicochemical, optical, mechanical, barrier and release properties. The selected extract provided antioxidant functionality while preserving suitable packaging performance. Release tests confirmed the potential of the films as active carriers for food-contact applications. Ongoing shelf-life tests on fresh-cut fruit are being carried out under refrigerated storage conditions.

MULTIFUNCTIONAL EUGENOL-BASED NANOGELS THROUGH COPOLYMER DESIGN: ANTIOXIDANT ACTIVITY, INTRINSIC FLUORESCENCE, AND DRUG ENCAPSULATION

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Amphiphilic nanogels were synthesized by dispersion copolymerization of an eugenol-based methacrylate (EUMA) and hydroxyethyl methacrylate (HEMA). Preserving the phenolic moiety of eugenol enabled a single-motif design with intrinsic antioxidant and antimicrobial activities. Dynamic Liught Scattering (DLS) showed nanogels with sizes between 80–210 nm, with higher EUMA content promoting more compact structures. Notably, the nanogels exhibited intrinsic pH-dependent fluorescence (420 nm), attributed to oxidative coupling of eugenol units, enabling self-reporting behavior without external dyes. Encapsulation of usnic acid (UA) significantly improved its aqueous solubility and reduced *in vitro* cytotoxicity while preserving antibacterial activity against Gram-positive bacteria.

SOLVENT-FREE GRAFTING OF PBS OLIGOMERS ONTO CELLULOSE NANOFIBERS FOR ENHANCED BIOCOMPOSITE COMPATIBILITY

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Nanocellulose, especially cellulose nanofibers (CNFs), is of great interest due to its excellent mechanical properties, low density, non-toxicity, and thermal stability. However, its high hydrophilicity limits its applications. To address this issue, CNFs were chemically modified through a three-step process: 1) oxidation of cellulose fibers; 2) mechanical extraction of CNFs; 3) solvent-free grafting of poly(butylene succinate) (PBS) oligomers onto the cellulose chains. The grafting process used succinic acid and 1,4-butanediol while evaluating different catalysts, temperatures, and reaction times. The results confirmed successful PBS grafting, offering promising prospects for investigating the incorporation of these modified CNFs into PBS polymer matrices to develop sustainable polymer composites.

MECHANOCHEMICAL POLYMER-TO-POLYMER RECYCLING OF POLYLACTIC ACID

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Mechanochemistry represents a promising sustainable approach for polymer recycling, enabling chemical transformations through mechanical. In this work, a solvent-free and catalyst-free strategy for the closed-loop recycling of poly(lactic acid) (PLA) is presented. By tuning ball-milling parameters, controlled radical-induced depolymerization of PLA with different molecular weights was achieved, yielding low-molecular-weight oligomers. Remarkably, further adjustment of milling time promoted the in situ repolymerization of these species, restoring molecular weights comparable to those of the pristine polymer. The entire process occurs in the solid state and relies exclusively on mechanical activation. This approach provides a sustainable alternative for PLA end-of-life management and demonstrates the potential of mechanochemistry for circular polymer recycling.

(Meth)-acrylated tanni acid as a bio-based adhesion promoter for EB-curable coatings

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Electron beam (EB) curing is a solvent-free, energy-efficient technology for advanced coatings that enables photoinitiator-free polymerization, thereby minimizing extractable species. This study investigates partially acrylated tannic acid derivatives as bio-based adhesion promoters for EB-curable acrylic coatings in metal food packaging. The additives were incorporated at varying concentrations and evaluated on metal substrates. The results demonstrated enhanced adhesion, flexibility, and resistance to corrosion-induced delamination, particularly at an optimal loading of 1.0 wt%. These findings highlight the significant potential of combining EB curing with bio-based additives to develop sustainable, high-performance coatings for food packaging applications.

ENVIRONMENTALLY FRIENDLY UPCYCLING OF PHA-BASED COPOLYMERS INTO BRANCHED MULTIFUNCTIONAL OLIGOMERS

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This study addresses two fundamental aspects that make the use of bioplastics sustainable and circular, namely their recycling and valorization of the products resulting from this process. Following this rationale, poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) (PHBH) was upcycled through a green solventless approach to functional oligomers having branched structures. The developed oligomers were used as additives to impart functionality to porous films based on the starting high molecular weight PHBH, prepared by exploiting a phase inversion method using Cyrene®, a solvent derived from cellulose. The developed films were tested in terms of water and ion retention, showing promising results. Moreover, enzymatic hydrolysis of the systems using *Humicola insolens* Cutinase at different concentrations and in different media was investigated.

AMORPHOUS BLENDS OF PLA AND PHA FOR WATERBORNE COATINGS AND FOAM APPLICATIONS

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This study presents a strategy to overcome the limited environmental biodegradability of poly(lactic acid) (PLA) by blending it with an amorphous polyhydroxyalkanoate (PHA). Two processing routes were explored: waterborne dispersion—used to create paper coatings and free-standing films—and melt-compounding, utilized for producing low-density foams via supercritical CO_2 foaming. Despite the inherent immiscibility of the two polymers, the blends demonstrated excellent processability by both techniques. Crucially, the addition of PHA accelerated the biodegradation of the PLA phase under home-composting conditions. A 30% PHA content found to achieve home-compostable status for films, while foams exhibited slower degradation.

INVESTIGATION INTO THE POTENTIAL OF POLY(B-AMINO ESTER)-BASED VITRIMERS

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Vitrimer materials are crosslinked networks containing dynamic covalent bonds that, in the presence of appropriate stimuli, allow the material to flow, making it reprocessable. Among te various types of vitrimers, one of the most promising system consists of poly(β-amino ester)s synthesized by the Aza-Michael reaction of acrylate and amine monomers. In this communication, poly(β-amino ester)s synthesized using different amounts of both bifunctional and trifunctional acrylates will be presented. The influence of the trifunctional acrylate on the thermal and reprocessing properties of the materials will be discussed. Furthermore, an innovative reprocessable system based on poly(β-amino ester)s oligomers cured by radical polymerization with a methacrylic monomer will be presented.

FORMULATION AND CHARACTERIZATION OF POLYHYDROXYALKANOATE BLENDS WITH WASTE PROTEIN FIBERS FOR PACKAGING APPLICATION

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This study explores a sustainable strategy to develop polyhydroxyalkanoate-based blends for flexible packaging applications. A tailored compatibilization approach, involving the synthesis of sulfonated PHBH (PHBH-SO_3) as compatibilizer, was investigated to improve the integration of functional components derived from agri-food waste within the hydrophobic PHBH. Thermal characterization of the resulting materials, processed into films by conventional compression molding, indicates an effect of the incorporated bio-based phase on polymer crystallization, presumably acting as a nucleating agent. Contact angle measurements confirmed the retention of PHBH hydrophobic behaviour. Ongoing mechanical and viscoelastic assessments will further evaluate their potential as sustainable alternatives for flexible packaging

DEVELOPMENT AND INDUSTRIAL PROCESSING OF CELLULOSE-BASED MATERIALS FOR RIGID PACKAGING APPLICATIONS

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In this research project fully cellulose-based materials through bio-derived functional additives application and industrial processing of the cellulosic material have been developed. The synthetic additives were applied onto cellulose substrates by spray coating methodology and moulded into three-dimensional objects, bottle's cap and bottle-neck shaped by dry compression moulding technology. The resulting materials showed excellent water barrier performance and biologically active properties. Structural, thermal, and mechanical characterization confirmed integrity and suitability for rigid packaging applications.

USE OF FRUIT PEELS FOR THE DEVELOPMENT OF BIO-BASED HYDROGELS

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This work presents a bio-based semi-interpenetrating hydrogel for wastewater treatment, derived from agricultural biomass such as green kiwi and green apple peels. The gel network was formed through free radical polymerization using HEMA and PEGMA chains crosslinked with N,N-methylene-bis(acrylamide), in presence of cellulose, hemicellulose, and the other main componens of the dried peel. Methylene blue was used to evaluate adsorption performance and network stability with hydrogel based on Green kiwi peels, while green apple gel was also tested with diclofenac sodium (DCF), a non-steroidal anti-inflammatory drug, and norfloxacin (NOR), a fluoroquinolone antibiotic. The results indicate that fruit-peel-based hydrogels can maintain their polymer network while showing promising adsorption capacity toward dye and drug molecules.

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Short-fiber thermoplastic biocomposites combine the processability of thermoplastics with the improved end-of-life options of bio-based matrices and natural fibers. Their mechanical performance strongly depends on the fiber–matrix interfacial shear strength (τ_y), commonly measured by pull-out tests. However, pull-out specimens are often prepared without pressure, whereas pressure is always present during composite manufacturing. As a result, measured τ_y values may not reflect real processing conditions. Here, we investigate the pressure dependence of τ_y in a PLA–hemp model system, showing that τ_y markedly increases with specimen-preparation pressure due to enhanced matrix penetration into hemp-fiber surface roughness, which increases the effective fiber–matrix contact area.

STRUCTURAL CONTROL AND AMYLOID REINFORCEMENT OF WASTE-DERIVED PROTEIN FILMS

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Bioplastic films were developed through the valorization of waste proteins from black soldier flies (BSFs) and sericin. Following proteomic characterization, the films were prepared and their properties were correlated with the structure of the proteins. Higher molecular mass and transitions towards β-sheet architectures were found to significantly improve mechanical performance. Protocols specific to the proteins were developed for amyloid fibrillization, which further enhanced the properties of the films in both pure protein systems and blends with biodegradable polymers. Lyophilised amyloid-containing proteins were also used as nanofillers to reinforce biodegradable polymer matrices. Overall, amyloid fibrillization proved to be an effective strategy for producing protein-based materials with properties comparable to those of commercially available biopolymers.

PROSPECTIVE LIFE CYCLE ASSESSMENT OF TYRE MANUFACTURING: EVALUATING INDUSTRIAL DECARBONISATION PATHWAYS

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(INSERIRE UN ABSTRACT DI NON PIU' DI 8 RIGHE)

The tyre industry is progressively shifting towards renewable and recycled materials, with leading manufacturers targeting approximately 40% sustainable material content by 2030. This work uses a cradle-to-gate Life Cycle Assessment (LCA) of a representative passenger car tyre, developed from primary industrial production data, as the baseline for prospective decarbonisation scenarios based on current industrial sustainability roadmaps. Alternative strategies are assessed through comparative LCA to quantify their potential for reducing the environmental footprint of tyre manufacturing and to identify the most promising material-oriented decarbonisation pathways.

