12th Green Chemistry and Nanotechnologies in Polymeric Materials

Donostia / San Sebastián
15-17 June, 2026

GCNPM 2026

EHU

12th CONFERENCE ON GREEN CHEMISTRY AND NANOTECHNOLOGIES IN POLYMERIC MATERIALS

DONOSTIA / SAN SEBASTIÁN

15-17 JUNE, 2026

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Conference Presentation

Donostia / San Sebastián, June 2026

12th Conference on Green Chemistry & Nanotechnologies in Polymeric Materials

Dear colleagues and friends,

It is a great pleasure to welcome you to the 12th edition of the *Green Chemistry and Nanotechnologies in Polymeric Materials (GCNPM 2026)* here in San Sebastián.

Since its beginning in 2010, the GCNPM conference series has grown into a well-established meeting point for researchers, scientists, and professionals committed to advancing sustainable solutions in polymer science. Over the years, it has fostered an active international community, encouraging the exchange of ideas and the development of innovative approaches to address the environmental challenges associated with polymeric materials. We are delighted to see this spirit continue in the present edition, bringing together participants from diverse backgrounds and disciplines.

This conference provides a valuable opportunity not only to share recent scientific achievements, but also to strengthen collaborations, build new connections, and explore future directions in the field. We hope that the program will stimulate insightful discussions and inspire new perspectives that will contribute to ongoing progress in green chemistry and polymer technologies.

We are especially pleased to host you in San Sebastián, a city that combines a rich cultural heritage with a dynamic and forward-looking environment. Beyond the scientific program, we encourage you to enjoy the unique atmosphere, gastronomy, and natural beauty that make this city such a special place.

We hope that you will find the conference both intellectually rewarding and personally enjoyable.

We wish you a productive and inspiring stay and thank you for being part of GCNPM 2026.

With kind regards,

Arantxa Eceiza & Nagore Gabilondo

Conference Chairs

General Information

Venue

All conference activities will take place at the Faculty of Engineering of Gipuzkoa (Plaza Europa 1, 20018, Donostia / San Sebastián).

Conference rooms and activities

Ground Floor
Registration: On-site registration takes place on Monday, 15 June 2026, from 8:30 to 13:00 and will continue the next days from 8:00 to 16:00. The registration desk will be located on the *ground floor*, opposite the conference room.
Oral presentations: Oral presentations will take place in the *conference room* located on the ground floor.
Sponsors' exhibition area: Sponsors' exhibition stands will be located on the *ground floor*, next to the conference room.

1st Floor
Streaming room: Conference sessions can also be followed via streaming in the room located on the *first floor*. Working spaces will be available for attendees.

2nd Floor
Poster session: The poster session will take place on the *second floor*. It is scheduled for Monday, 15 June 2026: 18:00-19:30 with pintxos and drinks. However, the posters will remain on display until the end of the conference for discussion on further coffee break sessions.
Coffee breaks and lunches: Coffee breaks and meals will be served on the *second floor*.

Tenis Ondarreta
Gala dinner: The gala dinner will take place on 16 June 2026 at 20:00 at *Tenis Ondarreta* (Paseo Eduardo Chillida 9, 20008 Donostia / San Sebastián).

Presentations

The Conference presentations will consist of plenary lectures, invited lectures and oral communications:

- Plenary lectures: 45 minutes long.
- Keynotes: 30 minutes long.
- Oral communications: 15 minutes long.

Technical aspects: Data-Video-Projector connected to a local computer (running on Windows operating system) will be available for MS PowerPoint (.pptx, .ppt) and Adobe Acrobat (full screen formatted .pdf). For other facilities, we advise to contact the organizers. The local computer is available, using own computers is exceptional and please inform about such requirement in advance.

We recommend providing your presentation in registration at least one session before the lecture is scheduled.

Recordings

Audio/video recording of the lectures or copying of lecture files is not allowed without the prior consent of the speaker. The organizers reserve the right to take photographs for documentation during the meeting. In case you do not want to be photographed, please kindly inform the photographer or organizers.

Poster session

The poster sessions will take place on the second floor of the Faculty of Engineering of Gipuzkoa.

Materials for fixing posters will be provided on-site. Posters should be mounted at the beginning of the conference and removed once the conference has finished.

Each poster board is identified with a code. You can find the code corresponding to your poster in this book of abstracts.

Special Awards

Two awards were granted in recognition of outstanding poster contributions presented by Young Researchers. The awards were as follows:

Best Poster Award: 300 €

Second Best Poster Award: 150 €

All Young Researchers who were eligible and presented a poster at GCNPM 2026 were automatically considered for these awards. The evaluation took into account the scientific quality of the work, the clarity of the presentation, the visual organization of the poster, and the ability of the presenter to discuss and communicate the research.

The winners, who were announced during the conference, were:

Best Poster Award: Gabilton C. S. Adão

Second Best Poster Award: Laura Martellosio

How to Get Here

Donostia / San Sebastián is a well-connected city, making it accessible by air, train, bus, or car.

By air: The San Sebastián Airport (EAS) is located 20 km away from the city, with daily connections to Madrid and Barcelona. The nearby Bilbao Airport (BIO) (100 km) and Biarritz Airport (BIQ) (50 km, France) offer a wide range of national and international flights.

Airport	Bus Service
San Sebastián Airport (EAS) – 20 km	Lines **E21** and **E30** connect the airport with the city centre in about 30 minutes.
	Line **E28** connects the airport directly with the conference venue in approximately 30 minutes.
Bilbao Airport (BIO) – 100 km	**Direct buses** to San Sebastián run approximately every hour, with a journey time of around 75 minutes.
Biarritz Airport (BIQ) – 50 km	**Regional buses** link the airport to San Sebastián in about one hour.

By train: The San Sebastián train station provides regular connections with Madrid, Barcelona, and cities in northern Spain.

By bus: The San Sebastián bus station provides regular connections with Madrid, Barcelona, and cities in northern Spain.

By car: San Sebastián is easily accessible via the A-8 motorway, which connects to the national and international road network.

Getting Around Donostia / San Sebastián

San Sebastián is an accessible city, making it easy to move around and enjoy its main attractions.

The conference will take place at the Faculty of Engineering of Gipuzkoa, located at Plaza Europa 1. The venue is well connected by public transport (**Dbus** and **Euskotren**) and can be easily reached from different parts of the city.

On foot: Many of the city's highlights are within walking distance.

By bike: The city has an extensive network of bike lanes and a public bike rental system.

By train: Amara is the main Euskotren station in the city centre of San Sebastián (Plaza Easo 9). The nearest Euskotren stop to the conference venue is Lugaritz. From Lugaritz it's about a 15-minute walk to the Faculty of Engineering of Gipuzkoa (Plaza Europa 1).

By bus: San Sebastián has a reliable urban bus network (Dbus) that connects the city centre with the conference venue and main points of interest. Lines 5, 25 and 33.

By car: Driving is possible, but exploring the city is often more enjoyable without it.

Emergency Phone Numbers

Emergency services: 112

Local police: 092

Topics

The conference programme encompasses a wide range of topics, highlighting innovative strategies and sustainable solutions to address current environmental challenges:

- Biobased monomers and polymers, natural polymers.
- Environmental degradation of polymers.
- Recycling and upcycling of polymers.
- Production design of sustainable polymers.
- Enzymatic reactions in macromolecular chemistry.
- Environmental-friendly polymerizations.
- Dynamic networks, vitrimers.
- Sustainable solutions in polymer nanotechnologies.
- Global Threat of plastic pollution (environmental analysis, ecotoxicity, technological solutions).

Conference Programme

MONDAY, 15 JUNE 2026	
8:30-13:00	Registration and welcome coffee
10:00-10:30	Opening
10:30-11:15	Plenary Lecture PL-1 **Sylvain Caillol** *(France)* From natural phenols to circular polymers: a platform strategy for sustainable functional materials.
11:15-11:45	Keynote KN-1 **H. Beneš** *(Czech Republic)* Sustainable thermosetting foams – from design to end-use properties.
Lecture Session 1	
Chaired by Prof. Sylvain Caillol	
11:45-12:00	Oral Communication O-1 **M. L. Auad** *(United States)* Bio-oil-derived polymeric systems: non-isocyanate bio-based polyurethanes & UV-curable resins.
12:00-12:15	Oral Communication O-2 **M. Aguirre** *(Spain)* Dibutyl Itaconate (DBI): a unique biobased monomer to tune waterborne coatings and adhesives.
12:15-12:30	Oral Communication O-3 **S. Monasterio** *(Paralab, Spain)* Advanced characterization and turnkey solutions for polymer systems: practical insights and application-driven approaches.
12:30-14:00	Lunch
14:00-14:45	Plenary Lecture PL-2 **Alessandro Gandini** *(Brazil)* Macromolecular materials incorporating chitosan: my various groups' contributions.

Lecture Session 2	
Chaired by Dr. Hynek Beneš	
14:45-15:00	Oral Communication O-4 **S. Bonardd** *(Spain)* Azo-functionalized chitosan films as strategy for increasing its CO_2 capture capacity.
15:00-15:15	Oral Communication O-5 **J. Navratilova** *(Czech Republic)* Spent coffee ground as a versatile bio-based additive in polypropylene..
15:15-15:30	Oral Communication O-6 **L. Ghirro** *(Portugal)* Alkaline–thermal restructuring of lupin protein for enhanced interfacial performance
15:30-15:45	Oral Communication O-7 **A. Altaee** *(Australia)* Feasibility of applying double crosslinked carrageenan adsorbent hydrogel in the electrokinetic process.
15:45-16:00	Oral Communication O-8 **I. Sardón** *(Indart3D, Spain)* Direct pellet additive manufacturing for sustainable polymer processing.
16:00-16:30	Coffee-Break
Lecture Session 3	
Chaired by Prof. Aleksander Prociak	
16:30-16:45	Oral Communication O-9 **I. Otaegi** *(Spain)* Valorization of tire-derived rubber in polypropylene blends: from model systems to recycled polymer matrices.
16:45-17:00	Oral Communication O-10 **P. Jutrzenka Trzebiatowska** *(Poland)* Utilization of collected ocean-bound plastic in the framework of COP project.
17:00-17:15	Oral Communication O-11 **P. Blyweert** *(France)* Natural poly-β-myrcene from Chios mastic gum as a renewable platform for elastomeric materials.
17:15-17:30	Oral Communication O-12 **V. Martinez** *(Hauschild-SpeedMixer, Germany)* Literature-based analysis of SpeedMixer uses in polymeric materials relevant to green chemistry and nanotechnology.
17:30-18:00	Keynote KN-2 **A. Tercjak** *(Spain)* Atomic Force Microscopy as a tool to study conductive and mechanical properties of multifunctional (bio)nanocomposite materials.
18:00-19:30	Poster Session/Pintxos & Drinks

TUESDAY, 16 JUNE 2026	
8:30-9:15	Plenary lecture PL-3 **Luc Avérous** *(France)* Linking polymer science and sustainability for a greener future: Decades of innovation in biobased polyurethanes.
9:15-9:45	Keynote KN-3 **F. Barreiro** *(Portugal)* Polymer-based solid dispersions as a platform for innovation in advanced applications.
Lecture Session 4	
Chaired by Prof. Luc Avérous	
9:45-10:00	Oral Communication O-13 **A. Toldy** *(Hungary)* Sustainability meets safety: designing flame retarded fibre-reinforced vitrimer composites.
10:00-10:15	Oral Communication O-14 **N. Collay** *(France)* Catalyzed urethane exchange in polyurethane covalent adaptable networks: from molecular investigations to rheological behavior.
10:15-10:30	Oral Communication O-15 **M. Kirpluks** *(Latvia)* Bio-based β-amino polyester vitrimer-like networks with reprocessable thermoset performance.
10:30-11:00	**Coffee-Break**
11:00-11:30	Keynote KN-4 **E. Diamanti** *(Greece)* Engineered bioactive composite hydrogels: from enzyme spatial dynamics to enhanced transdermal delivery of natural bioactive compounds.
Lecture Session 5	
Chaired by Prof. Juan Francisco Rodríguez	
11:30-11:45	Oral Communication O-16 **M. Rodríguez-Aranda** *(Spain)* Synergistic lignin-quercetin hybrid particles: multifunctional bioactive additives in cosmetic formulations.
11:45-12:00	Oral Communication O-17 **V. Jencova** *(Czech Republic)* Precision surface modification of biodegradable fibrous scaffolds via controlled enzymatic degradation.
12:00-12:15	Oral Communication O-18 **M. Ferri** *(Italy)* Waste-derived multifunctional hydrogels based on chitosan and tannins as active wound dressings.
12:15-12:30	Oral Communication O-19 **K. González** *(Spain)* 3D-printed starch tablets for the delivery of microfluidic-encapsulated probiotics.

12:30-14:00	Lunch
14:00-14:30	Keynote KN-5 **R. Hosseinpourpia** *(Sweeden)* More sustainable wood products with biobased polymers.
Lecture Session 6	
Chaired by Dr. Raquel Rodríguez	
14:30-14:45	Oral Communication O-20 **M. B. Coltelli** *(Italy)* Fatty amines from renewable sources and biopolymeric materials from biorefinery.
14:45-15:00	Oral Communication O-21 **N. Belgacem** *(France)* Vegetal biomass: the raw material of tomorrow.
15:00-15:15	Oral Communication O-22 **J. Santos** *(Portugal)* High thermal resistance coatings based on forestry byproducts.
15:15-15:30	Oral Communication O-23 **J. Braz** *(Portugal)* Polyester block copolymers as compatibilizers for natural fiber composites.
15:30-15:45	Oral Communication O-24 **J. L. Mendoza Quiala** *(Chile)* Transparent lignocellulosic materials functionalized with coumarins for biobased luminescent solar concentrators (LSC).
15:45-16:15	Coffee-Break
16:15-16:45	Keynote KN-6 **R. Rodríguez** *(Spain)* PFAS-free waterborne acrylic coatings: from the lab to their validation in packaging and textile sectors.
Lecture Session 7	
Chaired by Prof. Reza Hosseinpourpia	
16:45-17:00	Oral Communication O-25 **S. Rubio** *(Spain)* Design of biobased latex coatings: copolymerization strategies with hydrophobic methacrylates.
17:00-17:15	Oral Communication O-26 **E. Gabirondo** *(Spain)* Fluorescent eutectogels for the detection of PFAS in water.
17:15-17:30	Oral Communication O-27 **I. Olazabal** *(Spain)* Development of functionalized non-isocyanate polyurethane (NIPU) resins for advanced 3D printing applications.
17:30-17:45	Oral Communication O-28 **C. A. M. dal Berto** *(Portugal)* Development of bio-based waterborne polyurethane adhesives: a sustainable approach for the footwear industry.

17:45-18:00	Oral Communication O-29 **L. Hofbauer** *(Austria)* The influence of alcohol properties in Lewis base catalyzed isocyanate reactions.
20:00	**Conference Dinner**
WEDNESDAY, 17 JUNE 2026	
8:30-9:15	Plenary lecture PL-4 **David Mecerreyes** *(Spain)* 3D printing of ionic and electronic conductive polymers.
9:15-9:45	Keynote KN-7 **J. F. Rodríguez** *(Spain)* Nanofluids for thermal energy storage and delivery.
Lecture Session 8	
Chaired by Prof. David Mecerreyes	
9:45-10:00	Oral Communication O-30 **A. Jiménez** *(Spain)* Development and validation of TPS-based functional biomaterials with biofertilizer and metal adsorption properties.
10:00-10:15	Oral Communication O-31 **S. Locatelli** *(Argentina)* Mixed ionic-electronic conducting eutectogel based on k-carrageenan for bioelectronics.
10:15-10:30	Oral Communication O-32 **R. A. Fernandes** *(Portugal)* Valorization of coffee silver skin for the production of high-performance bio-adhesives.
10:30-11:00	**Coffee-Break**
11:00-11:30	Keynote KN-8 **A. Prociak** *(Poland)* Challenges in the sustainable development of polyurethane foams.
Lecture Session 9	
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11:30-11:45	Oral Communication O-33 **T. B. Schreiner** *(Portugal)* Scalable bio-based isocyanate-terminated polyurethane prepolymers for coated textiles applications.
11:45-12:00	Oral Communication O-34 **M. Szostak** *(Poland)* A new modified polypropylene to replace PC/ABS lend in the production of seat covers.
12:00-12:15	Oral Communication O-35 **M. Kucala** *(Poland)* Viscoelastic polyurethane foams obtained from renewable raw materials - laboratory scale *vs.* continuous process.