FROM THIOL-ENE CHEMISTRY TO BIO-BASED POLYMERIC NETWORKS: MULTIFUNCTIONAL LIMONENE-DERIVED MATERIALS

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Limonene, an abundant terpene derived from citrus waste, and limonene epoxide were exploited through thiol-ene chemistry to produce two complementary classes of bio-based materials. First, linear and branched thiols were used to prepare poly(thioether-*co*-limonene) networks, which were combined with recycled poly(vinyl butyral) (PVB) to obtain materials with enhanced mechanical properties and excellent UV-shielding performance. The same thiol chemistry was applied to limonene epoxide to prepare multifunctional epoxy precursors, which were cured with bio-based di- and tricarboxylic acids to obtain epoxy resins. Overall, the results highlight the versatility of thiol chemistry as a sustainable strategy for developing multifunctional polymers from renewable resources and recycled materials.

EMERGING CONCEPTS FOR SUSTAINABLE BIOCOMPOSITES

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The transition toward a circular bioeconomy is reshaping polymer composite design, promoting materials that combine high performance with sustainability. Recent advances span traditional composites, dynamic covalent networks, and hydrogel-based systems. Biocomposites are evolving from static structures to adaptive, multifunctional materials integrating renewable matrices and bio-based fillers. In tire applications, biochar can replace up to 50% of carbon black while maintaining comparable properties. Covalent adaptable networks based on Priamine® 1071 provide reprocessable, flexible matrices with rapid stress relaxation, suitable for soft strain-sensing composites. In parallel, photocurable collagen hydrogels offer biomimetic, porous platforms for biomedical and absorbent applications. Overall, current research emphasizes the convergence of bio-derived feedstocks, dynamic chemistries, multifunctionality, and circularity as key directions for next-generation biocomposites.

TUNING PLLA CRYSTALLIZATION KINETICS VIA REACTIVE EXTRUSION BRANCHING STRATEGIES

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Poly (L-lactic acid) (PLLA) a diffused biodegradable and renewable thermoplastic polyester with a few drawbacks that limit its wider commercial exploitation A major limitation hindering the large-scale industrial application PLLA is its slow crystallization kinetics, which results in brittle behavior and poor thermal resistance

This contribution presents the synthesis of long-chain branched PLLA via reactive extrusion. The synthesized branched PLLAs exhibited enhanced crystal nucleation with a strong concentration-dependent effect. This strategy provides a robust approach to overcome the performance bottlenecks of commercial PLLA, expanding its viability for high-performance sustainable packaging and engineering applications.

DESIGNING VANILLIN-BASED DYNAMIC NETWORKS FOR THE DEVELOPMENT OF SUSTAINABLE THERMOSETS FOR FUTURE GENERATION COMPOSITES

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The present work contributes to the optimization of traditional thermosets, aiming to overcome the challenge of their poor recyclability while preserving excellent thermal and mechanical properties for high-performance applications. Two distinct formulations were developed, using vanillin as a competitive building block compared to fossil-based analogues and a dynamic cross-linked network that can be reprocessed when stimulated by heat. Once the vitrimeric behaviour was assessed, further tests were performed to investigate advanced functionalities of these materials. The higher T_g thermoset exhibited no chemical degradation along with promising flame resistance properties. On the other hand, the lower T_g formulation was investigated as a smart material demonstrating outstanding shape memory behaviour.

MELT-PROCESSING OF DIALCOHOL CELLULOSE FIBRES/STARCH BLENDS: PROCESSING STRATEGIES, STRUCTURE AND PROPERTIES

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Growing concerns about fossil-based plastics have driven interest in renewable alternatives like cellulose and starch-based polymers. However, their strong hydrogen bonding intermolecular interactions raise glass transitions above degradation temperatures, which hinders melt-processing. Chemical modification of cellulose into dialcohol cellulose fibres (DALC) reduces glass transition, enabling water assisted melt-processing. Starch can also be melt-processed using suitable plasticizers, such as isosorbide. DALC/starch blends were produced using either a one-step co-extrusion process or a two-step process involving pre-formed thermoplastic starch pellets. Higher starch content reduced melt-viscosity, improving processability. The blend composition and processing route influence the mechanical properties. Selected compositions demonstrated successful mechanical recycling and composting biodegradation, confirming the potential of these bio-based thermoplastic alternatives.

Beyond Biodegradability: Comparative LC-MS Profiling of Plastic Additive Release from Fossil-Based and Biodegradable Agricultural Mulch Films into Soil

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Biodegradable mulch films (BMF) are promoted as eco-friendly alternatives to polyethylene (PE), yet both contain plastic additives (PAs) that can leach into agricultural soil during burial. This study presents a comparative UHPLC-MS/MS investigation of PA profiles in PE and PBAT films and contacting soils under real field conditions. PE remained intact with stable PA content throughout burial, while PBAT progressively degraded, releasing micro- and nanoplastics and showing significant PA compositional changes. Hydrophobic PAs persisted in plastic fragments; polar species migrated preferentially into soil. These findings show that polymer biodegradability does not ensure reduced environmental impact of associated additives, urging inclusion of their fate in sustainability assessments of agricultural plastics.

MULTISCALE POLYMER ANALYSIS: CORRELATING CHEMICAL STRUCTURE, THERMAL BEHAVIOR, AND RHEOLOGICAL RESPONSE THROUGH COMPLEMENTARY ANALYTICAL TECHNIQUES

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Polymer properties arise from structural features extending from the molecular to the macroscopic scale. This contribution presents an integrated approach combining XRD, DSC, gas pycnometry, Raman, and SAXS. XRD, DSC, and pycnometry provide complementary information on crystalline phases, thermal transitions, crystallinity, and skeletal density. Raman spectroscopy enables real-time monitoring of structural evolution during polymer processing, while RheoSAXS correlates nanoscale organization with rheological response. Selected examples include polypropylene crystallinity, polyethylene crystallization, and shear-induced transitions in lamellar systems. The combined workflow improves structure–process–property understanding and supports material development and process optimization.

WHEN MOLECULAR IMPERFECTION WORKS: SUSTAINABLE POLYESTER COPOLYMERS WITH INDUSTRIAL POTENTIAL

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ABSTRACT

Sustainable ABA segmented copolyesters based on commercially available ε-caprolactone and L-lactide were synthesized through a scalable one-pot bulk polymerization using technical-grade monomers and industrially relevant catalysts. Despite the structural heterogeneity generated under these conditions, the materials retained typical thermoplastic elastomer behavior, combining high extensibility with efficient energy dissipation and elastic recovery. Moreover, they proved highly effective as PLA toughening agents, increasing the strain-at-break of commercial PLA from about 4% to over 90% while maintaining technologically relevant mechanical properties. These results demonstrate the potential of scalable polyester architectures for high-performance and recyclable PLA-based materials.

BIO-BASED AND ANTIFUNGAL BY DESIGN: UV-CURED ESO/ESSENTIAL OIL COMPOSITES FOR NEXT-GENERATION ACTIVE PACKAGING

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We engineered a novel device blending natural essential oils (EOs) into a cationically UV-cured epoxidized soybean oil (ESO) matrix, targeting food shelf-life extension and waste reduction. Photo-rheology and ATR-FTIR showed EO loading delays crosslinking onset yet speeds gelation, thus reducing the final epoxy-group conversion from 81% to 70%. DMTA analysis revealed an induced EOs plasticizing effect leading to the formation of samples with lower Tg and storage modulus. PTR-ToF-MS and GC–MS tracked EO release kinetics and oxidation VOC byproducts released by the samples stored at 6, 20 or 35°C. As a proof of concept, antifungal tests against *Penicillium spp.* confirmed real-world applicability. Together, these results spotlight ESO-based UV-cured systems as a sustainable, high-performance route to next-gen active packaging.

NATURAL ANTIOXIDANT EFFECT OF HAZELNUT SHELL POWDER IN PBS BIOCOMPOSITES UNDER ACCELERATED UV AGING

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PBS biocomposites containing 10, 20 and 30 wt.% hazelnut shell powder were subjected to accelerated UV aging in a QUV chamber for up to 90 days. Molecular changes before and after aging were investigated by SEC and MALDI-TOF mass spectrometry. SEC analyses showed that the reduction in number-average molecular weight after 90 days decreased with increasing filler content, while neat PBS exhibited the largest increase in polydispersity. MALDI-TOF results confirmed a lower extent of molecular degradation in the filled systems. The enhanced photo-oxidative stability is likely due to the preferential oxidation of polyphenols in hazelnut shells, acting as sacrificial antioxidants. Mechanical testing also supported the effectiveness of hazelnut shell powder as a sustainable UV-stabilizing filler.

Mechanical Recycling of Multi Coupled Material Body Seals Based on Thermoplastic Elastomers in the Automotive Industry

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The growing demand for sustainable materials has increased interest in Thermoplastic Elastomers (TPEs) for automotive applications due to their recyclability and elasticity. This work investigates the mechanical recycling of post-industrial multi-material sealing profiles without prior separation. The recycled material was reprocessed and characterized before and after ageing. Mechanical tests showed good hardness, tensile, tear, and compression set properties. Thermal ageing had a limited effect on performance. UV exposure caused only minor degradation and color variation. TGA, DSC, and ATR-FTIR confirmed the material's compositional stability. These results demonstrate the feasibility of recycling complex TPE-based sealing systems for circular automotive applications.

EUGENOL-DERIVED POLYMERIC NETWORKS AS ECO-FRIENDLY AND CIRCULAR WET-STRENGTH AGENTS FOR HIGH-PERFORMANCE PAPER PRODUCTS

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This study introduces sustainable alternatives to toxic synthetic paper wet-strength agents by developing novel eugenol-derived polymeric systems. Two routes were investigated: a solvent-free homopolymerization and a radical thiol-ene click copolymerization subsequently photo-crosslinked in situ. When impregnated into cellulose substrates, these green networks successfully imparted robust hydrophobic properties and established continuous fiber bridges that closely mimic the natural moisture-shielding function of lignin. Tensile testing confirmed significant enhancements in wet mechanical strength and overall resilience, successfully matching industrial benchmarks.