12:15-12:30	Oral Communication O-36 **A. Barquero** *(Spain)* Degradable polymers by radical ring opening copolymerization of CKAs.
12:30-14:00	Lunch
14:00-14:30	Keynote KN-9 **C. Bakkali-Hassani** *(France)* On-demand primary amine release by Lewis pair formation in vinylogous urethane covalent adaptable networks.
Lecture Session 10	
Chaired by Prof. Agnieszka Tercjak	
14:30-14:45	Oral Communication O-37 **A. Maokhamphiou** *(France)* Development of bio-based covalent adaptable network fiber-reinforced composite battery casing.
14:45-15:00	Oral Communication O-38 **K. Polaczek** *(Czech Republic)* Poly(vinylogous urethane) foams from acetoacetate-functionalized vegetable oils.
15:00-15:15	Oral Communication O-39 **J. Lang** *(Austria)* Opportunities and challenges of acrylates and methacrylates in epoxy-amine covalent adaptable networks.
15:15-15:30	Oral Communication O-40 **L. Lenzi** *(Italy)* Biobased levulinates for imine covalent adaptive networks in rubber materials.
15:30-16:00	Coffee-Break
Lecture Session 11	
Chaired by Prof. Filomena Barreiro	
16:00-16:15	Oral Communication O-41 **M. Koutný** *(Czech Republic)* Biodegradable polyesters deeply remodel the soil microbiome.
16:15-16:30	Oral Communication O-42 **A. Fina** *(Italy)* Crystallization of biopolyesters within graphene-based nanopapers.
16:30-16:45	Oral Communication O-43 **E. Acha** *(Spain)* Catalyst-to-feed ratio effects in the thermo-catalytic upgrading of fibre-reinforced composite pyrolysis volatiles.
16:45-17:00	Oral Communication O-44 **J. M. Luque** *(Spain)* Cellulose nanofibers as multifunctional nano-carriers for nanoparticle dispersion and green porosity generation in PLA.
17:00-17:15	Oral Communication O-45 **H. Kaddami** *(Morocco)* Deep investigation on novel dialdehyde-based superabsorbent for agricultural applications.
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Development of Bio-Based Polyurethane Prepolymers for Sustainable Cork Composite Insoles.

P-2 **L. Ahmetović**, P. Cruza Rodelgo, M. J. Ramos, I. Gracia, M. T. García, J. F. Rodríguez, J. M. García Vargas *(Spain)*

Preparation and characterization of bio-based non-isocyanate polyurethanes (NIPUs) using terpenes and CO_2.

P-3 **M. S. Alam**, M. Elorza Romero, A. Sangroniz *(Spain)*

Biobased and biodegradable copolyesters for packaging applications.

P-4 **N. Aranburu**, I. Otaegi, G. Guerrica-echevarría *(Spain)*

Elucidating the role of ionic liquids in biodegradable aliphatic polyester blends and nanocomposites.

P-5 **I. Nafarrate**, J. Berganza, M. J. Suárez, P. Valiente, L. Urbina *(Spain)*

Sustainable production of polyhydroxyalkanoates from local waste and their potential in film applications.

P-6 **F. Carrascosa**, I. Gracia, J. M. García-Vargas, M. J. Ramos, J. F. Rodríguez, M. T. García *(Spain)*

Sustainable Processing of Mechanically Enhanced PLGA Scaffolds foaming via Supercritical CO_2.

P-7 **C. Castaño**, A. Gil Moreno, A. Candela Gil, M. V. Navarro *(Spain)*

Bio-based flexible hydrophilic foams for ornamental applications.

P-8 V. Ferrer, T. Oñate-Valdés, C. Fuentealba, V. Hernández, J. Santos, **D. Escobar-Avello** *(Chile)*

Pilot-scale extraction of tannins from eucalyptus globulus bark: a circular bioeconomy strategy for sustainable wood protection.

P-9 **X. Erdocia**, A. Gálvez, A. Morales, J. Labidi, **R. Fernández-Marín** *(Spain)*

Pine resin terpenes as renewable additives for chitosan-based functional materials.

P-10 **E. Gabirondo**, L. C. Tomé *(Spain)*

Eutectic Systems Inspired Molecular Imprinted Polymers for Cancer Biomarkers Recognition.

P-11 **F. González**, J. M. García-Vargas, M. J. Ramos, J. F. Rodríguez, I. Gracia, M. T. García *(Spain)*

Sustainable supercritical CO_2 route to functionalizable soybean oil monomers for radiopaque NIPUs.

P-12 I. Barreto, R. A. Fernandes, N. Ferreira, M. Peixoto, J. M. Martins, **L. H. Carvalho** *(Portugal)*

Improving bonding and water resistance properties of bio-adhesives derived from grape stalks.

P-13 **A. Ivdre**, L. Vasilevska, D. L. Eihe, M. Kirpluks, R. Pomilovskis *(Latvia)*

Effect of short-fiber fillers on polymer resins synthesized via michael 1,4-addition.

P-14 **C. Jagtap**, L. Sangroniz *(Spain)*

Development of sustainable semicrystalline polyesters.

P-15 **L. López-Gómez**, A. Pineda, A. García *(Spain)*

Sustainable functionalization of chitosan via mechanochemistry: a comparative study of schiff base formation.

P-16 **E. Malewska**, H. Benes, K. Polaczek, M. Kurańska, A. Prociak *(Poland)*

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P-17 R. A. Fernandes, A. Sousa, **J. M. Martins**, L. H. Carvalho *(Portugal)*

Collagen-based bio-resins from rabbit skin vermicelle for the wood industry.

P-18 **N. Mel**, I. Dávila, X. Erdocia, J. Labidi *(Spain)*

A novel approach for lignin depolymerization via iridium-catalysis.

P-19 **J. Mendizabal**, K. Gonzalez, L. Ugarte, A. Eceiza, R. Fernandez *(Spain)*

From marine waste to medicine: extraction, characterization, and use of alginate from the Basque coast in dermatological therapies via 3D printing.

P-20 **M. G. Rodríguez**, I. Olazabal, O. Gordobil, R. Herrera, A. Saralegi, A. Eceiza *(Spain)*

UV-Curable waterborne polyurethane acrylate coatings with reactive diluents for wood.

P-21 I. A. dos S. Matusinho, P. P. Souza, **P. S. de O. Patricio** *(Brazil)*

Biodegradable TPS/PBAT-based systems incorporating collagen waste for controlled nitrogen release.

P-22 **L. Ugarte**, U. Ortega, N. Zaldua, K. González *(Spain)*

Development of 3D-printable mycelium-based biocomposites for sustainable material applications.

P-23 I. Degutytė, **V. Valeika** *(Lithuania)*

Bioactive films based on collagen derivatives.

P-24 **R. F. Cardoso**, C.T. Paula, E. Gabirondo, L. C. Tomé *(Portugal)*

Design of innovative polymer materials from eutectic monomers.

P-25 **P. de Souza Lima**, A. Hašpl, K. Polaczek, O. Kopilec, O. Sedláček, H. Beneš *(Czech Republic)*

Polymer networks based on renewable vanillin.

P-26 **A. C. Lima**, T. Calvo-Correas, A. Eceiza, M. M. Dias, A. Santamaria-Echart, M. Filomena Barreiro *(Portugal)*

Natural soft solid materials based on Pickering emulsion-filled gels.

P-27 **L. Martellosio**, M. Ferri, L. Lenzi, A. Tauro, A. Dorigato, M. Degli Esposti, D. Morselli P. Fabbri *(Italy)*

Versatility of triphenylacetic glyceroate as a bio-based plasticizer for bio- and fossil-based polymers.

P-28 **S. Alfaro Araya,** M. Jarpa-Parra, Y. Rivas Tiznao, E. Castro Inostroza (*Chile*)

Obtaining high-value bioactive compounds from agroindustrial waste using green technology.

P-29 **K. Strnadová**, J. Mikule, Š. Hauzerová, E. Chudobová, D. Chvátil, D. Lukáš *(Czech Republic)*

Analysis of microparticles arising from degradation of nanofibrous materials.

P-30 **T. Calvo-Correas**, A. Barbosa, L. Vignau, I. Zalakain, M. Pinto, A. Eceiza *(Spain)*

Coaxial and multilayer electrospun systems for encapsulating waste derived bio-PCMs.

P-31 **P. Jutrzenka Trzebiatowska**, O. Cavdar *(Poland)*

Glycolysis of riverine PET waste via magnetic catalysts.

P-32 **M. Kurańska**, E. Malewska, M. Kucała, N. Kowalik, J. Sędzimir, A. Put, H. Ożóg, O. Matysik, E. Stanik, S. Michałowski, A. Prociak *(Poland)*

Towards zero-waste bioinsulation: circular economy approaches in polyurethane biofoam technology.

P-33 **M. M. Osama**, P. L. de Hoyos-Martínez, I. Egues, J. Labidi *(Spain)*

Esterification of lignocellulose nanofibers from construction and demolition waste wood.

P-34 **B. Sture-Skela**, D. L. Eihe, R. Pomilovskis, U. Cabulis *(Latvia)*

Depolymerisation of PU and PIR foams with diehtylene glycol and tall oil-based polyols.

P-35 **S. Wilczewski**, K. Skórczewska, M. Osial, R. Yanar, J. Szulc *(Poland)*

Natural antioxidants as thermal stabilizers for recycled soft PVC.

P-36 **W. Wyderkiewicz**, J. Miedzianowska-Masłowska, M. Masłowski *(Poland)*

Bio-circular composites: recycled polypropylene reinforced with lignocellulosic fibers and biochar.

P-37 **I. Zalakain,** M. Ibarrola, A. Claver, I. Alfonso, T. Calvo-Correas, A. Eceiza *(Spain)*

Use of biological waste for the production of thermal systems.

P-38 **J. Henrotte**, F. Zaccaria, A. Ginzburg *(Belgium)*

When ethylene meets sulfur.

P-39 **M. L. Auad**, L. Carias, J. Graneros, C. Mandurai, D. Hartmann, M. Sakhaharmy, S. Adhikari (*United States*)

UV-curable resins based on bio-derived precursors.

P-40 T. B. Schreiner, J. R. Manhique, L. L. Aquino, M.S.C.A. Brito, Y. A. Manrique, R. J. Santos, L. M. R. Mesquita, C. Coelho, J. Meireles, M. J. Ferreira, A. Santamaria-Echart, **M. F. Barreiro** *(Portugal)*

Sustainable thermoplastic polyurethanes for footwear applications: from laboratory to pilot scale.

P-41 **U. Cabulis**, V. Dhalivala, V. Yakushin, A. Kovalovs *(Latvia)*

Numerical study and research of composite structure with rigid polyurethane foam.

P-42 **A. Gil Moreno**, A. Candela Gil, C. M. Muñoz Martí, M. V. Navarro Bañón *(Spain)*

Oxidised starch additive for polyurethane coatings and foams: influence of the extraction route.

P-43 **A. Larruscain**, C. Peña-Rodríguez, A. Arbelaiz *(Spain)*

Study of the biodegradation process of PBAT and PBAT/ Latxa wool fiber composites under composting and marine conditions.

P-44 **K. Lewandowski**, P. Altmajer, J. Mirowski, Z. Altmajer (*Poland*)

Hybrid biodegradable polymer composites filled with wood flour and talc.

P-45 **L. Vignau**, I. Berasarte, T. Calvo-Correas, A. Retegi, A. Eceiza, N. Gabilondo *(Spain)*

Valorization of coffee waste for the production of bacterial cellulose-reinforced PHBV biocomposites.

P-46 **M. Ibarrola**, T. Calvo-Correas, A. Eceiza, A. Claver, I. Alfonso, I. Zalakain *(Spain)*

Obtaining membranes composed of polyurethane and phase change materials (PCM).

P-47 **A. Selmanović**, I. Olazabal, A. Kutnar, R. A. Herrera Diaz *(Slovenia)*

Structural characterization and solvent resistance assessment of enzymatically functionalized tropical wood extractives from industrial residues.

P-48 J. R. Manhique, **S. S. Bernardoni**, L. L. Aquino, T. B. Schreiner, R. J. Santos, M. J. Ferreira, M. F. Barreiro, A. Santamaria-Echart *(Portugal)*

Development and evaluation of non-isocyanate polyurethanes using different amines for footwear applications.

P-49 **P. Weiss**, D. Schuster, C. Slugovc *(Austria)*

Active ester curing of epoxides producing low dielectric thermosets.

P-50 **O. Kopilec**, O. Sedláček, H. Beneš *(Czech Republic)*

Synthesis of biobased vitrimers from renewable D-isosorbide.

P-51 F. Recupido, **K. Polaczek**, F. Orabona, L. Tammaro, G. C. Lama, Z. Wang, L, Verdolotti, M. Lavorgna, H. Xia *(Italy)*

Enabling Circularity in Bio-Based PU Foams through Diels–Alder Chemistry.

P-52 **K. Havlíčková**, N. Marousková, Š. Hauzerová, Jana Müllerová, Vít Novotný, D. Lukáš, V. Jenčová *(Czech Republic)*

Degradation-controlled release of curcumin from PCL nanofibrous scaffolds.

P-53 **F. Panagiotou**, I. A. Aziz, D. Mantione, D. Mecerreyes E. Gabirondo *(Spain)*

Synthesis of zwitterionic poly(terphenyl piperidinium) copolymers for fuel cells.

P-54 M. Peña-Ortiz, A. García, S. Marqués, **L. Serrano** *(Spain)*

Waste-valorized bacterial nanocellulose in edible coatings for longer-lasting cherry tomatoes.

P-55 **W. F. Silva**, C. B. Ferreira, P. H. F. C. Barros, C. H. M. Ribeiro, R. S. Goulart, P. C. Silva, J. Labidi, M. L. Bianchi *(Brazil)*

Phytotoxicity assessment of lignin nanoparticles using *Eruca Sativa* seeds as a biological model.

P-56 **P. A. Silveira da Silva**, P. H. G. Cademartori, R. A. Delucis, A. P. Acosta, J. Labidi *(Brazil)*

Cellulose nanofibers as a strategy for microstructural control in rigid polyurethane foam.

P-57 **T. Tanisha**, A. Eceiza, O. Gordobil *(Spain)*

Controlled microfluidic synthesis of lignin nanocarriers for lipophilic active encapsulation.

P-58 **N. Zabalegui**, A. Retegui, S. Torresi, A. Eceiza, R. Fernández *(Spain)*

Technical pathways in lithium-ion battery recycling: a comparative analysis of pyrometallurgy, hydrometallurgy, and direct regeneration.

P-59 **A. Etchecopar**, C. Courreges, S. Nolivos, R. Grimaud, J. Allouche, N. Gabilondo *(France)*

Enzymatic surface nanostructuring of biopolymer-silica hybrid materials.

P-60 **M. Iturrondobeitia**, E. Rodriguez-Hortelano, H. Afonso, C. Alfaro, J. Ibarretxe *(Spain)*

Evaluating biodegradable polymers as a marine safe materials using LCA methodology.

P-61 **H. G. Saraiva**, J. Braz, A. I. C. Romeiro, M. A. F. F. Reis, R. C. Rebelo, R. Moreira, A. C. Fonseca (*Portugal*)

Development of sustainable biocomposites using bio-based polyesters and natural fibres.

P-62 **L. Ezquerra Riega**, M. d. M. Cammarata, A. Saralegi, A. Eceiza (*Spain*)

Bio-based crosslinked NIPUs from epoxidized soybean oil with Diels-Alder reversible networks.

Abstracts of Plenary Lectures

PL-1

From Natural Phenols to Circular Polymers: A Platform Strategy for Sustainable Functional Materials

S. Caillol

ICGM, Montpellier, France
(corresponding author: sylvain.caillol@enscm.fr)

Cashew nutshell liquid (CNSL) is a unique, non-edible, phenolic lipid derived from agricultural waste, offering an exceptional combination of aromaticity, functionality, and intrinsic reactivity. CNSL represents a highly versatile molecular platform for the sustainable design of next-generation polymeric materials. Beyond CNSL, other naturally occurring phenolic compounds—such as lignin-derived phenols —represent a rich and largely untapped source of bio-based building blocks for polymers.In our work, we have developed a platform-based functionalization strategy to transform CNSL and other natural phenols into monomers suitable for the synthesis of a wide range of polymers, including polyurethanes, phenolics, epoxy resins, alkyds, and poly(meth)acrylates.This approach enables the rational design of materials with tunable thermal, mechanical, and interfacial properties, while maintaining a high bio-based carbon content. Beyond polymer synthesis, these intermediates offer compelling opportunities to substitute toxic or petroleum-based components traditionally used in polymer formulations, such as bisphenols, aromatic amines, and plasticizers. Particular emphasis was placed on the use of CNSL derivatives as safer, renewable alternatives aligned with regulatory and health constraints. Finally, we recently highlighted emerging applications of CNSL-based compounds as recycling and reprocessing agents for end-of-life polymeric materials, contributing to material circularity. By combining bio-based synthesis, functional performance, and end-of-life considerations, this work illustrates how CNSL can serve as a cornerstone of a circular and sustainable polymer design framework.

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PL-2

Macromolecular Materials Incorporating Chitosan: My Various Groups' Contributions

A. Gandini

Retired, Grenoble Polytechnic Institute, France, Aveiro University, Portugal, University of San Paulo, Brazil
(corresponding author: agandini@iqsc.usp.br)

The present lecture will provide a succinct account of research activities carried out at the above universities under my supervision, where chitosan was the main actor. They include:

1. Chitosan and cellulose: (a) chitosan spreading onto and penetrating into paper sheets; (b) spinning of chitosan/nanocellulose microfibers; (c) chitosan as hydrolytic protector of cellulose/cement composites: (d) Chitosan/bacterial cellulose and chitosan/nanofibrillated cellulose film composites.
2. Chitosan as corrosion inhibitor complement.
3. Oxypropylation of chitosan rejects.
4. Chitosan-based polymer electrolytes.
5. Chitosan-based Diels-Alder hydrogels for drug carriers.

Each of the topics will be illustrated by what I consider as relevant contributions to the much wider progress on the state of the art related to the remarkable role of chitosan as a renewable resource in providing a decisive alternative platform of macromolecular materials for the XXI century, on the vigorous way to replace the still dominating fossil fuel counterparts.