ENGINEERING CIRCULAR POLYESTERS THROUGH MOLECULAR ARCHITECTURE: FROM THERMOPLASTIC ELASTOMERS TO DYNAMIC COVALENT NETWORKS

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ABSTRACT

We used molecular architecture to design bio-based, circular polyester materials, including thermoplastic elastomers and dynamic polymer networks. Using Fe catalysts, ABA triblock copolymers were synthesized with semicrystalline PLLA hard segments and soft amorphous midblocks. These synthetic methodologies proved scalable under industrially relevant conditions using more common monomers and catalysts, yielding more heterogeneous architectures that however act as highly effective toughening agents, increasing commercial PLA's strain-at-break from 4% to over 90%. The study also introduces bio-based vitrimers from star-shaped PLA oligomers, offering shape-memory behavior and stress relaxation. Ultimately, these architectures enable material circularity via efficient depolymerization and chemical recycling.

Altri

CONTRIBUTI ORALI

Materiali polimerici ibridi e (nano)compositi sintesi, caratterizzazione e applicazioni

Transparent self-extinguishing silica-epoxy nanocomposites based on Novolac resin

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Sol-gel chemistry was used to synthesize transparent fire-resistant silica-epoxy nanocomposites based on Novolac resin. Unlike conventional systems, this approach forms well-dispersed amorphous silica nanoparticles, maintaining high transparency (~80% transmittance). A small amount of phosphorus-based additive allows to achieve self-extinguishing without any dripping and achieve UL94-V0 rating during vertical burning tests. The nanocomposites also show significantly reduced heat release rate, demonstrating improved fire safety. Compared to traditional hybrid systems based on bisphenol A diglycidyl ether, this method avoids particle crystallization and opacity at higher filler loadings. Overall, it offers a scalable and efficient strategy for developing multifunctional high-performance materials for advanced applications.

SOLVENT-FREE PROCESSING OF HIGH β-PHASE POLY(VINYLIDENE FLUORIDE) FILMS FOR ENERGY CONVERSION APPLICATIONS

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Poly(vinylidene fluoride) (PVDF) is one of the most widely studied electroactive polymers owing to its ferroelectric properties. However, conventional processing generally promotes the non-polar α phase, limiting its electromechanical response. In this work, high β-phase PVDF films were produced through a solvent-free cold pressing and annealing process using a commercial low-cost PVDF grade. The influence of compressive stress, number of stacked layers and annealing temperature on phase transformation were investigated. The optimized process promoted the formation of the electroactive β phase and increased the piezoelectric strain coefficient (d_{33}). The proposed approach represents a simple, cost-effective and scalable route for the fabrication of electroactive PVDF films for sensing and energy-conversion applications.

HYBRID MICROGELS BASED ON PNIPAM AND NATURAL PROTEINS: FROM MOLECULAR INTERACTIONS TO BIOMATERIAL APPLICATIONS

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Hybrid microgels were prepared by integrating thermo-responsive PNIPAM with keratin, sericin, or fibroin extracted from textile waste, using either a synthetic pathway or physical mixing. Keratin and sericin formed stable colloidal particles via both methods, showing different covalent/physical interactions, while fibroin required physical mixing due to its high aggregation tendency. Biomedical trials revealed powerful synergistic effects between the components. Keratin integration enhanced caffeic acid encapsulation efficiency up to 90% compared to pure PNIPAM. Moreover, the hybrid thin films demonstrated outstanding dual functionality: the structural proteins successfully promoted human cell viability and growth, while the thermal transition of PNIPAM enabled smart, non-enzymatic cell detachment upon cooling.

TOWARDS SUSTAINABLE ELECTRICAL CABLE INSULATION: DESIGN OF A NOVEL POLYETHYLENE-BASED COMPOSITE SYSTEM

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Polyethylene (PE) is widely used for electrical insulation, but its limited mechanical strength and thermal resistance require cross-linking to improve its thermomechanical performance. Although cross-linked polyethylene (XLPE) offers excellent properties, its permanent network makes recycling difficult. Two main strategies have been proposed to improve the sustainability of PE-based insulating materials: the development of recyclable polyolefin blends or composites and the use of click chemistry-based curing.
This work introduces a sustainable alternative based on an LLDPE composite containing functionalized phases reacting through thermally activated and catalyst-free reactions. The resulting material exhibited a higher Young's modulus and improved water vapor barrier properties compared with neat LLDPE.

CYCLODEXTRIN-GRAFTED CHITOSAN SCAFFOLDS FOR ENHANCED CURCUMIN DELIVERY

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The present work focused on the development of cyclodextrin (CD)-functionalized chitosan (CS) scaffolds for curcumin (CUR) delivery. β- and γ-CDs modified with maleic or succinic anhydride were covalently grafted onto CS through EDC/NHS-mediated coupling, producing porous matrices after freeze-drying. The functionalization strategy significantly improved curcumin encapsulation efficiency compared to pristine CS, with γCD-based systems reaching values above 80% due to the larger cavity size of γ-CD. The successful loading of CUR into the polymeric network was confirmed through FT-IR, DSC, and TGA characterization. Furthermore, the CUR-loaded systems preserved antioxidant activity and exhibited strong antibacterial properties and biocompatibility,emphasizing their potential as multifunctional biomaterials suitable for controlled drug delivery applications.

LONG VS. SHORT CHAIN COVALENT FUNCTIONALIZATION IN THE PREPARATION OF MECHANOCHROMIC POLYMERS

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A polymeric perylene bisimide-based macromechanophore bearing poly(ε-caprolactone) spacers (M-PBI) was synthesized and covalently incorporated into SEBS-g-MAH and LLDPE-g-MAH matrices. Its optical, mechanical, and thermal properties were evaluated against a short-spacer analogue (P-PBI) and a physically blended system (S-PBI). Both M-PBI and P-PBI exhibited a pronounced mechanochromic response upon deformation, whereas S-PBI showed no detectable optical changes. M-PBI enabled crosslinked films while preserving the mechanical integrity of the polymer matrices. These results highlight that mechanophore architecture critically governs force transduction and mechanochromic performance in polymer systems.

EFFECT OF SILANE COUPLING AGENT CONTENT ON STRAIN-INDUCED CAVITATION IN SILICA-FILLED SBR

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This study investigates the effect of silane coupling agent content on strain-induced cavity formation in silica-filled styrene-butadiene rubber (SBR). The macroscopic volume variation during uniaxial tension was eveluated via Digital Image Correlation (DIC), while a microscale characterisation was performed using *in-situ* micro-CT. Both techniques showed that higher TESPT concentrations increases the material's propensity to form cavities. While increased coupling agent content was expected to strengthen the rubber-filler interface and decrease debonding, the observed behaviour is attributed to the higher crosslink density induced by the sulphur present in the coupling agent. To confirm this hypothesis, ongoing research is investigating compounds in which the sulphur content is adjusted in order to maintain constant crosslink degree.

SYNTHESIS AND NANOSTRUCTURATION OF DPP-BASED FLUORESCENT POLYESTERS FOR BIOIMAGING

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The recent advancements in fluorescent materials for bioimaging, together with the current attention on greener chemistry, led to the development of fluorescent systems made with biobased or biodegradable polymers.
In this context, diketopyrrolopyrrole (DPP) derivatives guarantee high tuneable fluorescence, high stability and the possibility to covalently incorporate it in polymeric matrix such as polyesters, obtaining a potentially biodegradable intrinsic fluorescent polymer.
This work focuses on the synthesis of emissive polymers containing DPP as the main fluorescent core, covalently integrated as a defect into a polyester derived from 1,4-butanediol and hexanedioic acid and the subsequent nanostructuring to obtain nanoparticles tested as staining dyes for bioimaging applications.

SILICA-BASED NANOSTRUCTURED MIXED OXIDES VIA SOL-GEL FOR THE ENHANCEMENT OF FIRE RESISTANCE AND RECYCLABILITY OF EPOXY RESINS

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The development of epoxy resins requires sustainable additives for the improvement of fire resistance and innovative strategies, such as the design of covalent adaptable networks, for enabling their reprocessing. Sol-gel methodology can provide tailored mixed oxide nanofillers, either ex-situ or by in-situ growth within the epoxy matrix. Silicon-, phosphorus-, and niobium-based mixed oxides were developed as multifunctional additives using both approaches. Such fillers can promote reprocessing through transesterification of epoxy polyesters while enhancing thermal stability and fire performance, owing to their tunable acidity and porous structure. Moreover, P-modified silica nanostructures grown within the epoxy matrix achieve uniform dispersion and pave the way toward sustainable, fire-safe epoxy nanocomposites.

ELECTROSPUN MALTODEXTRIN-DERIVED CARBON FIBERS: A SUSTAINABLE PLATFORM FOR GOLD-BASED CATALYSTS

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The polymer industry still relies on fossil resources, motivating the development of sustainable materials. This work presents a one-step electrospinning route to carbon fibers decorated with gold nanoparticles. Maltodextrin and citric acid solutions containing $HAuCl_4 \cdot 3H_2O$ were electrospun and pyrolyzed at 700 °C under N_2. A mild air activation treatment improved gold accessibility while preserving fiber morphology. Characterization confirmed carbon nanofibers with in-situ formed metallic Au nanoparticles. Lower Au loadings produced smaller nanoparticles and higher catalytic activity. Glycerol oxidation showed enhanced performance for small Au nanoparticles, mainly yielding glycolic acid. This study demonstrates a sustainable route for carbon-based gold catalysts for biomass valorization.

MULTIFUNCTIONAL AND SUSTAINABLE VITRIMER SYSTEMS

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We report a solvent-free, photocurable vitrimeric system based on bio-derived building blocks incorporating dynamic imine bonds, enabling intrinsic self-healing. The resin was UV-cured in the presence of functionalized silica nanoparticles to form crosslinked composite networks in which the nanoparticles were covalently integrated. The incorporation of 2% w/w functionalized silica nanoparticles enabled complete healing in less than five minutes at temperatures as low as 80 °C, while simultaneously imparting enhanced scratch resistance. Electrochemical impedance spectroscopy showed that pristine coatings provided excellent corrosion protection on steel substrates. The coatings were fully removed from substrates by exploiting transimination pathway of imine bonds.