I will be speaking here to pay my heartful homage to the very skillful and creative young researchers from many countries who carried out these investigations. Their name will be spelled-out for each of their achievement.

PL-3

Linking Polymer Science and Sustainability for a Greener Future: Decades of Innovation in Biobased Polyurethanes

L. Avérous

BioTeam, ECPM, Université de Strasbourg, 25 rue Becquerel, 67087 Strasbourg, Cedex 2, France
(corresponding author: luc.averous@unistra.fr)

Nowadays, the use of renewable carbon feedstocks from various sustainable resources is increasingly considered because it offers the intrinsic value of a reduced carbon footprint and improved life cycle analysis (LCA). Compared to conventional fossil-based materials, innovative macromolecular architectures with improved or additional properties can then be obtained.

In this presentation, we report several developments from our research activities, with academics and companies collaborations (e.g., Figure 1), on the synthesis, characterization, and processing of innovative, renewable polyurethanes (PUR, PIR, TPU, and NIPU). These systems present controlled macromolecular architectures with different designs and morphologies (membranes, foams[1], ...) for a wide range of applications. These materials are synthesized from different biobased building blocks, which can be directly extracted from biomass or obtained from white biotech (fermentation,): (i) linear aliphatic structures from different glycerides and derivate (dimer fatty acids,), sugar-based molecules, bacterial polyesters, (ii) cycloaliphatic from different sustainable building blocks[4] and (ii) aromatic from lignins[5,6], tannins[7], furans ... A large range of renewable materials with improved properties and durable applications are developed/synthesized, for a greener and durable future. The end-of-life of these materials is now also widely considered, including bio-recycling[8,9] cradle-to-cradle approaches, or different vitrimer architectures[10].

Figure 1

Insulation panels based on aromatic and biobased foams, produced at an industrial Level (in collaboration with Soprema group)

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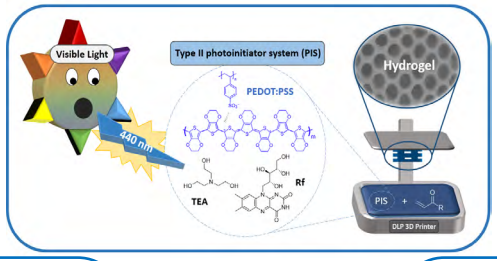
PL-4

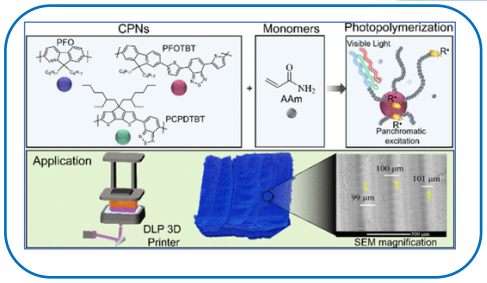
3D Printing of Ionic and Electronic Conductive Polymers

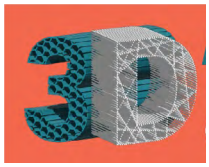
D. Mecerreyes
POLYMAT, University of the Basque Country, Donostia / San Sebastián
IKERBASQUE, Basque Foundation for Science, Bilbao
(corresponding author: david.mecerreyes@ehu.es)

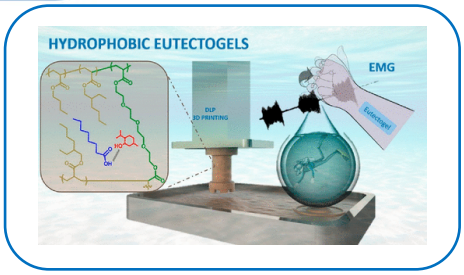
In this presentation we will show our recent developments in the additive manufacturing 3D printing of functional bio-based polymers. Our main goal is to develop conducting polymers to be used in functional devices. For this purpose, in the last years we optimize the 3D printing of ionic conductive polymers, electronic conductive polymers and optically active polymers. During our presentation the 3D-4D printing of different polymer systems will be showed as well as its different applications in bioelectronic devices, batteries or smart windows:

- Conductive polymers such as poly(3,4-ethylenedioxy thiophene) PEDOT.[1]
- Ionic conductive systems such as hydrogels, iongels and biobased eutectogels.[2]
- The use of semiconducting polymer nanoparticles in 3D printing and its use in obtaining hydrogels with photodynamic properties.[3]









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Abstracts of Keynotes

KN-1

Sustainable Thermosetting Foams - From Design to End-Use Properties

H. Beneš[1], O. Gotkiewicz[1], K. Polaczek[1], K. Skleničková[1], O. Kočková[1], M. Halecký[2], P. Parcheta-Szwindowska[3], J. Datta[3]

[1] Institute of Macromolecular Chemistry, Czech Academy of Sciences, Heyrovského nám. 2, Prague 6, 162 00, Czech Republic
[2] Department of Biotechnology, University of Chemistry and Technology, Prague 6, Technická 5, 166 28, Czech Republic
[3] Department of Polymer Technology, Faculty of Chemistry, Gdansk University of Technology, 11/12 Gabriela Narutowicza Street, 80-233 Gdansk, Poland
(corresponding author: benesh@imc.cas.cz)

Due to their versatility and simple foaming, polyurethane (PUR) foams are the most widely produced polymeric foams utilized in various industrial sectors. However, conventional PUR foams are thermosets are typically produced from toxic aromatic isocyanates (MDI or TDI) and rely heavily on petrochemical feedstocks. The PUR foams are thus composed of permanent covalent networks, which are not readily reprocessed or recycled. Therefore, researchers and producers seeking non-isocyanate solutions and easy-to-recycle alternatives to conventional PUR foams.

This contribution presents several strategies how to improve sustainability of the thermosetting foams. The first approach uses aliphatic isocyanates instead of aromatic ones, reducing thus overall harmful impact of the foam production. Moreover, these foams are able to be biologically degraded by various types of microorganisms, and therefore can be applied in biological and biotechnological applications, e.g. for wastewater treatment[1]. The second approach introduces into the PUR foam structure a easily cleavable ester bonds, which improve recyclability of the foams via solvolysis[2]. Another strategy involves fabrication of non-isocyanate polymeric foams based on vinylogous urethane chemistry from bio-based vegetable oils. These foams can be reprocessed and re-shaped using conventional processing technologies, such as moulding or extrusion, thanks to the rapid and catalyst-free transamination of vinylogous urethanes. As a result, the foam can be physically recycled - reprocessed to elastomeric products, applicable as adhesives, cast systems or sealants.

Acknowledgments

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KN-2

Atomic Force Microscopy as a Tool to Study Conductive and Mechanical Properties of Multifunctional (Bio)Nanocomposite Materials

A. Tercjak, J. Gutierrez

'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering of Gipuzkoa, University of the Basque Country (UPV/EHU), Europa Plaza 1, 20018 San Sebastian, Spain (corresponding author: agnieszka.tercjaks@ehu.eus)

Nowadays, the main interest of many research groups is focused on the development and characterization of multifunctional (bio)nanocomposite materials. The characterization of these materials required advanced techniques, which allow to investigate their properties at the nanoscale to better understand their final behavior at the macroscale.

Atomic force microscopy (AFM) is one of the widely used techniques to study topography and morphology of multifunctional (bio)nanocomposite materials. Furthermore, this technique is also able to measure different final properties of (bio)nanocomposite materials such as conductive properties (electrostatic force microscopy (EFM) for qualitative measurement, tunneling atomic force microscopy (TUNA) for quantitative measurement) or mechanical properties (PeakForce quantitative nanomechanical mapping (PeakForce QNM which simultaneously maps topography, elastic modulus and adhesion of (bio)nanocomposite materials.

In this work, we will show the advantages of using AFM techniques to correlate the morphology of (bio)nanocomposite materials with their final conductive or/and mechanical properties using EFM, TUNA or PeakForce QNM techniques.

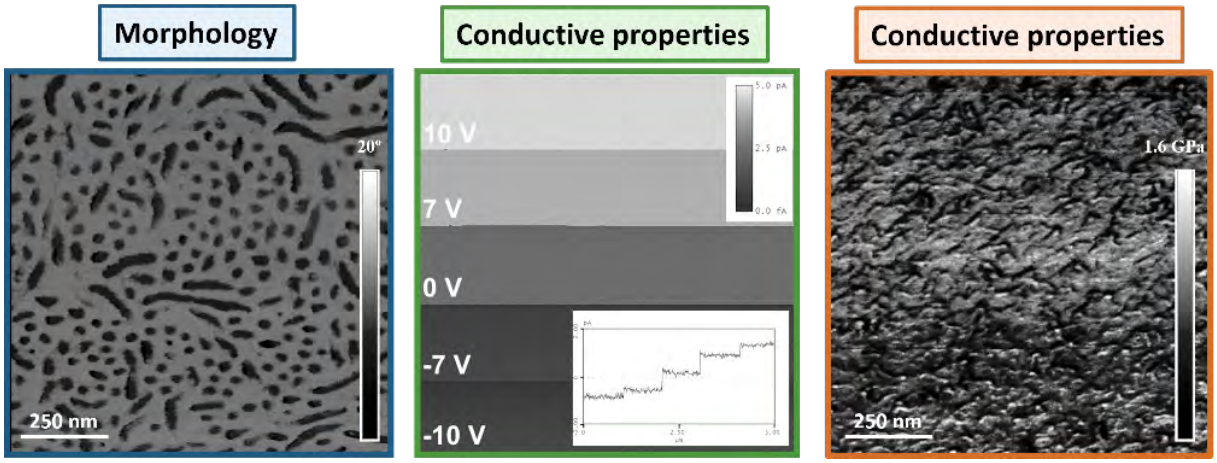

Figure 1

AFM phase, TUNA and PeakForceQNM images

Acknowledgments

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KN-3

Polymer-Based Solid Dispersions as a Platform for Innovation in Advanced Applications

A. Santamaria-Echart[1,2], **M. F. Barreiro**[1]

[1] CIMO, LA SusTEC, Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal
[2] 'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering of Gipuzkoa, University of the Basque Country (UPV/EHU), Europa Plaza 1, 20018 San Sebastian, Spain
(corresponding author: barreiro@ipb.pt)

Solid dispersion (SD) technology is an effective strategy for enhancing the solubility, stability, and functionality of poorly water-soluble compounds by dispersing them in hydrophilic carriers. Although synthetic excipients have traditionally been used, growing interest is shifting toward natural polymeric carriers due to their biodegradability, biocompatibility, sustainability, and compatibility with emerging green formulation technologies.

This keynote will focus on the evolving role of natural polymeric carriers in SD systems and their contribution to innovative applications beyond conventional delivery approaches. Special emphasis will be placed on the use of polysaccharides, proteins, gums, and other bio-based polymers as multifunctional carriers that enhance compound stabilisation, improve controlled-release behaviour, and enable the design of advanced functional systems. Emerging applications will include smart encapsulation technologies, bioactive delivery platforms, natural colour and flavour stabilisation, Pickering-emulsion-based structures, biodegradable active packaging materials, and hybrid biomaterial systems for next-generation formulations.

The presentation will further explore how natural polymeric carriers are driving innovation in SD technology by enabling sustainable, high-performance, and adaptable systems with broad industrial relevance. Current scientific and technological challenges will also be discussed alongside future perspectives for research and industrial implementation. Overall, the keynote will highlight the transformative potential of natural polymeric carriers in advancing innovative and sustainable solid dispersion technologies.

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KN-4

Engineered Bioactive Composite Hydrogels: From Enzyme Spatial Dynamics to Enhanced Transdermal Delivery of Natural Bioactive Compounds

E. Diamanti, M. Zoumpanioti, V. Papadimitriou

Institute of Chemical Biology, National Hellenic Research Foundation, 11635 Athens, Greece
(corresponding author: ediamanti@eie.gr)

The transdermal delivery of natural bioactive compounds (NBCs) is limited by the barrier function of the skin and the low stability and bioavailability of many actives. Biocatalytic strategies offer a promising approach to overcome these challenges by modulating biological barriers while preserving compound integrity. In this context, this work focuses on the development of bioactive composite hydrogels as platforms for enhanced transdermal delivery, aiming to exploit the full therapeutic potential of NBCs through controlled enzymatic activity. Hydrogel systems are engineered to combine encapsulated NBCs with surface-immobilized enzymes, such as hyaluronidase, capable of locally remodeling the extracellular matrix and facilitating penetration. Particular emphasis is placed on the role of enzyme spatial distribution and binding dynamics in governing performance, where insights from intraparticle kinetics[1] and the Sabatier principle in heterogeneous biocatalysis[2] highlight the importance of optimized enzyme-support interactions and controlled mobility. In parallel, compartmentalization strategies[3] based on capsule formation enable protection and regulated release of biomolecules, decoupling protective and biocatalytic functions. Overall, this approach establishes a framework for integrating biocatalysis into hydrogel-based systems, advancing the design of next generation transdermal delivery platforms.

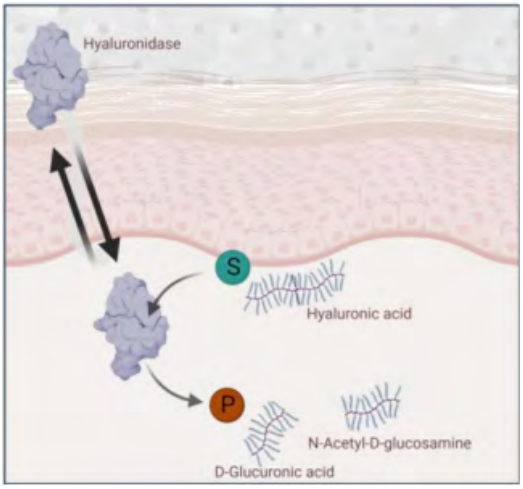

Figure 1

Schematic illustration of hyaluronidase catalyzing the hydrolysis of hyaluronic acid (S) by cleaving linkages between N-acetylglucosamine and glucuronate (P), along with the enzyme association/ dissociation equilibrium between the hydrogel (HG) and the skin

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KN-5

More Sustainable Wood Products with Biobased Polymers

R. Hosseinpourpia
Department of Forestry and Wood Technology, Linnaeus University,
Lückligs Plats 1, 35195 Växjö, Sweden
College of Forest Resources and Environmental Science, Michigan Technological University,
Houghton, Michigan 49931, United States
Linnaeus University Centre for Competitive Timber Structures, Linnaeus University,
Universitetsplatsen 1, 351 95 Växjö, Sweden
(email: reza.hosseinpourpia@lnu.se)

Global environmental challenges are driving a transition toward sustainable materials, which often requires replacing non-renewable and fossilderived chemicals with materials that are renewable, benign, and compatible with circularity principles. Biobased polymers such as lignin, starch, cellulose derivatives, tannins, hemicelluloses, proteins, chitosan, and other naturally occurring macromolecules are promising candidates for replacing traditional non-renewable polymers and chemicals in wood products. Their functional properties enable them to serve as adhesives, surface protectants, hydrophobizing agents, and durability modifiers in wood products. However, a direct replacement of well-performing conventional polymers and chemicals with biobased ones remains a challenge. This presentation, therefore, highlights recent progress in using natural polymers to bond, protect, and improve the hydrophobic character of wood products.

Wood adhesives play a major role in the forest products industry. The market analysis for wood adhesives and binders is expected to grow to USD 30.7 billion by 2035. Growing concerns about fossil-derived origins, carcinogenic formaldehyde emissions, and environmental impacts have spurred interest in developing alternative adhesives from bio-based sources. A range of bio-derived compounds has been investigated for the preparation of bioadhesives, while limited formulas have been able to fulfil requirements for industrial implementations. Challenges for the substitution of conventional wood adhesives and selected alternative approaches will be communicated.

Wood inherently suffers from biodegradability, poor mechanical strength, and dimensional instability when exposed to abiotic and biotic agents. The conventional approach to protecting wood is treatment with biocidal preservatives, which offer long-lasting durability by toxidizing wood, while posing significant issues in post-processing the products after service life. Modification of wood through chemical, thermal, enzymatic, or hydrothermal techniques improves its material properties, with the added advantage that the resulting products release non-toxic substrates during post-processing. Recent developments in the employment of biopolymers such as humins and tannins to improve wood properties will be shared.

KN-6

PFAS-Free Waterborne Acrylic Coatings: From the Lab to Their Validation in Packaging and Textile Sectors

R. Rodriguez, O. Echeverria, B. Perez, H. Villaverde
TECNALIA, Basque Research and Technology Alliance (BRTA)
Paseo Mikeletegi 2, 20009, Donostia / San Sebastian, Spain
(corresponding author: raquel.rodriguez@tecnalia.com)

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) constitute a broad family of synthetic compounds developed since the 1940s and present in numerous industrial applications and consumer products. Their use has been especially widespread in the field of coatings, thanks to highly valued properties such as strong water and oil repellency, remarkable thermal stability, non-stick behavior, and friction reduction. However, their persistence in the environment and their ability to accumulate in living organisms have generated increasing concern, placing PFAS at the center of an important environmental and public-health debate[1].

In response to this situation, industry and the scientific community are actively working on the development of alternatives that offer comparable performance without relying on harmful substances. The substitution of compounds associated with chronic effects on human health and the environment is particularly urgent in consumer products, where exposure is direct and frequent. In this context, designing non-toxic coatings that maintain the functional properties of PFAS-based systems while reducing their environmental impact has become a highly relevant technological challenge and a strategic line for moving toward safer and more sustainable solutions.