FUNCTIONAL POLYMERS FOR THE OPTICAL DETECTION OF AMINES: FROM BIO-INSPIRED TO NATURAL SENSING UNITS

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Real-time monitoring of volatile amines is crucial for environmental monitoring and smart food packaging. Polymeric optical sensors offer cost-effective, instrument-free detection. Traditional bio-inspired chromophores, such as metalloporphyrins, suffer from non-green synthesis and potential toxicity. To overcome these limitations, natural pigments are ideal candidates owing to their edibility and sustainability; however, physical blending leads to unwanted dye migration. This contribution highlights the synthetic evolution toward sustainable optical sensors, focusing on the smart, covalent anchoring of natural sensing units (such as curcumin) to the polymer backbones, to prevent leaching while maintaining excellent sensing efficiency.

INTERCALATED SODIUM BENTONITE IN THERMOPLASTICIZED CORN STARCH: TUNING OXYGEN BARRIER AND MECHANICAL PERFORMANCE FOR FLEXIBLE FOOD PACKAGING APPLICATIONS

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This study reports thermoplasticized corn starch (TPCS) bio-nanocomposite films reinforced with Sodium Bentonite (BNa, 0.5-5 wt%), prepared via solution casting, melt mixing and compression molding using glycerol as plasticizer. XRD confirmed disruption of native starch crystallinity, yielding an amorphous matrix with intercalated clay morphology that aggregated above 3 wt% filler. Oxygen permeability dropped up to 35-fold versus neat TPCS, competitive with EVOH, while Young's Modulus and tensile strength peaked at 4 wt% BNa, with reduced elongation at break. Beyond 4 wt%, aggregation slightly worsened mechanical performance, and water vapor permeability remained high due to matrix hydrophilicity, confirming TPCS/BNa as a promising oxygen-barrier packaging material.

STUDY OF THE HIGH-PRESSURE H_2 EXPOSURE EFFECT ON THE MECHANICAL BEHAVIOUR OF NBR BASED COMPOUNDS

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Hydrogen infrastructure requires elastomeric seals capable of maintaining their mechanical integrity under high-pressure gas exposure. This work investigates three NBR-based formulations with different filler contents and matrix compositions. Specimens were exposed for 7 days to pure gaseous H_2 at 100 bar and 23 °C or at 230 bar and 70 °C. After 48 h of post-exposure storage, the mechanical behaviour was evaluated through uniaxial tensile tests and fracture tests. H_2 exposure at 100 bar and room temperature produced limited changes in mechanical properties. Conversely, the higher pressure and temperature exposure affected the mechanical behaviour, irrespectively of the gas nature. The results indicate that, for the testing conditions, pressure-temperature history plays a major role in the ageing of the studied compounds.

DEVELOPMENT AND CHARACTERIZATION OF SANDWICH COMPOSITES WITH THERMAL MANAGEMENT AND MECHANICAL PROPERTIES

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The increasing demand for lightweight structures with integrated thermal management capabilities has driven to the development of multifunctional composite materials. In this work, sandwiches were fabricated using an epoxy (EP) foam core embedded with microencapsulated phase change materials (PCMs) that provided thermal regulation properties to the final composites. Microstructural analyes confirmed a homogeneous distribution of PCMs within EP, while thermal tests revealed enhanced energy storage capacity with effective heat absorption and release within a targeted temperature range. Mechanical tests demonstrated that the developed sandwiches exhibited good flexural and compressive properties.

ECO-FRIENDLY DYE–PORPHYRIN COPOLYMER FOR ORGANIC SOLAR CELLS: FROM TERNARY DONOR TO INTERFACIAL LAYER

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The aim of this work is the development and step-by-step characterizations of a novel cationic thiophene based copolymer, including ionic phosphonium salt and dye-tetraphenylporphyrin (TPP) moiety in side chains, with an iconic property of solubility in a wide range of polar solvents. Synthesized by using simple, low-cost, and straightforward procedures, the material is used to fabricate completely halogen-free (i.e., from ethanol) ternary organic solar cells (OSCs). The new polymer is tested as photoactive layer and as cathode interlayer in OSCs. Furthermore, to improve and optimize the best performing device, a successful post-metalation with Zn of the porphyrin core is carried out, and a ternary OSC is fabricated, resulting in an improve in photoconversion efficiency of ~20% compared to the not-metalated one.

FURANIZED CELLULOSE NANOCRYSTALS FOR THE PREPARATION OF DIELS-ALDER RUBBER COMPOSITES

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In recent years, cellulose nanocrystals (CNCs) have attracted significant interest as sustainable reinforcing agents for polymer composite materials. In this work, CNCs, extracted from hemp pulp, were functionalized with furanic groups and characterized by FT-IR and SS-NMR spectroscopy. The functionalized CNCs were used as sustainable nanofillers in rubber matrices based on furan-functionalized polybutadiene. Using a bismaleimide crosslinker, the composites were crosslinked througth reversible Diels–Alder reactions. Mechanical and thermal analyses showed that the incorporation of furan-functionalized CNCs improved the elastic modulus and tensile strength compared with both the neat matrix and composites containing unmodified CNCs. Furthermore, the materials exhibited effective reprocessability, highlighting the potential of this strategy for the development of sustainable, recyclable, and high-performance rubber composites.

SMART POLYMERIC ARCHITECTURES BASED ON PHOTOSWITCHES: FROM ADHESIVES TO RESPONSIVE NANOCARRIERS

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Arylazoisoxazoles (AIZs) show promising photoisomerization properties, enabling isothermal phase transitions or controlled polarity changes, over polymeric materials. In this work, we present the development of AIZ-based systems for two key applications: light-actuated reversible adhesives and supramolecularly functionalized micellar nanocarriers for controlled hydrophobic cargo release. Upon light irradiation, the *trans-cis* transition of AIZs allows for the modulation of adhesion strength, outperforming traditional monomers, and enables the controlled loading and release of guest molecules in Polymerization Induced Self-Assembled micelles without the need for thermal or solvent-based treatments.

ENGINEERED POLYMER-BASED COMPOSITES FOR RADIATIVE COOLING SYSTEMS

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Urban areas are experiencing a significant rise in temperature due to the high concentration of buildings, roads, and other infrastructures that absorb and retain heat more efficiently than natural landscapes. Passive daytime radiative coolers (PDRCs) are physical systems capable of achieving a net irradiation of energy from the Earth's surface towards outer space, even under direct sunlight. To achieve this amazing feat, PDRCs require tailored photonic properties, namely high reflectivity over the solar-radiation range and selective absorbance (or equivalently emittance) in the mid-IR atmospheric transparency window (8-13 µm). Here, PDRCs made of silica-loaded polyolefin thin films hot-pressed onto Ag-coated stainless-steel slabs were fabricated and their photonic response correlated with the thermodynamic radiative efficiency.

ENHANCED HYDROLYTIC DEGRADATION OF PLA GREEN COMPOSITES BY NANOMETRIC ZNO COVALENTLY BOUND ON NATURAL FIBRES VIA ALD

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Biopolymers are promising alternatives to conventional plastics, although their degradation in natural environments is often limited. In this study, the degradation rate of poly(lactic acid) (PLA) was enhanced through the incorporation of ZnO nanoparticles. Green composites were developed by combining PLA with natural fibres functionalized with ZnO nanoparticles covalently anchored via atomic layer deposition (ALD). The natural fibres acted as carriers, improving nanoparticle dispersion and increasing the interfacial contact area within the polymer matrix. Hydrolytic degradation tests were carried out under different environmental conditions. The results demonstrated that fibre-bound ZnO effectively promotes PLA degradation, highlighting the potential of this strategy for the development of more environmentally responsive and sustainable biopolymer-based materials.

CAPACITIVE SENSOR BASED ON POROUS LIQUID CRYSTALLINE GEL

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Capacitive temperature sensors are promising for soft and wearable electronics due to simple architecture, but their sensitivity is limited by the weak thermal response of conventional solid dielectrics. Liquid crystal materials offer higher dielectric responsiveness, yet their fluid nature limits mechanical stability and long-term operation. In this work, we present a capacitive sensor based on a Liquid Crystal Gel (LCG), where a nematic liquid crystal (5CB) is confined within a porous, crosslinked polymer matrix. The LCG functions as an active thermo-responsive dielectric combining thermally induced liquid crystal reorientation and polymer contraction. This dual mechanism, that enhances capacitive modulation, is demonstrated over repeated heating–cooling cycles in air and under water immersion.

PYROLYSIS-DERIVED TELECHELIC POLYPROPYLENE AS A MECHANOCHROMIC PROBE FOR VISUALIZING STRESS REDISTRIBUTION AND CAVITATION IN POLYOLEFIN-BASED MATERIALS

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Controlled pyrolysis of isotactic polypropylene was used to produce pyrene-functionalized telechelic oligomers acting as mechanochromic additives. Incorporated into HDPE, LLDPE, POE, and PCL matrices, these materials enabled the visualization of deformation mechanisms through fluorescence changes. While LLDPE and PCL exhibited the expected decrease in excimer emission upon stretching, POE showed an unusual fluorescence enhancement linked to cavitation. Microscopy and scattering analyses, supported by computational investigation, revealed that void formation around polypropylene-rich domains increased the local concentration of pyrene units, promoting excimer formation. This strategy provides a simple optical method to monitor stress redistribution, interfacial debonding, and cavitation in polymer systems.

FROM HYDROPHOBIC TO HIGH-PERFORMANCE WATER FILLED POLYMERIC FILMS: A NEW PARADIGM IN WATER PURIFICATION MATERIALS

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This work introduces an innovative strategy for producing water-filled films of hydrophobic thermoplastic polymers without relying on hydrophilic chemical functionalization. The method is is particularly effective for high-surface-area (HSA) nanoporous crystalline (NC) PPO films generated through rapid cocrystallization induced by the uptake of nonvolatile guest molecules.Water-filled HSA NC PPO films exhibit superior adsorption performance compared to sulfonated PPO and conventional polymer adsorbents, especially for removing trace organic contaminants from dilute aqueous solutions. This high efficiency highlights their potential in drinking-water purification, removal of persistent chemicals, and preconcentration of organic pollutants for analytical applications.

EMISSIVE BOTTLE-BRUSH COPOLYMERS FOR SOFT OPTO-ELECTRONIC VIA ORTHOGONAL POLYMERIZATION

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Soft optoelectronic devices require materials that combine conductivity, flexibility, and efficient light emission. Suitable diketopyrrolopyrroles-based monomer was designed to enable orthogonal polymerization ractions, generated bottle-brush architectures. This macromolecular design reduced aggregation-caused quenching by sterically separating the π-conjugated chains, leading to enhanced solid-state fluorescence while preserving electrochemical performance and stability. Furthermore, "peripheral" functionalization with specific flurophores has led to develop FRET (Förster Resonance Energy Transfer) emitters for interactive sensing platforms. This strategy offers a versatile approach to multifunctional soft optoelectronic materials with tunable emissive and conductive properties.

EVALUATION OF THE SELF-HEALING BEHAVIOUR OF MULTIFUNCTIONAL THERMOPLASTIC COMPOSITE LAMINATES

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Self-healing composites are innovative materials capable of autonomously restoring mechanical properties after damage, reducing maintenance needs and extending service life. This study investigates intrinsic self-healing mechanisms in thermoplastic composites, focusing on microcrack repair activated by external stimuli (such as temperature). The research aims to develop self-healing thermoplastic matrices based on polyamide 6 (PA6) and polylactic acid (PLA), evaluating different healing agents and compatibilizers. The optimized matrices were used to manufacture fiber reinforced laminates. The results demonstrated the recovery of mechanical strength and fracture toughness, highlighting the effectiveness of the self-healing process and the potential of these composites for durable, high-performance structural applications.

FUNCTIONAL POLYMER HYBRID HYDROGELS FOR MULTI-ADSORPTION OF OPPOSITELY CHARGED EMERGENT POLLUTANTS

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The increasing occurrence of emerging pollutants in water demands multifunctional materials capable of removing diverse contaminants simultaneously. Here, functional polymer hybrid hydrogels were developed via a one-pot polymerization strategy incorporating methacrylate-functionalized mesoporous silica nanoparticles. The introduction of polymerizable methacrylate groups onto the nanoparticle surface enabled their covalent incorporation, forming a stable organic–inorganic network. This design enhances structural and mechanical properties, improves nanoparticle dispersion, and prevents leaching. The hybrid material combines complementary adsorption domains within a single platform, enabling simultaneous adsorption of emerging pollutants while enhancing structural integrity.

SHAPE-CHANGING MULTIPHASE MICROPARTICLES BASED ON LIQUID CRYSTAL EMULSIONS

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Complex multiphase emulsions containing liquid crystals (LCs) offer precise morphological control and dynamic tunability, enabling applications in optics, sensing, and soft matter. Here, we report a simple and scalable bulk-emulsification strategy that circumvents the reliance on microfluidic fabrication to produce liquid crystalline network (LCN) microparticles spanning single, double (Janus), and triple emulsion morphologies within a genuinely colloidal size regime (10–20μm). Across all morphologies, the particles exhibit robust, reversible, large-amplitude deformations under heating, as well as chemoresponsivity through anisotropic swelling in organic solvents.

FABRICATION OF POROUS MICROPARTICLES BY RAFT POLYMERIZATION

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Amphiphilic PS-b-PDMA and P4VP-b-PS block copolymers with high hydrophobic fractions were synthesized via RAFT polymerization to develop stable, mesoporous nanoparticles (p > 1). Self-assembly was achieved through solvent exchange or via Polymerization-Induced Self-Assembly (PISA). DLS, SEM, and 129Xe-NMR confirmed the formation of porous nanostructures, demonstrating high mesopore accessibility for PS-b-PDMA. Finally, encapsulation tests using the photosensitive molecule curcumin within the porous matrix were validated via UV-Vis spectroscopy. The complete absence of degradation products proved that these polymeric nanoparticles effectively shield and stabilize active compounds in aqueous media for advanced delivery

INVESTIGATING BACTERIA-DRIVEN ALGINATE HYDROGEL MATRIX DEGRADATION: A RHEOLOGICAL FRAMEWORK TO DISCRIMINATE BETWEEN CROSSLINKER DEPLETION AND BACKBONE CLEAVAGE

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Conventionally, 3D hydrogel matrices for cell encapsulation are designed as inert supports. This study challenges this paradigm by investigating the dynamic interaction between *Synechocystis* sp. PCC 6803 and calcium alginate matrices. Under nutrient starvation, a massive mechanical collapse is observed (G' dropping from kPa to Pa range). Using a rheological framework and polymer scaling theory, we decoupled two degradation mechanisms: bacterial sequestration of Ca^{2+} structural ions and enzymatic cleavage of the alginate backbone. The results demonstrate that the hydrogel acts as an active reservoir where bacteria metabolic needs drive matrix modification, transforming a simple scaffold into a responsive microenvironment.

Altri

CONTRIBUTI ORALI

Processabilitá e stampa 3D di materiali polimerici

FROM MARINE PLASTIC LITTER TO 3D PRINTING: OPTIMISING BLENDED POLYOLEFIN FORMULATIONS FOR ADDITIVE MANUFACTURING

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Le poliolefine miste (MPO) recuperate dall'ambiente marino rappresentano una risorsa in un'ottica di economia circolare. In questo studio sono state messe a punto formulazioni a base MPO additivate con antiossidante, compatibilizzante e biofiller, le quali sono state caratterizzate mediante analisi termiche, reologiche, morfologiche e meccaniche. I risultati hanno evidenziato un incremento della stabilità termo-ossidativa, una migliore processabilità e un comportamento reologico idoneo alla stampa 3D alimentata a granuli. Inoltre, l'azione sinergica di compatibilizzante e biofiller ha favorito l'adesione interfacciale e migliorato le proprietà meccaniche rispetto all'MPO non additivato. Lo studio conferma il potenziale delle plastiche marine come materiali funzionali per la manifattura additiva.

In Situ Stereocomplex Formation During Melt Extrusion: An Efficient Nucleating Strategy for Crystallization of High-Molecular-Weight PLA

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In this study we demonstrate that melt extrusion induces the crystallization of poly(lactic acid) (PLA) stereocomplexe (SC) in blends of high-molecular-weight PDLA/PLLA containing up to 12% stereodefects. The amount and thermal stability of the SC phase depend on blend composition and processing conditions. Despite their low concentration, in situ formed SC crystallites act as highly efficient nucleating agents for the α-form of PLA, with nucleation efficiencies ranging from ~60% to nearly 100%. The strongest nucleating effect was observed in blends containing moderately stereodefective PLLA. These results provide a simple, fully bio-based approach to tailor the crystallization kinetics and crystalline morphology of industrially relevant high-molecular-weight PLA without the need for conventional nucleating agents.

EFFECT OF NATURAL FILLERS AS SUBSTITUTES FOR GLASS FIBERS IN POLYAMIDE 6 COMPOSITES FOR LARGE-FORMAT ADDITIVE MANUFACTURING

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This work investigated clay, silica, and calcium carbonate as sustainable alternatives to glass fibers (GF) in PA6 composites for Large-Format Additive Manufacturing (LFAM) applications. Natural filler-reinforced formulations (≤10 wt%) were produced and compared with a 30 wt% GF reference. Rheological and thermal analyses showed that the fillers preserved the thermal behavior of PA6 while providing suitable processability for LFAM. Printing trials demonstrated good print quality and filler dispersion. Flexural testing revealed a good mechanical response and reduced anisotropy compared to the GF-reinforced composite. Despite their significantly lower loading, the selected natural fillers provided competitive performance, highlighting their potential as lightweight and sustainable reinforcements for LFAM applications.

INFLUENCE OF GRAPHENE ON THE ELECTRICAL AND MECHANICAL PROPERTIES OF SLS-PRINTED PA11

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This study focused on the production of innovative bio-based polyamide 11 (PA11) composites reinforced with 2 wt.% graphene (PA11G) via Selective Laser Sintering (SLS), with the aim of developing multifunctional materials suitable for advanced applications in food and healthcare, such as 3D-printed sensors and smart devices. PA11 reinforced with 1wt.% biochar was used as a reference (PA11B). After printing dumbbell specimens, PA11G shows improved consolidation and a more compact structure by microscopic analysis, and a reduced crystallinity through DSC, confirmed by FT-IR amide group analysis. The findings also demonstrated that, in comparison to reference samples, graphene enhances the composite's stiffness, and electrical conductivity due to the formation of conductive network.

FUSED FILAMENT FABRICATION OF TPU/PCM COMPOSITES FOR THERMALLY ACTIVE WEARABLE SPORT APPLICATIONS

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Flexible TPU composites containing microencapsulated phase-change materials were developed for fused filament fabrication of thermally active wearable components. The printed materials retained significant latent heat storage capability with good stability after thermal cycling. Increasing PCM content improved thermal functionality but reduced ductility and fatigue resistance, especially because of porosity in printed samples. Under compressive fatigue, mechanical stiffness decreased markedly, while melting and crystallization enthalpies remained largely preserved, generally above 80%. These results show that thermal functionality is more robust than mechanical performance, making TPU/PCM composites promising for customized thermally active insoles and sport wearables.

EXTENDING RUBBER FRACTURE CHARACTERIZATION METHODS TO LAYER ADHESION ASSESSMENT IN 3D-PRINTED TPU

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This study investigates the feasibility of extending experimental methods for the characterisation of fracture behaviour in bulk rubber to evaluate layer adhesion in 3D-printed TPU specimens. The effects of printing temperature, layer thickness, and external cooling were systematically evaluated by measuring the J-integral, an energy-based fracture parameter, both at fracture onset and during the crack growth. A layer thickness of 0.2 mm provides the highest J-integral values, while increasing the printing temperature to 240°C only slightly improves fracture performance, with external cooling having a negligible effect.