The aim of the work carried out has focused on the synthesis of new water-based, partially bio-based acrylic systems capable of providing water and oil repellency in the absence of PFAS. To achieve these properties, the polymer systems were designed using monomers capable of reducing surface energy. The design of the chemical composition was complemented by a controlled final morphology at the nanometric scale, achieved through the incorporation of nano-additives, which enhanced repellency and optimized coating performance. Various polymerization strategies were implemented, and the influence of parameters such as the type of bio-monomer (and its functionality), its concentration were evaluated along with their impact on the final properties of the copolymers, including glass transition temperature, mechanical properties and water and oil repellency. The PFAS-free water-based acrylic systems have been validated for the packaging and textile sectors.

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KN-7

Nanofluids for Thermal Energy Storage and Delivery

J. F. Rodríguez[1], D. Lopez[1,2], F. J. Ramos[1,3], A. M. Borregero[1], M. Carmona[1]

[1] Department of Chemical Engineering, Institute of Chemical and Environmental Technology, Faculty of Chemical Sciences and Technologies, University of Castilla-La Mancha, Avda. de Camilo José Cela s/n, 13005 Ciudad Real, Spain

[2] Department of Thermal Energy Storage, Iberian Center for Research in Energy Storage (CIIAE), Avda, de la Universidad s/n, 10003 Cáceres, Spain

[3] Department of Vegetal Production and Agricultural Technology, Higher Technical School of Agricultural and Forestry Engineering, University of Castilla-La Mancha, Pº de los Estudiantes s/n, 02006 Albacete, Spain

(corresponding author: juan.rromero@uclm.es)

Beyond the concept of the incorporation of Thermal Energy Storage (TES) materials into the building envelope as passive energy accumulators[1] would be the concept of active energy accumulation in slurries with improved heat storage capacity with respect to pure water.

The proper dispersion of ultra-fine nanoparticles in the widely used working fluids gives the opportunity of having thermally enhanced (higher thermo-physical properties) new fluids which are named as nanofluids. The incorporation of phase change materials as nano or submicron particles or capsules to a water or glycol-based emulsion could provide the additional TES features to the nanofluid. The enhanced thermo-physical properties of nanofluids make these fluids preferable among other working fluids and give the ability of being applicable in a wide range of thermal applications, for example, in radiant floors, solar collectors and electronic devices heat sinks, conditioning the living environment, energy storage systems, etc.

Our group has developed highly concentrated slurries with nanocapsules containing phase change materials (NPCSs) in just one step where the whole reactant mass constitutes the thermal fluid. Attending to the physical stability of the crosslinked copolymer shell, the optimal NPCS is achieved with a precursors content of 38.1 wt% (PCM, S, DVB and AIBN sum). In these conditions, a slurry of NPCS ($dn_{0.5}$ = 76.0 nm) with a solids content of 40.5 wt%, $|\zeta|$ of 52.8 nm, acceptable viscosity (86.10 mPa s at 680 s^{-1}) and ΔH_L of 46.45 J g^{-1} is achieved. In addition, the NPCS maintains its good properties two years after its production[3].

Acknowledgments

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KN-8

Challenges in the Sustainable Development of Polyurethane Foams

A. Prociak, M. Kurańska, E. Malewska, S. Michałowski, M. Kucała

Cracow University of Technology, Faculty of Chemical Engineering and Technology,
Warszawska 24, 31-155 Cracow, Poland
(corresponding author: aleksander.prociak@pk.edu.pl)

Polyurethanes (PURs) are among the six types of polymer materials produced in the largest quantities annually. In 2024, PURs accounted for 5.3% of global polymer production, representing over 22 million tons[1]. According to Reports Insights Consulting Pvt Ltd, the PUR market is expected to grow at a compound annual growth rate (CAGR) of 6.8% between 2025 and 2033. This market is estimated to be worth $78.5 billion in 2025 and reach $131.9 billion by the end of the forecast period in 2033[2].

The main factor influencing the increase in PURs production is the demand of porous materials for the furniture, automotive, and construction industries. The specific properties of flexible and rigid PUR foams, such as durability, excellent insulation, energy absorption, and comfort, make them a key material used in numerous solutions. This is due to the market demand for rigid PUR foams that provide effective thermal insulation while maintaining sustainable building practices, as well as the increasing demand from the furniture and automotive industries for lightweight and comfortable furniture and car seat components.

Innovations in PUR chemistry are leading to the development of more sustainable, bio-based, and high-performance materials, addressing growing environmental concerns and the need for improved product functionality[3]. Furthermore, the development of recyclable and biodegradable PUR materials contributes to a circular economy by minimizing waste and resource consumption[4].

The PUR market faces a complex set of challenges as the volatility of raw material costs, especially isocyanates and polyols, environmental concerns as well as the introduction of legislation, which often requires costly modifications to production processes and can impact competitiveness. Addressing these multifaceted challenges is crucial for the continued growth and sustainability of the PUR foams.

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KN-9

On-Demand Primary Amine Release by Lewis Pair Formation in Vinylogous Urethane Covalent Adaptable Networks

N. Arnould, A. Prieto, O. Giani, **C. Bakkali-Hassani**

ICGM, Univ Montpellier, CNRS, ENSCM, Montpellier, France
(corresponding author: camille.bakkali-hassani@umontpellier.fr)

Vinylogous urethane based covalent adaptable networks (VU-CANs) are known to undergo associative transamination reactions between free primary amines and the VU moieties in the network. The exchange reaction happens at elevated temperatures (>100 °C), even without the need of exogenous catalyst. The resulting materials generally exhibited fast relaxation times, excellent reprocessability but only limited creep resistance (the material flows at moderate temperature)[1]. However, the dynamic formation of Brönsted acid/base complexes was shown to promote/inhibit flow depending on the acid strength and hindrance by reversibly quenching the excess of primary amine[2]. In this work, we introduced Lewis pair (LP) reversible interactions in vinylogous urethane covalent adaptable networks (VU-CANs) as a tool to control their rheological properties through the simultaneous release of primary amine and Lewis acid catalyst. The formation of LP within the material between free primary amine and boron-based Lewis Acids (LAs) including different triaryl and one trialkyl boron (BR_3) was confirmed by ^{11}B solid NMR and extensive rheological characterizations. Depending on Lewis acid strength and steric hindrance, different behaviors were observed. Aryl substituents were found necessary to achieve suitable stability and while highly acidic $B(C_6F_5)_3$ promoted the covalent exchange even at moderate temperature, the introduction of mild LAs such as $B(Ph)_3$ or $B(mes)_3$ led to VU-CANs with low creep up to 150°C, fast exchange at 200°C and limited side reactions.

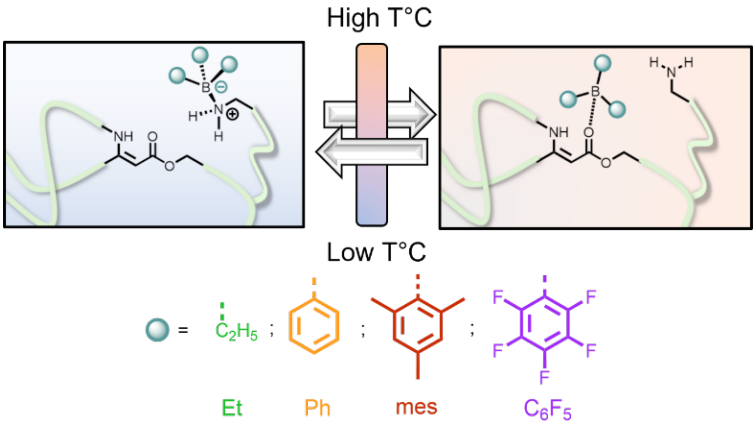

Figure 1

Amine-Borane Lewis Pair equilibrium for the reversible and controlled release of primary amine and catalyst

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Abstracts of Oral Communications

O-1

Bio-Oil-Derived Polymeric Systems: Non-Isocyanate Bio-Based Polyurethanes & UV-Curable Resins

M. L. Auad[1,2], L. Carias[1,2], J. Graneros[1,2], C. Mandurai[1], D. Hartmann[3], M. Sakhaharmy[3], S. Adhikari[3]

[1] Center for Polymers and Advanced Composites, Gavin Engineering Research Laboratory, Auburn University, 311 West Magnolia Avenue, Auburn, Alabama 36849, United States

[2] Department of Chemical Engineering, Ross Hall, Auburn University, 222 Foy Union Circle, Auburn, Alabama 36849, United States

[3] Department of Biosystems Engineering, Auburn University, 209 Tom E. Corley Building, Auburn, AL, 36849, United States

(corresponding author: auad@auburn.edu)

The use of biomass-based resources is currently a hot topic. In particular, fast pyrolysis bio-oil is an excellent candidate for bio-sourcing of polymeric resins. Their competitive cost, worldwide availability, and built-in functionality have catapulted their use as a source of macromonomers for polymer applications. Thus, the main purpose of this project is to design bio-oil derivatives as a rich, renewable chemical feedstock for the development of advanced polymeric materials. In particular, we have focused on the design of two complementary material platforms: non-isocyanate bio-based polyurethanes (NIPUs) and UV-curable resins, both derived from bio-oil precursors.

The NIPU pathway is currently under development, beginning with the amination of bio-oil to generate reactive amine functionalities from its oxygenated components. Also, epoxy-functional systems were carbonated to form cyclic carbonates, which then reacted with bio-oil-derived amines to produce non-isocyanate polyurethane (poly(hydroxyurethane)) networks. This approach aims to eliminate the use of toxic isocyanates while enabling tunable crosslink density and enhanced hydrogen bonding interactions. In parallel, UV-curable resins were developed by acrylating bio-oil with acryloyl chloride under controlled, low-temperature conditions to preserve functional group integrity and maximize substitution efficiency. To establish structure–property relationships, these systems were evaluated alongside model phenolic-based resins, enabling direct comparison between chemically defined and compositionally complex networks. Overall, this work highlights the trade-off between molecular control and sustainability, demonstrating that while model systems provide mechanistic insight, bio-oil-derived resins offer a scalable and renewable pathway for thermosetting materials.

O-2

Dibutyl Itaconate (DBI): A Unique Biobased Monomer to Tune Waterborne Coatings and Adhesives

J. Gupta[1], R. Tomovska[1,2], **M. Aguirre**[1]

[1] POLYMAT, Kimika Aplikatua Saila, Kimika Fakultatea,
University of the Basque Country UPV/EHU, Joxe Mari Korta Zentroa,
Tolosa Hiribidea 72, 20018 Donostia / San Sebastián, Spain
[2] IKERBASQUE, Basque Foundation for Science, Plaza Euskadi 5, 48009, Bilbao, Spain
(corresponding author: miren.aguirre@ehu.eus)

Itaconic acid (IA) and its derivatives are emerging as highly versatile, cost-efficient, and fully biobased monomers. Among them, dibutyl itaconate (DBI) stands out as a particularly promising candidate for next-generation acrylic and methacrylic systems. Yet, its broader adoption in (meth) acrylic waterborne polymers has been hindered by inherently slow propagation, unfavorable reactivity ratios, and notable depropagation effects at relatively low temperatures (~100 °C).

In this work, we tackle these limitations by carrying out a seeded semi-batch emulsion polymerization of DBI together with two partially biobased acrylates; 2-octyl acrylate (2-OA) and isobornyl acrylate (IBOA). We investigate the kinetics and microstructure of the resulting copolymers and examine how DBI content, process parameters, and feeding strategies affect polymer microstructure and properties. By measuring the reactivity ratios of the relevant monomer pairs, we designed optimized feeding profiles that enabled complete DBI incorporation into the final formulations.

The same monomer systems were then applied to develop pressure-sensitive adhesives (PSAs). Incorporating DBI significantly boosted tack and peel strength by reducing gel content and enhancing chain mobility, though at the cost of lower shear resistance. To address this, sulphated cellulose nanocrystals (sCNCs) were introduced as a reinforcing agent, improving the viscoelastic balance, cohesion, fibrillation stability, and shear performance, without sacrificing tack or peel.

Overall, this study demonstrates the versatility and potential of DBI as a tunable, biobased building block for both coating and adhesive waterborne formulations, paving the way for more sustainable high-performance polymer systems.

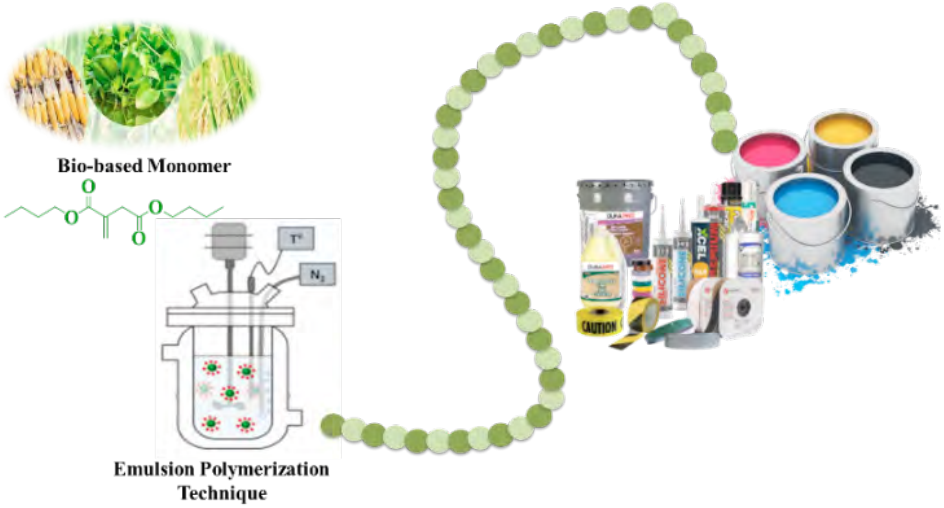

Figure 1

Incorporation of DBI by emulsion polymerization for coatings and adhesives

O-3

Advanced Characterization and Turnkey Solutions for Polymer Systems: Practical Insights and Application-Driven Approaches

S. Monasterio[1], L. Spencer[1], J. Carvalheira[1,2], M. Mota[2], R. Soares[1,2]

[1] Paralab SL, Barcelona, Spain
[2] Paralab SA, Gondomar, Portugal
(corresponding author: sara.monasterio@paralab.es)

Paralab is a technology solutions provider specialising in the distribution of advanced instrumentation for material characterisation and the development of turnkey projects tailored to laboratory, industrial, and environmental applications. Its complementary business lines position Paralab as a partner capable of bridging high-level analytical instrumentation with practical, on-demand process and production control systems. This integrated approach enables the delivery of high-impact solutions that support innovation and sustainability in response to evolving scientific and technological challenges.

Among advanced material characterisation techniques, thermal analysis plays a crucial role in polymer science, providing key insights into material behaviour under temperature variations—essential for design, processing, and end-use performance. In this work, several application examples are presented, including: (i) quasi-isothermal methods using Simultaneous Thermal Analysis (STA) to deconvolute overlapping thermal events and quantify polymer fractions; (ii) Differential Scanning Calorimetry (DSC) as an indirect quantification method based on melting enthalpy and crystallinity; and (iii) isothermal crystallisation techniques to distinguish and quantify polyethylene grades in recycled streams and complex formulations.

In parallel, customised turnkey solutions have been developed in collaboration with clients and partners, including systems for biomass deconstruction, hydrothermal liquefaction, and continuous-flow gasification or pyrolysis, as well as modular platforms for polymer synthesis and degradation. These solutions include CSTR reactors, flow chemistry units operating under standard and high-pressure conditions, and specialised technologies such as ohmic heating and photocatalysis systems.

By integrating analytical capabilities with application-driven engineering design, Paralab delivers robust and scalable solutions that enable research and industry to accelerate innovation in circular materials and low-carbon process development.

O-4

Azo-Functionalized Chitosan Films as Strategy for Increasing its CO_2 Capture Capacity

S. Bonardd[1,2], C. García[1,2], J. Hernández[1,2], B. Mishra[3], O. Ramírez[4], D. Díaz[1,2]

[1] AFM-NANO, Instituto Universitario de Bio-Orgánica Antonio González (IUBO-AG), Universidad de La Laguna, Avda. Astrofísico Francisco Sánchez 2, La Laguna 38206, Spain
[2] Departamento de Química Orgánica, Universidad de La Laguna, Avda. Astrofísico Francisco Sánchez 3, La Laguna 38206, Spain
[3] S. N. Bose National Centre for Basic Sciences, JD Block, Salt Lake: Sector-III, Kolkata 700106, India
[4] Departamento de Ingeniería Química y Bioprocesos, Escuela de Ingeniería, Pontificia Universidad Católica de Chile, Santiago 7820436, Chile
(corresponding author: sbonardd@ull.edu.es)

The need for efficient and sustainable CO_2 capture technologies has driven extensive research into advanced adsorbent materials.[1] However, many of the best-performing systems are still derived from petroleum-based precursors, creating a fundamental contradiction in terms of environmental sustainability. Herein, we present a biopolymer-based strategy for sustainable CO_2 capture via the chemical functionalization of porous chitosan films with azo groups (Figure 1). The functionalization, achieved via imine linkages, was confirmed by spectroscopic techniques (FTIR, NMR, XPS, and UV-Vis), while electron microscopy (SEM and TEM) revealed preservation of the porous architecture after modification. The introduction of azo groups led to a significant enhancement in CO_2 capture capacity, reaching 1.51 mmol/g at 273 K and 0.65 mmol/g at 298 K, corresponding to an approximately tenfold increase compared to pristine chitosan. Interestingly, and in agreement with previous studies, the incorporation of azo functionalities imparted a favorable N_2-phobic/CO_2-philic character, as evidenced by a decrease in N_2 adsorption capacity from 0.12 to 0.08 mmol/g at 298 K. This work provides a sustainable and scalable platform for the development of novel bio-based CO_2 adsorbents, paving the way for future studies that consider biopolymers not merely as feedstocks for support matrices or as precursors to charcoal-based porous materials.

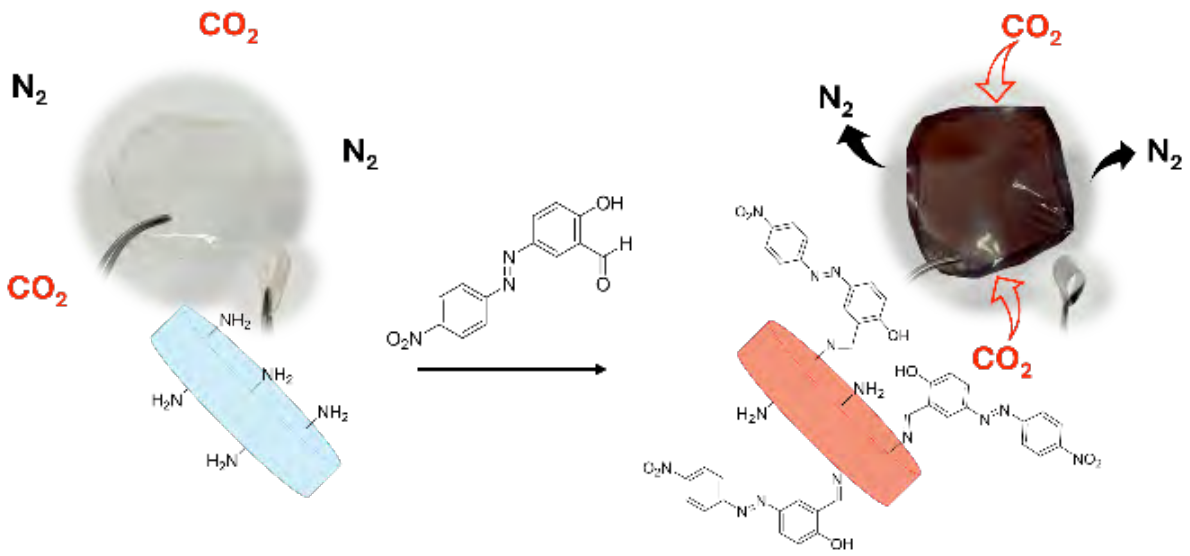

Figure 1

Azo-functionalization of porous chitosan films

Acknowledgments

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O-5

Spent Coffee Ground as a Versatile Bio-Based Additive in Polypropylene

J. Navratilova, L. Gajzlerova, T. Mlynkova

Department of Polymer Engineering, Faculty of Technology, Tomas Bata University in Zlin, Vavreckova 5669, 760 01 Zlin, Czech Republic
(corresponding author: j1navratilova@utb.cz)

This paper deals with the effect of spent coffee ground addition (SCG) on crystallization, mechanical properties and photodegradation of polypropylene (PP). PP/SCG mixtures were prepared in concentrations of 2, 4, 6 and 8 wt. %, with/without addition of compatibilizer - polypropylene/maleic anhydride copolymer (MAH). It was found that the addition of SCG increases the crystallization temperature of PP by up to 6 °C, thus acting as a heterogeneous nucleating agent. Moreover, in lower concentrations, it promotes the crystallization into less thermodynamically stable trigonal β-phase (Figure 1 left). The addition of MAH, nevertheless, completely suppresses specific β-nucleation. In terms of mechanical properties, the addition of SCG in small concentrations of up to 4 wt. % has no relevant effect on tensile strength; at higher concentrations, this value decreases. In mixtures with MAH, the effect of SCG is negligible in all tested concentrations. In both pure and MAH-modified PP an increase in impact strength is observed with the addition of SCG, which is more pronounced in the case of PP without MAH. The mixtures were also exposed to artificial ageing in Xenotest. It was found that the use of SCG already at low concentrations increases the resistance to photodegradation (Figure 1 right). The composite with 8 wt. % SCG retained its cohesiveness even after the longest UV exposure times. The presence of SCG in PP has a positive effect on the durability of the material and act as a natural antioxidant.

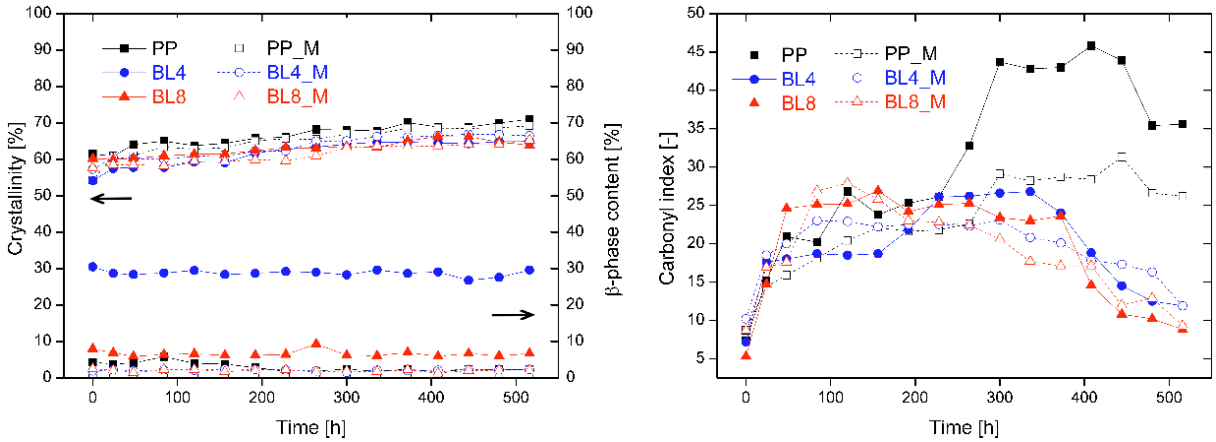

Figure 1

(left) Crystallinity and β-phase content
and *(right)* carbonyl index evolution of selected samples

O-6

Alkaline–Thermal Restructuring of Lupin Protein for Enhanced Interfacial Performance

L. C. Ghirro[1,2], A. Santamaria-Echart[1], M. M. Dias[2], M. F. Barreiro[1]

[1] CIMO, LA SusTEC, Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal

[2] LSRE-LCM, ALiCE, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, Porto, Portugal

(corresponding authors: asantamaria@ipb.pt, barreiro@ipb.pt)

Plant proteins are increasingly explored as sustainable biopolymers capable of forming functional colloidal structures, yet their native conformations often limit interfacial activity and particle formation[1]. In this work, the structural reorganization of lupin flour (LF) and lupin protein concentrate (LPC) induced by a combined pH-shifting (pH 12) and heat treatment (90 °C, 120 min) was investigated to engineer protein-based colloidal particles with improved performance for Pickering emulsions. The alkaline–thermal process significantly modified the polymeric conformation of the proteins, promoting controlled unfolding, exposure of hydrophobic domains, and redistribution of secondary structure elements, as confirmed by Fourier Transform Infrared spectroscopy. These transitions resulted in matrix-dependent changes in particle size, surface charge, wettability, and solubility. Treated LF-based particles (p-LF) displayed markedly enhanced solubility and interfacial activity despite increased hydrodynamic diameter, whereas treated LPC-based particles (p-LPC) exhibited a strong shift toward hydrophilicity and reduced interfacial tension, reflecting a deeper conformational reorganization. Both treatments improved adsorption kinetics and the ability to form cohesive interfacial layers, enabling the production of oil-in-water Pickering emulsions and even stabilizing double Pickering systems. Overall, the results showed that alkaline–thermal treatment is an effective tool to tailor plant-protein structure and functionality, unlocking new opportunities for designing sustainable, protein-based colloidal materials.

Acknowledgments

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O-7

Feasibility of Applying Double Crosslinked Carrageenan Adsorbent Hydrogel in the Electrokinetic Process

A. Altaee[1], R. Almalki[1], L. Alsaka[1], S. J. Zaidi[2]

[1] Centre for Green Technology, School of Civil and Environmental Engineering, University of Technology Sydney, 15 Broadway, NSW 2007, Australia
[2] UNESCO Chair in Desalination and Water Treatment, Center for Advanced Materials, Qatar University, Doha, Qatar
(corresponding author: ali.altaee@uts.edu.au)

Adsorbent electrodes integrate the benefits of traditional adsorbents with high conductivity, presenting a novel solution for electrokinetic (EK) processes. However, the application of hydrogel electrodes is often challenged by issues related to mechanical strength, chemical stability, and degradation in harsh soil environments. This study explores the potential of kappa-carrageenan (kC) hydrogel electrodes, enhanced with 0.3% activated carbon (AC) and double crosslinked with glutaraldehyde (GD) and FeCl3 to optimize their physicochemical properties and adsorption capabilities. Electrokinetic experiments were conducted using kaolinite and actual soil spiked with Zn^{2+} ions, comparing performance with graphite electrodes as a baseline. The results indicated a notable performance improvement, with hydrogel electrodes achieving a Zn^{2+} removal rate of up to 97.71% in kaolinite soil, compared to 3.37% for graphite electrodes. For real soil samples, the removal rates were 56.59% and 68.22% after 14 and 21 days, respectively. The reduced efficiency in real soil is attributed to the slower movement of the acid front and interactions with organic matter. Notably, the kC-based hydrogel electrodes maintained structural integrity even after 21 days, underscoring their potential for advancing soil remediation techniques in a decarbonizing context.

Acknowledgments

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O-8

Direct Pellet Additive Manufacturing for Sustainable Polymer Processing

I. Sardon

Indart3D – Tumaker, Irun, Spain
(corresponding author: isardon@indart3d.com)

Direct pellet extrusion additive manufacturing enables the processing of polymer pellets and composite feedstocks in material extrusion systems. This approach allows the direct use of recycled polymers and highly filled materials containing metallic or ceramic particles, expanding the range of processable materials for additive manufacturing.

Pellet-based systems provide a flexible platform for research and material development, allowing rapid evaluation of new formulations and processing parameters. In addition, the use of pellet feedstocks reduces intermediate processing steps and facilitates the implementation of sustainable material processing strategies.

This work highlights the potential of pellet extrusion additive manufacturing as a versatile tool for advanced polymer and composite processing.

O-9

Valorization of Tire-Derived Rubber in Polypropylene Blends: From Model Systems to Recycled Polymer Matrices

I. Otaegi, E. Erostarbe, N. Aranburu, G. Guerrica-Echevarría

POLYMAT and Department of Advanced Polymers and Materials: Physics, Chemistry, and Technology. University of the Basque Country (UPV/EHU)
(corresponding author: itziar.otaegi@ehu.eus)

The increasing accumulation of end-of-life tires and plastic waste poses a major environmental challenge [1], driving the development of new polymer materials based on secondary raw materials. Among the different valorization strategies, the incorporation of ground tire rubber (GTR) into thermoplastic matrices has attracted increasing attention as a route to produce functional materials while reducing waste streams [2].

In this work, virgin polypropylene (PP) is employed as a model thermoplastic matrix to establish a fundamental understanding of the processing–structure–property relationships governing PP/GTR blends prior to the introduction of recycled polymers. Different GTR contents are incorporated into PP through melt compounding using conventional industrial processing techniques. The influence of rubber loading on melt processability and mechanical performance is systematically evaluated in order to identify the most promising formulation.

Once the optimal composition is selected based on mechanical criteria, the same formulation is reproduced using recycled polypropylene to assess the transferability of the developed system to recycled matrices. In addition, compatibilization strategies are explored to improve the interfacial interaction between the polymer matrix and the rubber particles.

The results provide insights into the behavior of thermoplastic–rubber blends and contribute to the design of sustainable polymer materials incorporating tire-derived rubber.

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O-10

Utilization of Collected Ocean-Bound Plastic in the Framework of COP Project

P. Jutrzenka Trzebiatowska[1], E. Gontarek-Castro[1], G. Mihut[2], H. Tüzün[2]

[1] University of Gdańsk, Faculty of Chemistry, Department of Environmental Technology
Wita Stwosza 63, 80-308 Gdańsk, Poland
[2] Fondation Plast Center Danmark facilitator of the Innovation Network Danish Materials Network (DMN), Niels Bohrs Vej 6, 6700, Esbjerg, Denmark
(corresponding author: patrycja.jutrzenka-trzebiatowska@ug.edu.pl)

Plastic debris entering seas and oceans originates from both land- and sea-based sources and gradually fragments into microplastics. Around 80% of marine plastic pollution comes from land-based sources, including urban areas, and is transported mainly via rivers, canals, and harbours[1]. Due to the complex and transboundary nature of marine plastic pollution, there is an urgent need to address the entire lifecycle of marine plastic waste, including its sources, monitoring, collection, recycling, and reuse. Various waste management strategies can be applied to marine plastic waste, including reuse, mechanical and chemical recycling, solvent-based extraction, energy recovery, and biodegradation. The choice depends on polymer type, degradation level, contamination, and available infrastructure. Mechanical recycling is most common approach,particularly for homogeneous polyolefin waste, but degraded or contaminated plastics limit its efficiency. In such cases, chemical recycling methods such as glycolysis, pyrolysis, or hydrothermal liquefaction offer alternative pathways by converting polymers into valuable monomers or petrochemical fractions[3].

Within the framework of the Circular Ocean Plastic (COP) project, riverine plastic waste was collected from the rivers in Gdańsk and in Aarhus and several complementary recycling approaches were investigated to valorize these waste streams. Mechanical recycling of PP was evaluated as a direct material recovery route. In parallel, solvent-based recycling of polyolefins (PP and HDPE) was studied using environmentally friendly solvents to selectively dissolve and purify polymer fractions from contaminated waste. Chemical recycling strategies were also explored for condensation polymers (PET, PC) present in marine waste.

Acknowledgments

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O-11

Natural Poly-β-Myrcene from Chios Mastic Gum as a Renewable Platform for Elastomeric Materials

P. Blyweert[1], C. Nève[1,2], L. Lenen[1,3], N. Borie,[1] P. Lameiras[1], A.-L. Skaltsounis[2], M. Halabalaki[2], J.Hubert[3], J-H Renault[1]

[1] University of Reims Champagne-Ardenne, CNRS, ICMR UMR 7312, 51687 Reims, France
[2] Division of Pharmacognosy and Natural Products Chemistry, Department of Pharmacy, National and Kapodistrian University of Athens, Panepistimioupoli Zografou, Athens, Greece
[3] NatExplore, 51140 Prouilly, France
(corresponding author: pauline.blyweert@univ-reims.fr)

Biobased monomers and polymers, including terpene are central to the development of advanced, eco-designed materials. Among terpene-based building blocks, β-myrcene and its polymeric form are of particular interest thanks to their structural similarity to polyisoprene. Remarkably, a naturally occurring *cis*-1,4-poly-β-myrcene (PM) can be isolated from Chios mastic gum (CMG), a resin secreted by *Pistacia lentiscus,* a tree endemic to the Mediterranean region. Although often considered as a low-value byproduct of essential oil extraction, PM constitutes an underexplored source of fully biobased polymeric matter.[1] We report a sustainable and environmentally friendly strategy to extract, purify, and valorize natural PM into photocurable elastomeric materials. A solvent-based extraction followed by centrifugal partition chromatography (a scalable, solid-support-free liquid-liquid purification technique) enabled the isolation of enriched natural polymer fractions.[2,3] Subsequent formulation with bio-sourced reactive diluents and crosslinkers, allowed UV-induced curing into freestanding elastomers with tunable mechanical and physicochemical characteristics.

By integrating natural polymers, green purification technologies and low-energy photopolymerization, this study demonstrates the potential of poly-β-myrcene can serve as a renewable alternative to conventional elastomers. This approach highlights the value of terpen-based natural polymers in the eco-design of soft materials and opens new perspectives for sustainable applications in adhesives, seals, and rubber-like components.

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O-12

Literature-Based Analysis of SpeedMixer Uses in Polymeric Materials Relevant to Green Chemistry and Nanotechnology

V. Martinez
Hauschild GmbH & Co. KG, Hamm, Germany
(corresponding author: vmg@speedmixer.com)

Sustainable polymeric materials research requires formulation methods capable of processing viscous matrices, nanoparticle dispersions, waterborne systems, and solvent-reduced or solvent-free compositions with high homogeneity and reproducibility. This contribution presents a literature-based analysis of published studies in which Hauschild SpeedMixer® technology, based on dual asymmetric centrifugation, was used in polymeric materials relevant to green chemistry and nanotechnology.

The objective was to identify how SpeedMixer has been employed in developments aligned with the GCNPM scope and which formulation functions it has supported. The reviewed literature shows relevance to sustainable polymer nanotechnologies, bio-based polymer systems, waterborne formulations, printed electronics, and recycling-oriented materials. Reported examples include waterborne polyurethane/nanosilica dispersions, recyclable conductive pastes, and polyamide 6/CuO nanoparticle systems developed under Safe and Sustainable by Design approaches[1-3]. Across these studies, SpeedMixer was used to support dispersion, paste preparation, pre-mixing, and standardized sample preparation before downstream processing such as drying, melt blending, extrusion, printing, or compounding[4].