Altri

CONTRIBUTI ORALI

Chimica e fisica dei polimeri

ELECTROSPUN MEMBRANES OBTAINED FROM PLANT PROTEINS AND MALTODEXTRINS FOR THE TREATMENT OF GADOLINIUM-CONTAMINATED WASTEWATER

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The use of gadolinium-based contrast agents in MRI has led to the contamination of water resources. To address this issue, this study focuses on developing innovative biodegradable filtration membranes. These membranes were produced through electrospinning using zein and maltodextrins. Maltodextrin membranes have proven to be highly effective in removing free gadolinium, while activated carbon was incorporated into both zein and maltodextrin fibers to help retain complexed gadolinium. Tests showed successful removal in both aqueous solutions and simulated urine. However, efficiency significantly decreased when tested in real environmental matrices. Further optimization is needed to improve performance and viability for large-scale applications.

FROM AMPHIPHILIC RANDOM COPOLYMERS TO FUNCTIONAL NANO-CHELATORS: A NEW STRATEGY FOR RADIONUCLIDES SEQUESTRATION

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PEGMA-based amphiphilic random copolymers enable the formation of nano-objects below 20 nm through intramolecular single-chain folding, yielding unimolecular, or unimer, micelles. Their LCST-like thermoresponsiveness allows stimulus-controlled aggregation, potentially exploitable for material recovery. In this work, amphiphilic random copolymers bearing oxyethylenic and short fluorinated side chains as well as covalently linked DOTA-type chelating units were synthesized by RAFT polymerization. Their self-assembly and thermoresponsive behavior in water were studied by DLS and turbidimetry, while ^{68}Ga and ^{99m}Tc sequestration was assessed by radio-TLC. A proof of concept for chelating copolymer recovery is also presented.

A NOVEL MELAMINE-FREE WATERBORNE INTUMESCENT COATING FOR FIRE PROTECTION OF WOOD

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Wood is a renewable and sustainable construction material, but its high flammability limits its use in building applications. A melamine-free waterborne intumescent coating based on a urea–formaldehyde (UF) binder was developed, optimized, and successfully scaled up. The formulation showed good storage stability, reproducibility, and free formaldehyde content below 0.1 wt.%. Rheological analysis revealed shear-thinning behavior, confirming suitability for industrial application. Fire performance assessed by cone calorimetry, showed excellent fire protection properties. In parallel, ammonium polyphosphate modified additive (APP–EA–PCL) is being investigated as a multifunctional flame retardant combining carbon, nitrogen, and phosphorus sources within a single component, potentially replacing the conventional intumescent triad.

ELECTROSPINNING AND SOLUTION BLOW SPINNING OF WATER-BASED POLYMER SOLUTIONS FOR THE SUSTAINABLE MANUFACTURING OF NANOFIBROUS MATS

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ABSTRACT

The sustainable production of nanofibrous materials requires fabrication techniques that combine morphological control, scalability, and environmentally benign processing. This work compares electrospinning (ES) and solution blow spinning (SBS) for producing nanofibrous mats from a fully aqueous poly(vinyl pyrrolidone) (PVP) solution, directly assessing the influence of the spinning mechanism on fiber morphology. Both techniques successfully produced continuous nanofibers: ES yielded highly uniform fibers (~980 nm) with a narrow diameter distribution, whereas SBS generated thinner fibers (~430 nm) with greater size variability. These results demonstrate the feasibility of producing water-based nanofibrous mats while enabling control of fiber morphology for applications requiring tailored porosity and light scattering.

TACTICITY-INDEPENDENT CRYSTALLIZATION AS A DESIGN STRATEGY FOR CHEMICALLY RECYCLABLE SEMICRYSTALLINE POLYMERS

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Crystallization improves thermal and mechanical properties of synthetic polymers, but it usually requires high stereo- and regioregularity of the polymer molecular structure. Recent polyesters and polythioesters chemically recyclable to their monomers have revealed the phenomenon of tacticity-independent crystallization, as they are able to crystallize despite their stereoirregular or even atactic microstructure. Here, the crystal structures of stereoregular and atactic mono- and dimethylated poly(3-hydroxybutyrate)s and of poly(2-thiabicyclo[2.2.1]heptan-3-one) are discussed to identify the molecular factors responsible for tacticity-independent crystallization. These case studies provide design rules for semicrystalline, chemically recyclable polymers without the need for enantiopure monomers or highly stereoselective catalysts.

STRUCTURE-PROPERTY RELATIONSHIPS IN BIOPOLYMERIC CRYOGELS PRODUCED BY FREEZE-CASTING

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Cryogels are a very versatile and advantageous material, thanks to their low density, high specific surface and low thermal conductivity. This work aims to investigate this type of materials obtained by freeze-casting starting from a biopolymer solution, selecting a series of different production conditions that allow obtaining samples differing in microstructure and, consequently, with different properties and so different advantages in the applications. To evaluate the effect of the different process parameters, the samples obtained are characterized by density and porosity measurements, observation under a scanning electron microscope, compression tests and, after cross-linking, water absorption kinetics.

PRESSURE-INDUCED CRYSTALLIZATION AND POLYMORPHIC TRANSITIONS OF POLYBUTENE-1: HIGH-PRESSURE PVT STUDY

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Isotactic poly(1-butene) exhibits complex pressure-sensitive polymorphism, yet quantitative volumetric data remains limited. High-pressure PVT dilatometry was employed to monitor specific-volume changes during melt crystallization between 10 and 200 MPa. Results reveal that crystallization yields predominantly form II at $P \leq 60$ MPa, while hydrostatic pressure accelerates the solid-solid $II \rightarrow I$ transformation at 75–100 MPa. Beyond $\gtrsim$ 175 MPa, form I' dominates. From these dilatometric fingerprints, phase-resolved V(T,P) maps were successfully assembled. These findings offer practical inputs for shrinkage prediction and delineate pressure protocols to suppress metastable form II, mitigating delayed dimensional changes.

HEMIN-BASED AMPHIPHILIC RANDOM COPOLYMERS AS BIOMIMETIC AND RECYCLABLE CATALYSTS FOR ARGET-ATRP IN WATER

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Hemin represents a promising bioderived iron catalyst; however, its poor water solubility and challenging recovery still limit its practical application. Here, thermoresponsive amphiphilic random copolymers bearing short PEG and fluorinated side chains were designed as polymeric nanoplatforms to stabilize hemin in water, while enabling its recovery above their typical cloud point temperature. The copolymers were synthesized by RAFT polymerization and investigated in terms of aqueous self-assembly, LCST-type behavior, hemin incorporation, and electrochemical activity of the metal center. Their potential as biomimetic catalysts for aqueous ARGET-ATRP was assessed polymerizing $PEGMA_{500}$. The results support the development of bio-inspired and recyclable catalysts for sustainable aqueous controlled radical polymerization.

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Polimeri da fonti rinnovabili e degradabili, riciclo

DEVELOPMENT OF CELLULOSE FIBERS RECOVERY STRATEGY FROM SILICONIZED PAPERS

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Release liners are the paper substrates left after pressure-sensitive labels are peeled off and applied. They consist of highly refined cellulose fibers with a smooth surface, coated with a thin layer of polydimethylsiloxane (PDMS) that imparts release properties, but hinders the recyclability of the liners. This work proposes a strategy to remove silicone and recover cellulose fibers, by disintragation under controlled alkaline and thermal condition, to swell the fibers, followed by a surfactant–assisted flotation step that removes the silicone particles formed during pulping. The cleaned pulp is then formed into handsheet samples and characterized by FTIR, XRF, SEM-EDS and mechanical testing. This process enables the reuse of the desiliconized pulp as a valuable secondary raw material for the papermaking process.

PBAT/GRAPE POMACE BIOCOMPOSITE FOR FILM BLOWING APPLICATIONS

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The study explores the use of grape pomace (GP), a wine industry by-product, as a biofiller in biodegradable polymer films to promote sustainability and circular economy. GP is rich in lignocellulosic and antioxidant compounds, making it suitable for polymer enhancement. A masterbatch with PBAT was produced via twin-screw extrusion and used to create films containing 5% and 10% GP. The materials were tested for processability, rheological behavior, mechanical properties, aging, and biodegradability. Results showed good filmability with adequate melt strength and stretching behavior. Mechanical performance remained acceptable, with no significant embrittlement. GP influenced photo-oxidation and biodegradation kinetics. Overall, GP demonstrates strong potential for developing sustainable packaging films through film blowing.

ANTIOXIDANT AND UV-BLOCKING POLY(BUTYLENE SUCCINATE) FILMS VIA NITROXIDE RADICAL COUPLING FUNCTIONALIZATION

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Poly(butylene succinate) (PBS) was functionalized via nitroxide radical coupling (NRC) using a TEMPO derivative bearing a sterically hindered phenolic antioxidant group (BHB-TEMPO). The reaction was conducted in both solution and melt phases, yielding covalently bound antioxidant functionalities while preserving the molecular and thermal properties of PBS. The melt-phase process achieved the highest degree of functionalization. The resulting functionalized films demonstrated improved resistance to thermo-oxidative and photo-oxidative degradation, as well as effective UV-blocking properties. Notably, the most highly functionalized sample protected β-carotene from UV-induced degradation, indicating its potential for use in biodegradable, compostable active food packaging.

THERMAL METHOD TO RECOVER GLASS FIBERS FROM EPOXY RESIN COMPOSITES

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The accumulation of end-of-life wind turbine blades has a significant environmental impact due to the limited recycling options for glass fiber reinforced polymers. Mechanical recycling damages glass fibers and produces low-value fillers, while chemical methods are expensive and difficult to scale up. This work proposes induction heating as an alternative thermal recycling process to preserve the integrity of glass fibers. Fiber degradation is reduced compared to conventional pyrolysis by minimizing the direct contact of the fibers with the high-temperature environment. The recovered fibers present an uniform organic residue that has been evaluated as a compatibilizer in the production of new composites. The process appears scalable, uses recyclable conductor materials, and has the potential to reduce overall recycling costs.

INFLUENCE OF FAST PYROLYSIS BIO-OIL-DERIVED PHENOLIC-RICH FRACTION FROM LOGGING RESIDUES ON PLLA UV STABILITY

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The development of new biodegradable polymer formulations is essential to address the depletion of fossil resources and the environmental issues associated with conventional plastics. A novel PLLA-based blend containing 2 wt.% phenolic-rich fraction of fast pyrolysis bio-oil (FPBO), obtained from logging residues, was prepared and investigated to evaluate its behavior under UV ageing. Changes in structure, morphology, and mechanical properties during UV exposure were analyzed. Samples were subjected to UV irradiation for up to 23 days, and their ageing behavior was evaluated after 7 and 23 days in comparison with non-aged counterparts. The blend exhibited remarkable resistance to UV irradiation, retaining its functional properties even after 23 days of exposure, whereas the embrittlment of unfilled PLLA was already evident after 7 days.

Polyethylene Glycol-Assisted Film Stacking of Polylactide/Bacterial Cellulose Nanocomposites for Sustainable Food Packaging

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ABSTRACT

Bacterial cellulose (BC) is a renewable nanofibrillar material with high purity, biocompatibility and excellent specific mechanical properties, making it a promising reinforcement for biodegradable polymers. This work investigates PLA/BC nanocomposites prepared by film stacking and hot pressing, using PEG pre-impregnation of BC to improve processability and interfacial adhesion. PEG plasticization increased BC strain at break up to six-fold and promoted PLA penetration into the network, yielding well-bonded laminates. The optimized composites showed improved mechanical performance, reduced O2/CO2 permeability, UV-barrier behaviour, retained transparency, low water uptake and industrial compostability, highlighting their potential for sustainable food packaging.

Biopol4Soil - BIODERIVED POLYMERIC GRANULES AND NON-WOVEN FABRICS FOR SUSTAINABLE AGRICULTURE: BIODEGRADABILITY AND PHYTOTOXICITY EVALUATION

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The Biopol4soil project investigates bioderived cross-linked maltodextrin granules and electrospun maltodextrin/zein non-woven fabrics for agricultural applications. Neutral and cationic maltodextrin granules exhibited remarkable water retention capacities between 622% and 734%, demonstrating potential for deployment in soil remediation and soil conditioning. Biodegradation studies in simulated soil solutions confirmed the progressive weight loss and microbial accessibility over an eight-week testing period. Soil incubation tests revealed that non-woven fabrics underwent full biodegradation within two weeks in sub-alkaline soil characterized by high microbial biomass. In contrast, biodegradation in microbial biomass acid soil proceeded more slowly, with the hydrophobic zein protein content noticeably retarding structural breakdown.

CHARACTERIZATION OF HYDROLYZED POLYESTERS FROM AGRO-WASTE: EFFECT OF EXTRACTION CONDITIONS ON COMPOSITION

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The requirement to develop sustainable coatings has shifted the focus toward biobased polymers obtained from the valorization of agro-industrial byproducts. In this study, the effect of the main alkaline hydrolysis parameters on the composition of cutin extracted from tomato peels was investigated. The samples were characterized using NMR, IR-ATR, acid-base titration, GPC, and DSC. The analyses revealed that hydrolysis efficiency increased as the treatment temperature rose. GPC analysis showed significant variations in the percentages of oligomers, dimers, and monomers. DSC analysis confirmed the presence of a crystalline phase in all samples. The results provide useful information for optimizing cutin extraction processes for the development of sustainable coatings.

INFLUENCE OF GLOCHIDS AND COMPATIBILIZER ON THE RHEOLOGICAL, MECHANICAL AND BIODEGRADATION BEHAVIOUR OF PBAT AND PLA BIOCOMPOSITES

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This study investigates the use of glochids as a bio-filler in biodegradable polymer matrices, focusing on PBAT and PLA to clarify how the filler interacts with different polymer systems. Because fillers and matrices often show limited compatibility, a compatibilizer was also incorporated to enhance interfacial adhesion. The findings indicate that glochids and the compatibilizer play distinct roles in PBAT and PLA-based biocomposites. Glochids increase stiffness and viscosity in both matrices. The compatibilizer further raises viscosity at low shear rates and intensifies non-Newtonian behaviour, although the magnitude of these effects depends on the specific matrix. This suggests that the compatibilizer functions as a chain extender differently in PBAT and PLA. Its presence also alters the biodegradation kinetics of the resulting materials.

CIRCULAR VALORIZATION OF POST-CONSUMER POLYURETHANE FOAMS THROUGH MECHANICAL RECYCLING AND SUSTAINABLE COMPOSITE DESIGN

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The sustainable management of end-of-life polyurethane (PU) foams is a major challenge due to their thermoset nature. In this work, flexible PU foams from discarded mattresses were mechanically recycled through cryogenic grinding and compression molding to obtain densified panels. The effects of foam composition and processing parameters on material performance were investigated. Furthermore, volcanic ash was incorporated as a sustainable mineral filler to develop composite materials with enhanced properties. The recycled panels exhibited good structural integrity, improved thermal stability, and satisfactory mechanical performance, demonstrating the potential of this approach for producing value-added products.

ITACONIC ACID: A SUSTAINABLE PLATFORM ALTERNATIVE TO ACRYLIC ACID IN RADICAL POLYMERIZATION

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Acrylate polymers are industry standards for coatings and adhesives but lack sustainability and biodegradability. Itaconic acid derivatives offer bio-based alternatives, though limited by slow radical polymerization kinetics. This study employs RAFT polymerization to overcome these constraints, optimizing conditions using various chain transfer agents (CTAs) and initiators. Dithiobenzoates provided excellent molecular weight control for dimethyl itaconate (DMI), while the low-temperature initiator Vazo 70 significantly accelerated reaction rates compared to AIBN for dibutyl itaconate (DBI). The resulting DBI polymers exhibited film-forming characteristics with glass transition temperatures between -5 °C and 15 °C. Furthermore, poly(DMI) acted as an efficient macro-CTA to synthesize well-defined amphiphilic block copolymers containing itaconic acid. Ultimately, self-assembly of these amphiphilic systems successfully yielded monodisperse polymeric nanoparticles measuring 20–30 nm.

BIOBASED VITRIMERS USING EUTECTIC HARDENER SYSTEMS

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This work details the synthesis of fully bio-derived vitrimers cured via a green, non-toxic deep eutectic hardener. Dynamic covalent networks were fabricated by combining a cashew nutshell-derived epoxy resin with lignin-based diglycidyl ether of vanillyl alcohol (DGEVA), employing a 1:1 malic acid/ethyl lactate eutectic mixture as the crosslinker alongside zinc triflate as transesterification catalyst. The curing kinetics of mixtures with different blending ratios were analysed by DSC and FT-IR spectroscopy, and the thermal, mechanical, and dynamic properties of the resulting vitrimers were evaluated. The proposed approach provides a sustainable route toward high bio-based-content vitrimers obtained from renewable feedstocks and environmentally benign curing systems.

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POSTERS

Materiali polimerici ibridi e (nano)compositi sintesi, caratterizzazione e applicazioni

GRAPHENE OXIDE FUNCTIONALIZATION OF BACTERIAL CELLULOSE: EFFECTS ON THE STRUCTURE AND ADSORPTION PERFORMANCE

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This study investigates bacterial cellulose (BC) composites as sustainable adsorbent materials for removing organic contaminants from water. BC was produced as biofilms and beads, with graphene oxide (GO) added during bacterial growth to improve its adsorption properties. The resulting materials were chemically, morphologically, and thermally characterized and evaluated for the removal of Rhodamine 6G, Methyl Orange, and 2,4-dichlorophenol. Adding GO improved structural uniformity, thermal stability, and adsorption efficiency, allowing for the capture of anionic and neutral contaminants that regular BC could not remove effectively. Additionally, the interconnected porous network of the composites shows their potential for capturing micro- and nanoplastics from water.

RESIDUAL ANTIOXIDANT ACTIVITY OF WINERY BY-PRODUCT BIOFILLERS IN LDPE AND HDPE COMPOSITES

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Two winery by-product biofillers derived from grape seeds (WGS B1 and WGS GV3) were compared with commercial tannins and synthetic antioxidants (Irganox 1010 and B225). Thermal stability was assessed by TGA, and functional groups by ATR-FTIR. DPPH results, benchmarked against Trolox, showed that biofillers retain significant antioxidant activity. Biofillers and reference additives were melt-compounded with LDPE and HDPE at 180°C, maintaining a constant tannin content (0.8 wt.%). Composites were characterized by DSC and TGA, showing improved thermal stability. The antioxidant effect was further confirmed by thermal aging at 110°C. Notably, biofillers effectively transferred their antioxidant activity to the polymer matrices. These findings highlight the potential of untreated biofillers as multifunctional stabilizing additives.

UPCYCLING HAZELNUT BY-PRODUCTS INTO FUNCTIONAL ELASTOMERIC COMPOSITES FOR SUSTAINABLE SPORTS SURFACES

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Elastomeric compounds for sports flooring applications were developed using hazelnut-derived and bio-based additives and compared with a reference formulation containing conventional additives. Epoxidized hazelnut oil was used as plasticizer, lignin as antioxidant, and gallic acid immobilized on inorganic supports (silica, saponite, kaolin) to replace filler and antioxidant simultaneously. Tensile testing showed that most formulations exhibited mechanical properties comparable to the reference, with increased stiffness for the silica-based system and minor variations for the others. Lignin-based compounds showed slightly higher strength, whereas the saponite-based system was slightly weaker. These results confirm the feasibility of replacing conventional rubber additives with bio-based alternatives within a circular economy framework.

DEVELOPMENT OF LIGNIN-CONTAINING BIODEGRADABLE POLYMER BLENDS FOR FISHING NET APPLICATIONS

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Plastic pollution caused by abandoned fishing nets is a major threat to marine ecosystems due to ghost fishing. Biodegradable PBS/PBAT blends were developed as sustainable materials for fishing net applications. Lignin was incorporated as a natural UV absorber to enhance photostability and promote controlled degradation under sunlight. Different formulations were prepared by varying the lignin content and characterized through chemical, physical, and rheological analyses. Polymeric films were exposed to both natural and artificial UV radiation to evaluate their degradation behavior. Changes induced by UV exposure were investigated using colorimetric, morphological, and thermal analyses. The results confirmed the effectiveness of lignin in tailoring the UV response while maintaining suitable processability. These findings support the development of biodegradable fishing nets with reduced environmental impact.