Overall, SpeedMixer appears as an enabling formulation tool rather than an end technology. The literature associates it with homogeneous mixing, nanoparticle incorporation, viscous paste preparation, closed-container processing, and reproducible sample preparation. Its bladeless DAC principle is relevant when minimizing air entrapment, avoiding blade-material interaction, and reducing cleaning are important. Advanced configurations, including temperature control and variable counter-rotation, can help manage shear intensity, thermal build-up, and reproducibility. This analysis highlights the reported supporting role of DAC mixing in sustainable polymeric material development, without extending beyond the available published evidence.

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O-13

Sustainability Meets Safety: Designing Flame Retarded Fibre-Reinforced Vitrimer Composites

A. Toldy, Zs. Kovács, Á. Pomázi

Budapest University of Technology and Economics (BME), Faculty of Mechanical Engineering, Department of Polymer Engineering, Műegyetem rkp. 3., H-1111 Budapest, Hungary
MTA-BME Lendület Sustainable Polymers Research Group, Műegyetem rkp. 3, H-1111 Budapest, Hungary
(corresponding author: atoldy@edu.bme.hu)

Vitrimers are emerging as recyclable thermoset alternatives enabling circular composite design[1,2]; however, above their vitrimer transition temperature, they exhibit dripping similar to thermoplastics, which increases fire risk and makes flame retardancy a critical requirement[3]. In this work, a carbon fibre-reinforced polyimine vitrimer composites were developed with a synergistic flame retardant approach, integrating a gas-phase-active additive in the matrix and an intumescent vitrimer-based coating on the surface.

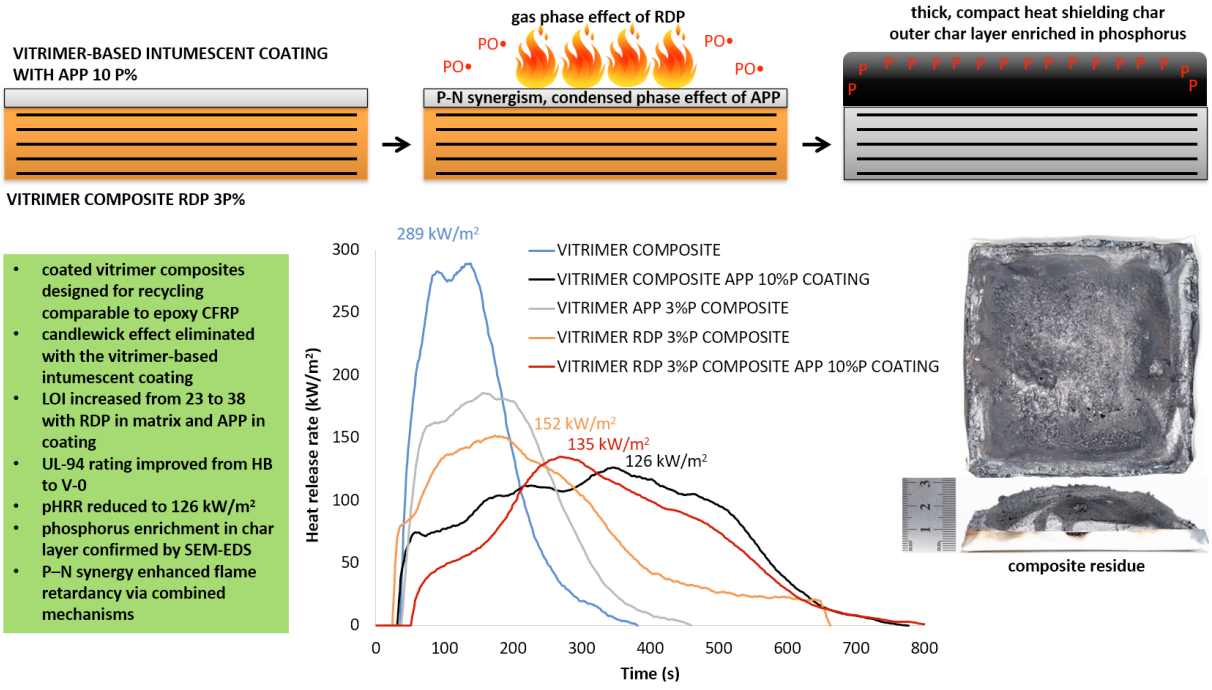

Figure 1

Flame retardancy results of the polyimine type vitrimer composites

Acknowledgments

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O-14

Catalyzed Urethane Exchange in Polyurethane Covalent Adaptable Networks: From Molecular Investigations to Rheological Behavior

N. Collay[1,2], P. Piluso[1], C. Bakkali-Hassani[2], L. Gonon[3], S. Caillol[2], V. Ladmiral[2]

[1] Univ. Grenoble Alpes, CEA, Liten, DTNM, 38000 Grenoble, France
[2] ICGM, ENSCM, CNRS, Université de Montpellier, Montpellier, France
[3] Univ. Grenoble Alpes, CEA, CNRS, Grenoble INP - UGA, IRIG, SyMMES, 38000 Grenoble, France
(corresponding author: nora.collay@cea.fr)

Polyurethane (PU) is the world's leading thermoset with production reaching 20 million tons in 2023.[1] PU thermosets can be mechanically and chemically recycled, though these processes have limitations.[2] CANs are thermosets with exchangeable covalent bonds triggered by stimuli allowing topological rearrangement within the chemical network. Bond exchanges enable CAN to undergo mechanical recycling using compression molding or thermoplastic processing techniques (extrusion/injection) if the exchange are fast enough. In PU-CAN, transurethanization and transcarbamoylation exchanges can be promoted by organic and organometallic catalysts which also limit secondary reactions involved during dissociative exchanges.[3] Fortman *et al.*[4] highlighted the differences in the activities of urethane exchange catalysts between molecular models and cross-linked materials. However, the kinetics of urethane exchange remain unexplored and are difficult to transpose to PU due to the effects of material structure. To improve our understanding of the role of catalyst nature on these exchanges, we monitored by GC-MS the kinetics and formation of by-products during molecular exchange reaction between two urethanes with various catalysts. Studies were conducted using organic catalysts such as TBD, DBU and APTS, as well as organometallic catalysts, including DBTDL, $Fe(acac)_3$, $Bi(neo)_3$, $Zr(acac)_4$, $Zn(acac)_2$ and $Ti(BuO)_4$. The formation of urea was revealed as a by-product when using dibutyltin dilaurate (DBTDL), indicating dissociation of urethanes, alongside the release of lauric acid and the formation of esters such as hexyl laurate and octyl laurate. The butoxide ligand formed a urethane as a byproduct when reacting with isocyanate while no ligand-related side reactions were observed with $Zr(acac)_4$, $Fe(acac)_3$, $Bi(neo)_3$ or DBU. Finally, PU materials synthesized with previous catalysts exhibited decreased crosslink density after 140 °C as indicated by elastic module loss in DMA, indicating dissociative exchanges. In conclusion, this two scales study provided a better understanding of catalysts impact on by-products formation during urethane exchange and help to provide a link between the molecular and macromolecular scales.

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O-15

Bio-Based β-Amino Polyester Vitrimer-Like Networks with Reprocessable Thermoset Performance

M. Kirpluks, R. I. Lazdins, R. Pomilovskis, A. Abolins, A. Fridrihsone

Polymer Laboratory, Latvian State Institute of Wood Chemistry,
Dzerbenes st. 27, Riga, Latvia, LV-1006
(corresponding author: mikelis.kirpluks@kki.lv)

The European Green Deal and Circular Economy Action Plan set a clear objective of achieving climate neutrality by 2050, placing strong emphasis on reducing fossil resource dependence and improving polymer recyclability. However, developing truly sustainable and circular thermoset materials remains a major challenge. Reducing dependence on fossil-based feedstocks while simultaneously improving recyclability, minimizing waste generation, and avoiding landfill disposal are among the central priorities for the polymer industry.

Vitrimers offer a promising solution by combining the mechanical robustness of thermosets with thermoplastic-like reprocessability through dynamic covalent networks. In this study, a bio-based β-amino polyester resin incorporating covalently adaptable networks was developed from renewable raw materials. The vitrimer system was synthesised via Aza-Michael addition using Priamine™ 1074 —a fully bio-based diamine produced by Cargill©— and a soybean oil-derived acrylate. For comparative purposes, tetraethylenetetramine was also employed as an alternative Aza-Michael donor and reacted with three petrochemical-based acrylates of varying functionality: butanediacrylate (difunctional), trimethylolpropane triacrylate (trifunctional), and pentaerythritol tetraacrylate (tetrafunctional). The functionality of the acrylate monomers played a critical role in governing the crosslink density and, consequently, the structural architecture of the resulting polymer networks.

The resins were characterised by FTIR, DSC, TGA, DMA, and tensile testing. Reprocessability was demonstrated through three hot-press recycling cycles with retained properties. The results indicate strong potential for these bio-based β-amino polyester systems as recyclable adhesives for fibreboard applications in the furniture sector, supporting circular material development.

Acknowledgments

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O-16

Synergistic Lignin-Quercetin Hybrid Particles: Multifunctional Bioactive Additives in Cosmetic Formulations

M. Rodríguez-Aranda, M. Peña, L. Serrano

BioPrEn RNM-940 Research Group, Inorganic Chemistry and Chemical Engineering Department, Universidad de Córdoba, Marie Curie Building (C-3), Ctra. Nnal. Km. 396, 14014 Córdoba, Spain
Faculty of Science, Instituto Químico Para la Energía y el Medioambiente (IQUEMA), Universidad de Córdoba, Marie Curie Building (C-3), Ctra. Nnal. Km. 396, 14014 Córdoba, Spain
(corresponding author: q92roarm@uco.es)

The development of multifunctional and sustainable ingredients for cosmetic formulations has gained increasing attention as an alternative to conventional synthetic additives. In this context, lignin and quercetin represent two naturally derived aromatic compounds with complementary physicochemical and biological properties[1]. Lignin exhibits strong ultraviolet (UV) absorption and intrinsic antioxidant activity, while quercetin is a well-known flavonoid with remarkable bioactive potential, including antioxidant and antimicrobial effects. However, the practical use of quercetin in topical formulations is often limited by its poor stability and low compatibility with complex matrices. In this work, hybrid lignin-quercetin particles were synthesized through a green solvent-exchange nanoprecipitation strategy designed to promote close interaction between two aromatic components. A preliminary surface charge analysis was conducted to identify optimal conditions for the process. The resulting particles were characterized in terms of morphology and photophysical behavior.

The obtained hybrid powders were incorporated into cream formulations to evaluate their potential as multifunctional cosmetic additives. Regarding photoprotective performance, creams formulated with 7 % organosolv and kraft lignin nanoparticles displayed transmittance values similar to those of an SPF 15 reference formulation. In contrast, creams containing the same percentage of hybrid powders prepared with different lignin-quercetin ratios (1:0.25, 1:0.5 and 1:0.75) showed a progressive improvement in UV-shielding properties. The optimal performance was observed for the 1:0.75 ratio whose transmittance spectra approached those of a commercial SPF 30 cream. Moreover, antioxidant assays confirmed that quercetin exhibited a higher intrinsic radical scavenging capacity than lignin. However, when combined with lignin, the antioxidant activity of the formulations remained at comparable levels, suggesting that the partial substitution of quercetin by lignin does not compromise this functionality and even enhance it. Additionally, antimicrobial test confirmed that the formulations exhibited a moderate antimicrobial activity, highlighting the potential of these lignin-quercetin mixtures as multifunctional cosmetic additives.

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O-17

Precision Surface Modification of Biodegradable Fibrous Scaffolds via Controlled Enzymatic Degradation

V. Jencova[1], S. Hauzerova[1], D. Lukas[1], P. Kejzlar[1], M. L. Auad[2], B. S. Beckingham[2], J. R. Stockdale[2], J. Granero Garcia[2], H. Benes[3], K. Havlickova[1]

[1] Technical University of Liberec, Liberec, Czech Republic
[2] Auburn Universtity, Auburn, Alabama, USA
[3] Institute of Macromolecular chemistry, Prague, Czech Republic
(corresponding author: vera.jencova@tul.cz)

Micro- and nanofibrous materials represent a cornerstone of tissue engineering due to their ability to closely mimic the native extracellular matrix (ECM). Their high porosity and exceptional surface-to-volume ratio provide an ideal environment for protein adsorption, which subsequently drives cell adhesion and proliferation. Particularly, planar nanofibrous layers with fine fiber diameters show immense promise for treating both chronic and acute wounds. However, to unlock their full potential, there is a growing demand to enhance the intrinsic bioactivity of these scaffolds. This study explores a novel approach: the use of partial enzymatic catalysis as a tool to tailor the surface topography of biodegradable polyester fibers. We demonstrate that the resulting morphological transformations are highly specific to the material composition (Fig. 1) and can be precisely tuned through strategic enzyme selection and process optimization.

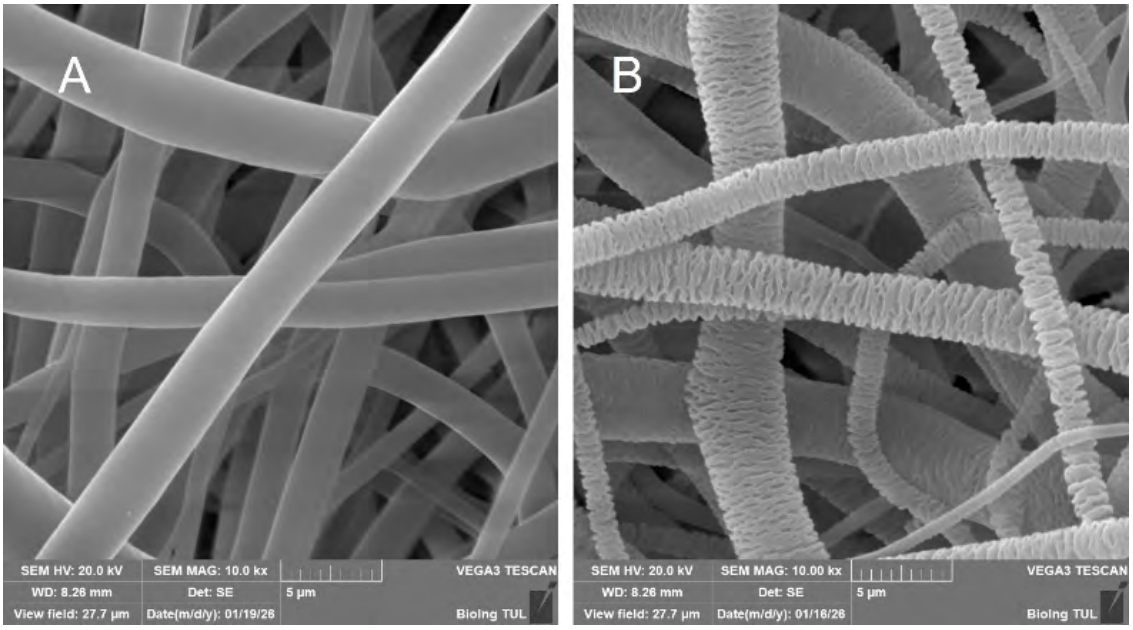

Figure 1

SEM images documenting the microfiber material without (A) and after partial enzymatic degradation (B)

Acknowledgments

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O-18

Waste-Derived Multifunctional Hydrogels Based on Chitosan and Tannins as Active Wound Dressings

M. Ferri[1,2], F. Ganzerli[3], A. Portone[3], T. Petrachi[3], E. Veronesi[3], D. Morselli[1,2], M. Degli Esposti[1,2], P. Fabbri[1,2]

[1] Department of Civil, Chemical, Environmental and Materials Engineering (DICAM), University of Bologna, Via Terracini 28, 40131, Bologna, Italy
[2] National Interuniversity Consortium of Materials Science and Technology (INSTM), Via Giusti 9, 50121, Firenze, Italy
[3] Technopole Mario Veronesi, Via 29 Maggio 6, 41037, Mirandola, Modena, Italy
(corresponding authors: micaela.degliesposti@unibo.it, davide.morselli6@unibo.it)

The development of multifunctional materials that actively promote wound healing process is crucial to address clinical and public healthcare challenges. Such systems are typically achieved by incorporating bioactive molecules into polymeric matrices, leading to dressings that can provide *all-in-one* advanced functions. In this work, a multifunctional hydrogel obtained by physical crosslinking of chitosan and wood-derived tannins is developed for active wound management. Specifically, chitosan/tannin films were prepared at increasing tannin concentrations (0, 1, 5, 10 wt%) through the solvent casting method. Tannins, as polyphenolic compounds derived from wood waste, act both as multifunctional additives and crosslinking agents, leading to the formation of a stable and highly swellable hydrogel. The material is obtained as a dry, rigid film, enabling easy handling and transportation, and undergoes a transition to a soft hydrogel upon hydration. In the swollen state, the material exhibits adequate Young's Modulus (~7 MPa, comparable to the stratum corneum's stiffness), improved flexibility, and suitable adhesion strength to adapt to joint movements. Polyphenolic tannins also provide the material with high antioxidant activity against DPPH radicals (100% RSA), showing potential in mitigating oxidative stress complications. Moreover, tannins can totally block skin-damaging UV light without significantly altering the material's transparency, thus allowing constant visual wound monitoring. *Ex vivo* wound healing studies on abdominoplasty-derived human skin demonstrate that tannin-containing formulations promote restoration of the skin barrier, facilitating progression toward tissue regeneration. Overall, these results show a promising strategy for the upcycling of agri-food waste into advanced materials for active wound management.

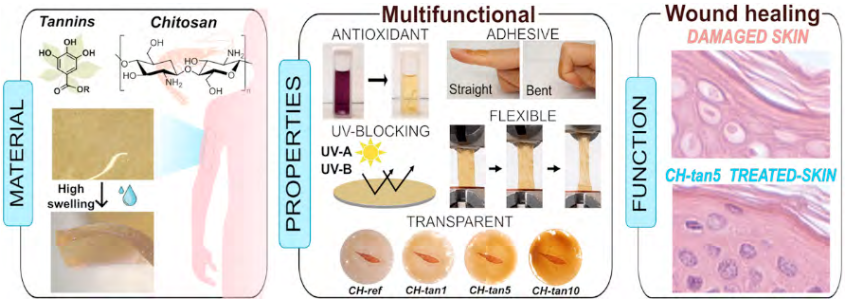

Figure 1

Overview of chitosan-tannin dressings and their wound healing performance

O-19

3D-Printed Starch Tablets for the Delivery of Microfluidic-Encapsulated Probiotics

K. González[1,2], L. Alonso[1,2], I. Berasarte[1], I. Serrano[1,2], N. Gabilondo[1]

[1] 'Material + Technologies' Group (GMT), Dept. of Chemical and Environmental Engineering, Faculty of Engineering of Gipuzkoa, UPV/EHU, Plaza Europa 1, 20018 San Sebastian, Spain
[2] Department of Graphic Design and Engineering Projects, Faculty of Engineering of Gipuzkoa, University of Basque Country (UPV/EHU), Plaza Europa 1, 20018 San Sebastian, Spain
(corresponding authors: nagore.gabilondo@ehu.eus, kizkitza.gonzalez@ehu.eus)

In a context where the global probiotic market is experiencing significant growth driven by the increasing demand of products associated with wellness and nutrition, the present work proposes an innovative approach to the development of functional foods. Specifically, starch-based 3D tablets loaded with either non-encapsulated or encapsulated probiotics were obtained. The effect of encapsulation on rheology of inks, the final properties of the printed tablets, and probiotic viability was evaluated.

Sodium alginate microparticles containing *L. rhamnosus GG* or *B. longum* were prepared by droplet based microfluidics. Printable inks were obtained by the gelatinization of normal maize starch[1]. Inks containing either non-encapsulated commercial probiotics or those encapsulated into microparticles were prepared and printed using a Voladora 3D printer adapted for syringe-based extrusion[1]. Finally, the samples were freeze-dried.

Firstly, it was demonstrated that all inks presented the required rheological behavior for adequate printability. SEM images showed that a well-defined interconnected porous micro-structure was not observed. According to these results, swelling experiments revealed that produced tablets disgregated immediately after immersion in different media, indicating that these tablets could be used to facilitate the oral administration of probiotics. Compression tests showed that tablets containing non-encapsulated probiotics were brittle, whereas those incorporating microcapsules exhibited improved mechanical properties. Finally, fluorescence and viability measurements suggested that the use of microparticles enhances the preservation of metabolically active probiotic cells compared to non-encapsulated probiotics.

In conclusion, this work establishes a novel technological platform for the generation of new probiotic delivery systems, aligned with current trends in advanced digestive health.

Acknowledgments

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O-20

Fatty Amines from Renewable Sources and Biopolymeric Materials from Biorefinery

M. B. Coltelli[1,2], D. Licursi[3], M. Rizza[2,3], F. Cartoni[1], M. V. Ruiz Mendez[4]; J. Pedroche[4], A. Serpico[5], A. M. Raspolli Galletti[2,3], A. Lazzeri[1,2]

[1] University of Pisa, Department of Civil and Industrial Engineering, Pisa, Italy
[2] National Interuniversity Center of Materials Science and Technology, Pisa research unit, Italy
[3] University of Pisa, Department of Chemistry and Industrial Chemistry, Pisa, Italy
[4] Consejo Superior de Investigaciones Científicas (IG-CSIC), Instituto de la Grasa, Sevilla, Spain
[5] Instituto Tecnológico del Embalaje, Transporte y Logística (ITENE), Valencia, Spain
(corresponding author: maria-beatrice.coltelli@unipi.it)

Fatty amines are important industrial chemicals widely used as key intermediates in the production of surfactants, emulsifiers, agrochemicals, personal care products[1], and functional materials. The FLEXIZYME project[2] develops a sustainable biotechnological platform to produce fatty amines from renewable biorefinery side streams. By combining enzyme engineering, biocatalysis, and AI tools, it enables efficient and selective amine synthesis under mild conditions. This approach reduces reliance on fossil resources and lowers environmental impact compared to conventional chemical processes. The resulting bio-based building blocks support the development of innovative biopolymeric materials within a circular bioeconomy framework.

Raw materials from the vegetable oil value chain and legume-based feedstocks were investigated for upstream processing. The extraction of amino acids from legumes generated polysaccharide-rich by-products, creating additional valorization opportunities. Renewable fatty amines derived from these streams were considered for integration into functional biopolymeric systems. This approach supports full biomass utilization and the development of sustainable, high-value bio-based materials.

Acknowledgments

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O-21

Vegetal Biomass: The Raw Material of Tomorrow

M. N. Belgacem

Univ. Grenoble Alpes, CNRS, Grenoble INP (Institute of Engineering Univ. Grenoble Alpes), LGP2, F-38000 Grenoble, France
University of Coimbra, Department of Chemical Engineering, Coimbra, Portugal
(corresponding author: Naceur.Belgacem@grenoble-inp.fr)

The present talk aims at using vegetal biomass, as a source of sustainable raw material for fine chemicals, energy and commodity and high-added values products. Thus, wood, as well as, agricultural and industrial residues can be readily extracted and used as such, as starting chemicals or can be suitably converted to second generation functionalized synthons to be used, as sustainable raw material to face our needs in material science and engineering area.

First, the major drawback and advantages of such strategy will be given before describing different strategies of exploiting this promising sustainable raw material:

1. The first strategy consists of extracting first generation high added-values natural monomers, oligomers and polymers and the application of the high-purity extracted materials in the above-mentioned fields. In this context, typical examples could be the extraction of high-added values hemicelluloses for application as a food- or cosmetic-additive or the preparation of sugars for bio-ethanol, bio-surfactants...
2. Then, converting some original molecules into second generation starting molecules, in order to substitute the use of fossil resources. Thus, high-added values lubricants were prepared starting from sugar-based chemistry for the hydrophilic moieties of the surfactant, whereas vegetal oil-based molecules have served for the hydrophobic counterpart. The other example, could be the preparation of 2,5-dicarboxy furan and its polymerization with ethylene glycol, in order to synthetize the substitute of poly(ethylene terephthalate), destined for packaging of liquids.
3. Then, the functionalization of natural products extracted from vegetal biomass, thus providing them new added-values properties will be discussed. Cellulose, the most abundant polymer in the earth is a hydroxy function-rich macromolecule, is suitable to undergo several chemical reactions (esterification, etherification, urethane formation, etc.) leading to the preparation of active surfaces. This strategy could be applied to cellulose from various origins, different morphologies and at several sizes

The common feature in all these strategies is the use of either wood or agricultural residues, which has two main advantages: rational valorisation of vegetal biomass, avoiding the concurrence of the raw material destined for food stream and using green conditions.

O-22

High Thermal Resistance Coatings Based on Forestry Byproducts

J. Santos[1,2], T. Gomes[3], D. Escobar-Avello[4,5], R. A. Fernandes[1,2], P. Magalhães[3], J. M. Martins[2,6], F. D. Magalhães[2], L. H. Carvalho[2,6]

[1] ARCP CoLAB-Associação Rede de Competência em Polímeros, 4200-355 Porto, Portugal
[2] LEPABE – Laboratory for Process Engineering, Environment, Biotechnology and Energy, ALiCE – Associate Laboratory in Chemical Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal
[3] Tintex Textiles SA, Zona Industrial, Polo 1, Campos, 4924-909 Vila Nova de Cerveira, Portugal
4 Unidad de Desarrollo Tecnológico, Universidad de Concepción, 4191996 Coronel, Chile
[4] Centro Nacional de Excelencia para la Industria de la Madera (CENAMAD), Pontificia Universidad Católica de Chile, Av. Vicuña Mackena 4860, Santiago de Chile, Chile
[5] Unidad de Desarrollo Tecnológico, Universidad de Concepción, 4191996 Coronel, Chile
[6] DEMad-Department of Wood Engineering, Instituto Politécnico de Viseu, Campus Politécnico de Repeses, 3504-510 Viseu, Portugal
(corresponding author: jorge.ucha@arcp.pt)

One of the most important by-products generated in the forestry industry is bark obtained during the debarking process. One of the primary natural barriers of trees against fire is associated with the polyphenols present in their bark[1]. This has led to numerous studies on the thermal resistance of condensed and hydrolysable polyphenols.

In this work, the feasibility of using eucalyptus bark (EB), pine bark (PB), and poplar bark (PPB), as well as alkali extracts obtained from these bark particles, as components in a biobased waterborne polyurethane dispersion (BWPU) formulation for textile coatings was evaluated. An alkali ultrasound-assisted extraction method in water was employed to obtain high-phenolic-content extracts from the bark.

The impact of incorporating 20% (d.b.) untreated bark particles, dry bark extracts, and bark particles after alkali extraction was assessed in terms of the reactivity and thermal stability of the BWPU coating formulation. The effect of bark components on the coating was evaluated using FTIR-ATR, Automated Bond Evaluation System (ABES), and TGA-DSC techniques. The results demonstrate good interaction between condensed and hydrolysable tannins from the different barks and the BWPU polymer matrix and highlight the positive impact of high-polyphenolic-content extracts on the thermal resistance of BWPU coating formulations. In addition, coated cotton fabrics were produced using the BWPU formulation with 20% (d.b.) bark particles or bark extracts. The coated fabrics were characterised in terms of mechanical properties (flexural resistance, tensile strength, and abrasion resistance), thermal conductivity, and fire resistance. The results demonstrate the feasibility of producing coated fabrics with improved properties through the incorporation of forestry by-products.

Acknowledgments

This work was supported by: national funds through FCT/MECI: LEPABE, UID/00511/2025 (https://doi.org/10.54499/UID/00511/2025) and UID/PRR/00511/2025 (https://doi.org /10.54499/UID/PRR /00511/2025) and ALiCE, LA/P/0045/2020 (https://doi.org/10.54499/LA/ P/0045/2020); This work was supported by project WASTES (COMPETE2030-FEDER-20758) co-funded by European Union through COMPETE 2030 and by national funds through FCT/MECI. The authors would like to thank ANID Vinculación Internacional FOVI 250309.

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O-23

Polyester Block Copolymers as Compatibilizers for Natural Fiber Composites

J. Braz[1], H. Saraiva[1], C. T. Paula[2], J. F.Costa[1], A. C. Fonseca[1]

[1] CEMMPRE, ARISE, Department of Chemical Engineering, Rua Sílvio Lima-Pólo II, 3030-509 Coimbra, Portugal

[2] IPN, Instituto Pedro Nunes, Associação para a Inovação e Desenvolvimento em Ciência e Tecnologia, Rua Pedro Nunes, 3030-199 Coimbra, Portugal

(corresponding author: jpgobraz@gmail.com)

Natural fiber–reinforced polymer composites have attracted increasing attention due to their sustainability and reduced environmental impact. However, poor interfacial adhesion between hydrophobic polymer matrices and hydrophilic fibers often limits their performance.[1]

In this work, polyester-based block copolymers were synthesized as non-reactive compatibilizers for polyester composites reinforced with natural fibers. Hydrophilic and hydrophobic polyester blocks were first prepared separately by melt polycondensation under nitrogen atmosphere using different combinations of diacids and diols to tune polymer polarity. Hydrophobic blocks were obtained from succinic acid with 1,4-butanediol or tyrosol, while hydrophilic blocks were synthesized from diethylene glycol combined with succinic or diglycolic acid. The polyester blocks were then coupled using different linking agents, including succinic anhydride, adipoyl chloride, and hexamethylene diisocyanate (HMDI), under mild conditions to avoid hydrolysis of the pre-formed polymers. The resulting copolymers were purified by precipitation and characterized by proton nuclear magnetic resonance (^{1}H NMR) spectroscopy and size exclusion chromatography (SEC). HMDI was shown to be the most efficient linking agent, yielding polyester-based block copolymers with molecular weights ≥ 20 kDa (Figure 1). The increase in molecular weight of the polyester-based block copolymers was found to depend on the molar equivalents of HMDI added to the reaction medium.

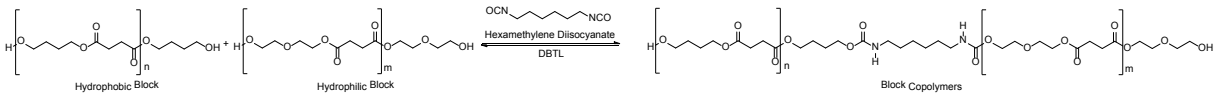

Figure 1

Synthetic strategy of coupling reaction using HMDI as a linking agent

Acknowledgments

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O-24

Transparent Lignocellulosic Materials Functionalized with Coumarins for Biobased Luminiscent Solar Concentrators (LSC)

J. L. Mendoza Quiala[1], C. A. Saldias Barros[1], N. Pizarro Urzua[2]

[1] Pontifical Catholic University of Chile, Santiago de Chile, Chile
[2] Andres Bellos University, Viña del Mar, Chile
(corresponding author: jumendoza@uc.cl)

This work presents the development of a biocomposite material based on functionalized transparent wood with properties for solar energy harvesting and concentration. The research utilizes balsa wood as a structural matrix, which undergoes a delignification process to remove chromophore groups, reducing the lignin content from 22% to 3%. Subsequently, the resulting matrices are impregnated with chitosan, a biodegradable polymer responsible for providing optical transparency to the final material due to its refractive index being like that of balsa wood. In this work, transparent wood matrices were obtained with total transmittance values near 70%, but low direct transmittance (~10%), indicating that the material is highly diffusive. While this scattering favors the initial radiation capture, it also limits optical guiding via total internal reflection, a key requirement for an efficient LSC. Therefore, future stages of this work must focus on reducing scattering losses.

To transform this material into a luminescent solar concentrator (LSC), umbelliferone (7-hydroxycoumarin) was incorporated as a photoactive molecule within the chitosan polymer matrix. Fluorescence studies demonstrate the occurrence of an excited-state proton transfer (ESPT) mechanism, evidenced by an emission centered at 432 nm corresponding to the anionic form of the coumarin, which leads to the formation of different species. The system showed a fluorescence quantum yield of 11.49% and multiexponential behavior in its lifetimes, suggesting the coexistence of various photoprotolytic species within the lignocellulosic matrix.

Acknowledgments

This work was supported by ANID Doctoral Scholarship /2024/ 21240927 and Fondecyt 1251811 and FONDEF ID25I10253.

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O-25

Design of Biobased Latex Coatings: Copolymerization Strategies with Hydrophobic Methacrylates

S. Rubio, J. R. Leiza, A. Barquero, E. González

POLYMAT, Kimika Aplikatua Saila, Kimika Falkultatea,
University of the Basque Country, UPV/EHU, Joxe Mari Korta Zentroa,
Tolosa Hiribidea 72, 20018 Donostia / San Sebastián, Spain
(corresponding author: edurne.gonzalezg@ehu.eus)

The transition toward sustainable materials has intensified the search for biobased monomers suitable for producing high-performance polymer dispersions. In this work, latexes with a high biobased content are synthesized via emulsion polymerization for use as protective coatings. To enhance the barrier properties of the final coatings, particular attention is given to hydrophobic biobased monomers. First, the emulsion homopolymerization of three soft biobased methacrylates is investigated; 2-octyl methacrylate (OMA), tetrahydrogeraniol methacrylate (TGM) and tetradecyl methacrylate (TDM). The challenges associated with polymerizing these monomers via emulsion polymerization are discussed. Subsequently, these soft biobased methacrylates are copolymerized with tetrahydrofurfuryl methacrylate (THFM), a harder and more hydrophilic biobased monomer. We found that the incorporation of the hydrophobic monomers is facilitated Increasing the THFM content. Among the different synthesized copolymers, OMA/THFM (87/13 wt%) and TGM/THFM (41/59 wt%) exhibit the best film-forming ability, suitable mechanical performance, and improved water resistance compared to a standard petroleum-based copolymer.

Acknowledgments

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O-26

Fluorescent Eutectogels for the Detection of PFAS in Water

E. Gabirondo[1,2,3], I. Matos[1], J. M. M. Araújo[1], A. B. Pereiro[1], L. C. Tomé[2]

[1] LAQV, REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, FCT NOVA, Universidade NOVA de Lisboa, Caparica, Portugal
[2] CEMMPRE, ARISE, Department of Chemical Engineering, University of Coimbra, Coimbra, Portugal
[3] POLYMAT and Department of Polymers and Advanced Materials: Physics, Chemistry and Technology, Faculty of Chemistry, University of the Basque Country; Donostia, Spain
(corresponding author: elena.gabirondo@ehu.eus)

Per- and polyfluoroalkyl substances (PFAS) are persistent contaminants detected in aquatic environments and linked to adverse health and ecological impacts.[1] Their analysis typically requires sophisticated chromatographic and mass-spectrometric methods, underscoring the need for simpler and faster detection strategies.