PREPARATION AND CHARACTERIZATION OF THERMORESPONSIVE FILMS OBTAINED FROM HYBRID PNIPAM/SILK FIBROIN SYSTEMS

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Poly(N-isopropylacrylamide) (PNIPAM) is a thermoresponsive polymer used for biomedical applications. In this work, PNIPAM/fibroin (SF) blends were prepared by physical mixing of preformed 650 nm and 300 nm PNIPAM microgels with SF solution. The resulting stable colloidal dispersion were used for obtaining homogeneous thin films. FT-IR spectroscopy confirmed both the presence of PNIPAM and SF within the hybrid materials. Thermal treatment (60–160 °C) significantly improved film stability in aqueous media. Swelling degrees at 25 and 40 °C showed thermoresponsiveness consistent with hydrophilic-to-hydrophobic transition of PNIPAM across its critical temperature. These findings highlight the potential of PNIPAM/SF hybrid films as sustainable and stimuli-responsive biomaterials.

DEVELOPMENT OF PBSA-BASED BIOCOMPOSITES REINFORCED WITH *CEIBA SPECIOSA* NATURAL FIBRES

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This work reports the development of biodegradable biocomposite laminates based on a poly(butylene succinate-co-adipate) (PBSA) matrix reinforced with the cottony seed floss of *Ceiba speciosa* (silk floss tree) fruit. Laminates were manufactured by the film-stacking technique, using the fibre both in flock form, as a core layer between PBSA skins, and in microparticle form, melt-blended into the skins themselves. In the first campaign, neat PBSA skins were combined with a core of untreated or $NaHCO_3$-treated flock fibres at two weight concentrations. In the second campaign, untreated flock fibres were combined with skins filled with 5 wt% of untreated or $NaHCO_3$-treated particles. The resulting sandwich laminates, which combined macro- and micro-scale reinforcement, achieved the highest stiffness among all tested configurations.

STABILIZATION OF MAGNETIC NANOPARTICLES IN LIQUID CRYSTALLINE POLYMERS VIA TAILOR-MADE LIGANDS

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Efficient mixing of magnetic nanoparticles (MNPs) with liquid crystalline (LC) matrices remains a key challenge in the preparation of corresponding composites. In this context, coating MNP surface with organic ligands that ensure their compatibility with the LC environment is one of the most promising approaches.
In this contribution, we present the use of tailor-made ligands for the stabilization of MNPs in mixtures with compounds typically used for the preparation of LC polymers. Superparamagnetic magnetite NPs were first coated with specifically designed ligands and subsequently introduced in the nematic LC solvent 5CB and in its mixture with LC cross-linker RM257. The second material enabled us to prepare self-standing films after polymerization. Finally, the magnetic properties of all obtained materials were investigated.

PHYSICS-INFORMED MACHINE LEARNING FOR PREDICTING OPTICAL TRANSMITTANCE AND HAZE IN TRANSPARENT WOOD

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Transparent wood (TW) is an emerging sustainable material whose optical performance depends on a complex interplay between composition, thickness, refractive index matching, and microstructure. Here, a physics-informed machine learning framework was developed to predict optical transmittance and haze using a literature-derived dataset of 95 transparent wood systems. Random Forest, Gradient Boosted Trees, and Multilayer Perceptron models were evaluated after robust preprocessing, missing-data imputation, and controlled data augmentation. Optical transmittance was predicted with good accuracy, whereas haze remained more challenging due to its strong dependence on microstructural heterogeneity. The results demonstrate the potential of machine learning as a tool for accelerating TW design and optimization.

PREPARATION AND CHARACTERIZATION OF UV-LED CURABLE BIO-BASED COATINGS CONTAINING POLYMERIC CARBON DOTS

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Bio-based UV-curable coatings represent a promising route toward sustainable advanced materials. In this work, polymeric carbon dots (PCDs) synthesized from citric acid and 1,4-phenylenediamine through an ultrasound-assisted process were incorporated into an acrylated epoxidized soybean oil (ESBOA) resin and UV-LED cured. The resulting coatings retained the characteristic fluorescence emission of the nanofiller while achieving complete photopolymerization. Thermal analyses revealed that PCDs slightly improved the thermal stability of the coatings without affecting the glass transition temperature or crosslinking density. These findings demonstrate the potential of polymeric carbon dots as multifunctional bio-derived nanofillers for fluorescent UV-LED curable coatings.

SUSTAINABLE TRANSPARENT WOOD BASED ON BIO-BASED ISOBORNYL ACRYLATE/METHACRYLATE MATRICES

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Transparent wood (TW) is an emerging sustainable material combining the hierarchical structure of wood with the optical properties of transparent polymers. In this work, delignified balsa wood was filled with bio-based poly(isobornyl acrylate) (polyIBOA), poly(isobornyl methacrylate) (polyIBOMA), and their copolymers. The developed composites exhibited high optical transmittance (up to 80%), significant light diffusion, low thermal conductivity (0.15–0.18 W m^{-1} K^{-1}), and homogeneous polymer distribution within the wood structure. The results demonstrate that isobornyl-based polymers are promising sustainable alternatives to conventional petroleum-derived matrices for transparent wood applications in energy-efficient buildings, optical devices, and advanced functional materials.

MICROPLASTICS RELEASE FROM PP-BASED BLENDS AND NANOCOMPOSITES

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Microplastics and nanoplastics release into the environment is a very important issue with significant threats in terms of environmental and health impact. A typical case is when they are generated from the degradation and fragmentation processes affecting plastic-based items mainly due to environmental and mechanical factors. It is further interesting to focus on multiphase polymer systems, such as polymer blends and nanocomposites, since microplastics (and, possibly, nanoplastics) could be generated both from the dispersed phase and the matrix. In this work, we focused on two polypropylene/polyester blends without and with a suitable compatibilizer, and a polypropylene nanocomposite with a commercial nanoclay, ad their microplastics release due to photo-oxidation and mechanical stress was investigated.

SUSTAINABLE ROUTES TO LEAD-FREE FLEXIBLE PIEZOELECTRIC POLYMER-CERAMIC FILMS FOR ENERGY HARVESTING

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Polymer–ceramic piezoelectric composites, combining the high breakdown strength and mechanical flexibility of polymers with the outstanding dielectric and piezoelectric response of ferroelectric ceramics, have arisen as promising candidates for next-generation flexible and sustainable energy-harvesting systems. Here, PVDF-based composite films containing 30 vol% $BaTiO_3$ (BT) particles were prepared using four fabrication routes: a one-step method based on hot pressing (HP), and three double-step procedures, namely, melt blending (MB), solvent casting (SC) and microwave irradiation and mixing (MW), all followed by a final hot pressing step. MW is proposed as an innovative, scalable, eco-friendly and energy-efficient approach to boost the development of lead-free flexible, high-efficiency piezoactive composites.

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POSTERS

Processabilitá e stampa 3D di materiali polimerici

PROCESSING AS A DESIGN TOOL FOR TAILORING MICROSTRUCTURE AND PROPERTIES IN COMPLEX POLYMER SYSTEMS

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Complex polymer-based systems often require more than compositional design: their final behavior is strongly governed by the microstructure generated during processing. This contribution highlights processing as an active design tool through three case studies in which the selection and optimization of the processing route are used to control morphology and material properties. Specifically, elongational flow compatibilizes PLA/PHBH blends, improving ductility; mixing sequence in HDPE/PA6/nanoclay blends controls clay localization and fire behavior; FFF of PP/nanoclay generates FR structures more effective than traditional technologies. Overall, these examples demonstrate that processing/microstructure/properties relationships can be deliberately exploited to design polymer systems with tailored performances.

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POSTERS

Chimica e fisica dei polimeri

FLUORINE-FREE PROTON EXCHANGE MEMBRANES: SYNTHESIS AND CHARACTERIZATION OF SULFONATED PPO-PBI NETWORKS FOR PEMWES

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(INSERIRE UN ABSTRACT DI NON PIU' DI 8 RIGHE)

Green hydrogen production via PEM water electrolyzers (PEMWE) is limited by the cost and environmental impact of perfluorinated membranes like Nafion. This study presents novel, fluorine-free proton exchange membranes based on sulfonated polyphenylene oxide (PPO-SO_3H) crosslinked with polybenzimidazole (PBI). PBI crosslinking provided robust structural integrity, restricting swelling below Nafion 117 levels while maintaining excellent thermo-mechanical stability. Crucially, optimized PPO-SO_3H-PBI membranes achieved an outstanding ion exchange capacity (IEC) of 1.44 mmol/g, outperforming the Nafion 117 benchmark (0.93 mmol/g) via synergistic proton conduction. These architectures demonstrate exceptional potential as cost-effective, high-performance solid polymer electrolytes for next-generation PEMWEs

TOWARDS CIRCULAR FLAME-RETARDED POLYPROPYLENE: FIRE PERFORMANCE AFTER RECYCLING AND AGING

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Plastics circularity requires flame-retarded (FR) materials retaining fire safety after service-life and recycling. Here, FR polypropylene (PP) circularity was investigated through two approaches. First, intumescent FRs or magnesium hydroxide were introduced into reprocessed PP to assess whether recycled matrices can be upgraded for fire-safe applications. Second, FR-PPs were subjected to repeated reprocessing cycles to evaluate fire-performance retention after mechanical recycling. FR properties remained nearly unchanged compared with virgin FR-PP, or even improved due to more efficient char formation, while mechanical properties and processability were preserved. Finally, thermo- and photo-oxidative aging before reprocessing was addressed, enabling a more realistic assessment of FR-PP circularity.

DESIGN OF CARBAZOLE-FUNCTIONALIZED POLY(TRIPHENYLAMINE)S FOR VISIBLE-DRIVEN WATER REMEDIATION

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Carbazole-functionalized polytriphenylamines (PTPAs) were synthesized via oxidative polymerization using iron(III) chloride. Two para-substituted monomers bearing 9H-carbazole and 3,6-dimethyl-9H-carbazole units yielded amorphous polymers (PM1 and PM2) with moderate molecular weights (≈ 5 kDa) and good film-forming ability. PM2 exhibits higher chloroform solubility due to suppressed cross-linking induced by methyl substitution. PM1 shows an optical band gap of 2.90 eV, consistent with visible-light responsiveness. Preliminary photocatalytic tests using methylene blue demonstrated efficient dye removal under visible light, indicating that these PTPAs are promising photoactive materials for environmental applications.

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