We report a fluorescent sensing platform based on eutectogels containing carbon dots (CDs) for PFAS detection in water. CDs were synthesized via a straightforward procedure and characterized by NMR, FTIR, DSC, TGA, and X-ray diffraction, confirming nanoscale carbonaceous structures with fluorescence-active functionalities.[2] Different CDs loadings were incorporated into polymer eutectogels.[3,4] Based on structural, thermal, and morphological characterization, including SEM, water uptake, and rheological measurements, the eutectogel containing 0.25 wt% CDs was identified as exhibiting optimal structural integrity and mechanical performance.

Under UV irradiation, the eutectogels exhibit stable fluorescence. Furthermore, exposure to PFBS and PFOA induces clear fluorescence changes, demonstrating the material's responsiveness, although without specific compound selectivity. Overall, this work highlights CD-eutectogel hybrid materials as a simple, rapid, and visually interpretable sensing platform, offering a promising route for practical and accessible screening of PFAS contamination in water.

Acknowledgments

The authors thank the financial support from the European Union under MAR2PROTECT project (grant agreement no. 101082048, https://mar2protect.eu/) and IONBIKE 2.0 project (grant agreement n. 101129945, https://doi.org/10.3030/101129945).

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O-27

Development of Functionalized Non-Isocyanate Polyurethane (NIPU) Resins for Advanced 3D Printing Applications

I. Olazabal, M. G. Rodríguez, A. Saralegi, A. Eceiza

'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering of Gipuzkoa, University of the Basque Country (UPV/EHU), Europa Plaza 1, 20018 San Sebastian, Spain (corresponding author: ion.olazabal@ehu.eus)

Driven by the demand for sustainable and safer materials[1], this work explores the synthesis and additive manufacturing of photocurable non-isocyanate polyurethane (NIPU) resins[2]. By using commercially available vinylene ethylene carbonate, two different diamines, and glycidyl methacrylate, we developed a scalable synthesis strategy that yields dual-functional resins with two distinct vinyl groups: methacrylate and vinylene. Photorheology studies were employed to optimize the curing kinetics for high-resolution 3D printing. The resulting materials were characterized in depth, demonstrating tunable thermal and mechanical properties. Interestingly, mechanical properties strongly depend on the resin's structure, with Young's modules ranging from 60 to 1100 MPa and elongation from 2 to 33%. Notably, the vinylene groups remain mainly unreacted after the initial 3D printing process, enabling subsequent surface functionalization via thiol-ene click chemistry—as confirmed by FTIR and contact angle measurements. This approach not only proves the viability of NIPUs for light-based 3D printing but also introduces a versatile platform for creating high-performance materials with tailored surface properties for diverse advanced applications.

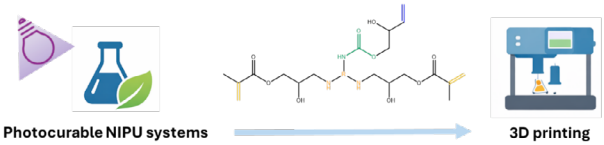

Figure 1

Schematic representation of the research

Acknowledgments

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O-28

Development of Bio-Based Waterborne Polyurethane Adhesives: A Sustainable Approach for the Footwear Industry

C. A. M. dal Berto[1], L. L. Aquino[1], T. B. Schreiner[1,2], I. P. Lima[3], M. J. Ferreira[4], A. Santamaria-Echart[1], M. F. Barreiro[1]

[1] CIMO, LA SusTEC, Instituto Politécnico de Bragança, Bragança, Portugal
[2] GICoS, Instituto Politécnico de Bragança, Bragança, Portugal
[3] Cipade - Indústria e Investigação de Produtos Adesivos, São João da Madeira, Portugal
[4] Centro Tecnológico do Calçado de Portugal (CTCP), São João da Madeira, Portugal
(corresponding author: barreiro@ipb.pt)

To enhance sustainability, waterborne polyurethane-urea dispersions (WBPUU) have gained attention for their non-toxic, non-flammable nature and low volatile organic compound (VOC) content[1]. This work aims to develop WBPUUs with over 50% bio-based content, free of organic solvents, for the footwear adhesives sector.

WBPUU dispersions were prepared via a two-step polymerization process, following a method developed within the research group and compliant with EU regulations, and subsequently analysed for adhesion strength, solids content, particle size, viscosity, pH, and zeta potential. Films were obtained from these dispersions and characterized for morphology and thermal properties. In this study, six WBPUUs were synthesised using bio-based polyols (80-100% natural-origin content), while one sample was prepared using a synthetic yet biodegradable polyol (PCL, polycaprolactone) as a tailor-made synthetic reference; the results were also compared with a commercial reference (Dispercoll®, Covestro).

WBPUU with ~70% bio-based content was obtained, exhibiting high stability and particle sizes comparable to those of the commercial sample. Films' thermal characterization showed crystalline melting peaks around 50 °C, indicating they might be suitable for use as adhesives under typical footwear production conditions. The use of this type of material contributes to environmental benefits and serves as an incentive for developing a sustainable materials supply chain.

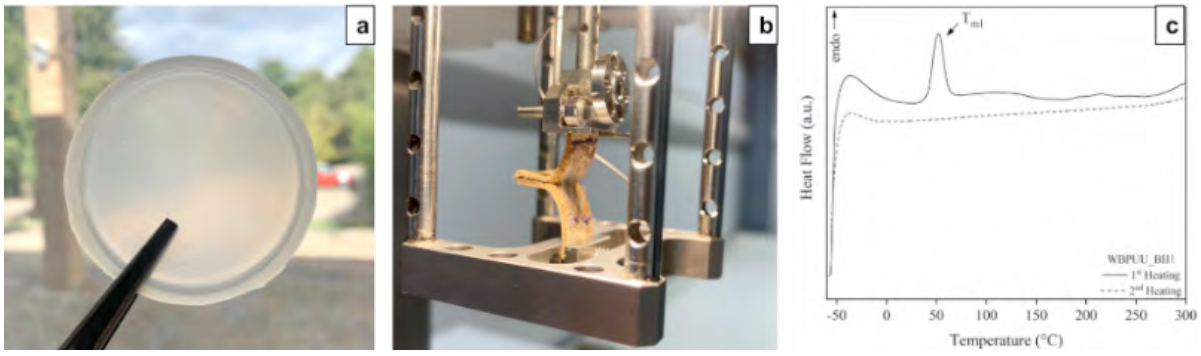

Figure 1

a) WBPUU film, b) DMA analysis, c) Example of a WBPUU thermogram

Acknowledgments

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O-29

The Influence of Alcohol Properties in Lewis Base Catalyzed Isocyanate Reactions

L. M. Hofbauer, C. Slugovc
ICTM, Technische Universität Graz, Stremayrgasse 9, 8010 Graz, Austria
Christian Doppler Laboratory for Organocatalysis in Polymerization,
Stremayrgasse 9, 8010 Graz, Austria
(corresponding author: slugovc@tugraz.at)

For room temperature curing of isocyanates, tin-based Lewis acid catalysis is state of the art. This is mainly due to its high activity and its selectivity towards side reactions with water. However, the replacement of tin-based catalysts for toxicological and environmental issues is an important goal for the practical application of this chemistry[1,2].

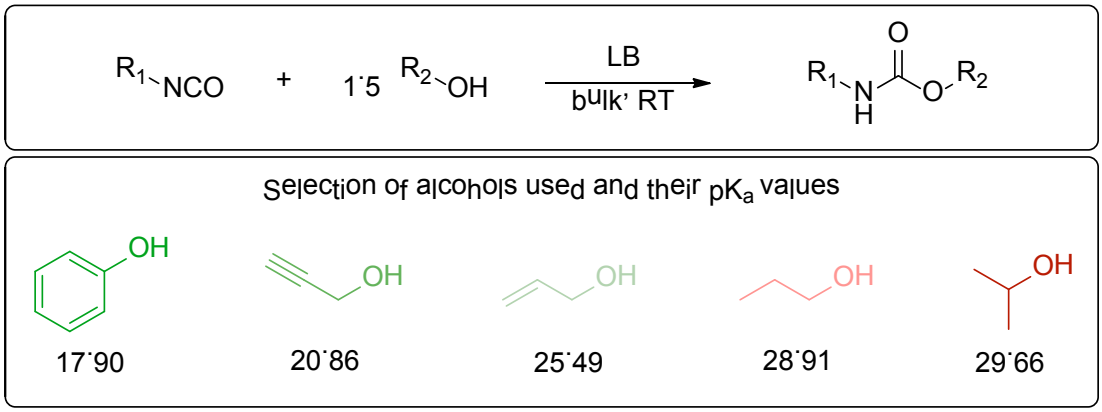

Figure 1

Typical reaction under investigation; reaction conditions:
1 equiv. isocyanate, 1.5 equiv. alcohol, 0.01 equiv. Lewis base, room temperature, solvent free.
Alcohols with different pK_a (DMSO) were tested[3]

In this contribution we present our findings on Lewis base catalysis in the reaction of isocyanates with aliphatic and aromatic alcohols at room temperature under solvent-free conditions. The focus is on determining the impact of the electronic properties of the alcohol on the reaction rate using various Lewis bases, with the Lewis acid dibutylin dilaureate (DBTL) serving as the reference. Results for aliphatic alcohols showed that none of the Lewis bases could compete favourably with DBTL in terms of catalytic activity. However, a strong dependence of the alcohols' acidity on the reaction rate was observed. In the case of Lewis base catalysis, more acidic alcohols react much faster than less acidic ones. The opposite trend is observed with DBTL. Here, the speed of the reaction increases with the nucleophilicity of the alcohols. Finally, we demonstrate the influence of the alcohol-to-isocyanate ratio for selected Lewis bases.

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O-30

Development and Validation of TPS-Based Functional Biomaterials with Biofertilizer and Metal Adsorption Properties

A. Jiménez, C. Pelegrín, C. Mellinas, M. Ramos, M. C. Garrigós

University of Alicante, Alicante, Spain
(corresponding author: alfjimenez@ua.es)

Tiger nut, generates large amounts of waste, including the dried plant after harvesting and the tuber residue from horchata production. Moreover, rice harvesting residues are abundant in traditional crops. Recovering these by-products within a circular economy framework can reduce their environmental impact, while obtaining high added-value chemicals to be used in combination with biopolymer matrices. This study proposes a comprehensive valorization strategy for by-products generated in the tiger nut and rice harvesting and processing to gear towards technological solutions with a direct impact on new biomaterials, agricultural sustainability and environmental management. The development of sustainable processes, such as ultrasound (UAE) and microwave-assisted extraction (MAE), presents great advantages compared to conventional techniques, since they allow more efficient and faster processes, with high potential for scaling-up, and greater protection of thermolabile constituents, with lower consumption of solvents and energy. Residues and by-products obtained from tiger nut and rice were used to obtain new intelligent biomaterials with the capacity to release biofertilizers for agricultural use. The performance of the extracts from tiger nut residues in thermoplastic starch (TPS) was evaluated under representative agricultural conditions, including the interaction with the soil and water environments. Laboratory tests were conducted, as well as some field trials. Specifically, release and column leaching tests and studies in aqueous media at different pH levels and temperatures were carried out, monitoring urea release and associated functionality. Additionally, phytotoxicity and ecotoxicity tests were performed to verify the safety of the leachates and to support the selection of formulations with a better balance between efficacy and sustainability. Release tests were performed under simulated soil conditions with TPS-based materials with rice and tiger nut extracts and the addition of ZnO nanoparticles. These innovative biomaterials showed a very good control on the release of active compounds. Leaching tests, leachate functionalities and phytotoxicity tests provided evidence of a modulable release and attenuation of the biological impact, providing a solid basis for future stages of optimization, scaling up, and validation under real conditions, aligned with the objectives of sustainability, circular economy, and reduction of environmental impact.

Acknowledgments

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O-31

Mixed Ionic-Electronic Conducting Eutectogel based on K-Carrageenan for Bioelectronics

S. Locatelli[1], L. I. Ronco[1], R. J. Minari[1], R. Rai [3], D. Mantione[3], D. Mecerreyes[3], G. C. Luque[1,2]

[1] Polymer Reaction Engineering Group, INTEC (Universidad Nacional del Litoral-CONICET), Güemes 3450, Santa Fe 3000, Argentina
[2] Center for Cooperative Research in Biomaterials CIC biomaGUNE, Donostia / San Sebastián, 20014, Spain
[3] POLYMAT University of the Basque Country UPV/EHU, Donostia / San Sebastián, 20018, Spain
(corresponding author: slocatelli@cicbiomagune.es)

Nowadays, interest in electrical stimulation and physiological signal recording has increased considerably in the medical field, leading to the development of biocompatible, flexible and conductive materials to improve the electrode-skin interface by reducing the impedance between them.[1] Eutectogels are green materials with great potential for these applications due to their stable properties compared with conventional hydrogels and their possible ionic conductivity. Moreover, materials that combine ionic and electronic conductivity are attractive because they have a dual function that matches both the ionic nature of biological tissues and the electronic nature of metal electrodes.

In this study, we present a mixed ionic-electronic conductive eutectogel based on k-carrageenan (kcar) prepared using two different deep eutectic solvents: choline chloride (ChCl): pyrocatechol (1:2) and ChCl: pyrogallol (1:1). The system incorporates the electrically conductive polymer poly(3,4-ethylenedioxythiophene) (PEDOT) at different concentrations, which is stabilized by the kcar molecule (kcar-PEDOT) instead of the commonly used polystyrene sulfonic acid (PSS) dispersant, thereby increasing the natural content of the gel. The natural-based eutectogel showed good ionic conductivity, with values between 2×10^{-3} and 6×10^{-3} S/cm (figure 1A) in a temperature range of 20-40 °C, a compression modulus of about 100 kPa and flexibility (figure 1B). These features make it suitable for bioelectronic interfaces in both signal recording and electrostimulation processes.

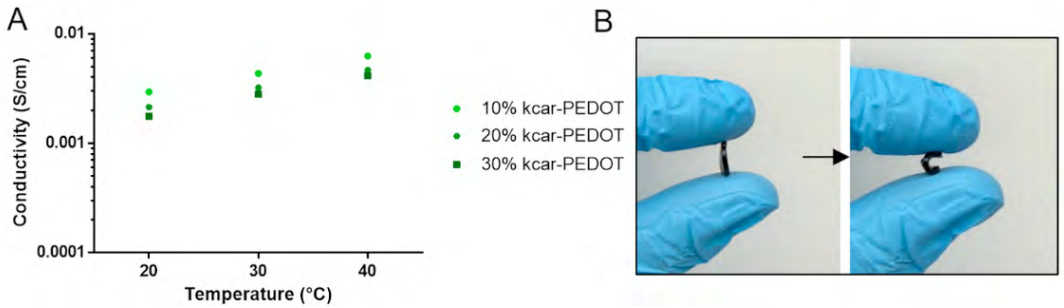

Figure 1

(A) Ionic conductivity of eutectogels with different kcar-PEDOT contents at 20, 30 and 40 °C, and (B) images showing the flexible properties of the eutectogels

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O-32

Valorization of Coffee Silver Skin for the Production of High-Performance Bio-Adhesives

R. A. Fernandes[1,2], B. Cardoso[1], N. Ferreira[1], A. Lima[3], J. M. Martins[2,4], L. H. Carvalho[2,4]

[1] ARCP – Associação Rede Competência em Polímeros, Porto, Portugal
[2] LEPABE, ALiCE – Faculty of Engineering, University of Porto, Porto, Portugal
[3] Feel Matter, Unipessoal Lda, Porto, Portugal
[4] DEMad-Department of Wood Engineering, Instituto Politécnico de Viseu, Viseu, Portugal
(corresponding author: raquel.fernandes@arcp.pt)

Coffee silver skin is a major by-product of the coffee roasting industry, representing around 7.5 kg per ton of roasted coffee annually in Portugal.[1] At present, coffee silver skin is mainly valorized at an industrial level through low-value applications such as direct combustion for energy production or as a low-cost filler in materials, with low added-value associated.[1] The high polyphenol content of coffee silver skin provides abundant reactive hydroxyl groups, enabling cross-linking reactions that make it a promising renewable raw material for the development of bio-based resins.[2]

In the present work, a high performance bio-adhesive was developed by using coffee silver skin extract and citric acid as cross-linker. The impact of citric acid was evaluated in both bonding and water resistance properties. Additionally, chemical interaction between both components was investigated through FTIR and HPLC analysis.

The results exhibit a positive contribution of citric acid for enhancing both adhesive and hydrophobicity properties, through the esterification reaction between polyphenols and carboxylic groups of citric acid. By tuning the polyphenolic extract:citric acid ratio and also the temperature of cure, it was possible to obtain an improved resin in terms of bonding and water resistance properties.

Acknowledgments

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O-33

Scalable Bio-Based Isocyanate-Terminated Polyurethane Prepolymers for Coated Textiles Applications

G. C. S. Adão[1], **T. B. Schreiner**[1,2], A. Zanella[1], P. Caetano[3], L. Sousa[3], M. J. Ferreira[4], A. Santamaria-Echart[1], M. F. Barreiro[1]

[1] CIMO, LA SusTEC, Instituto Politécnico de Bragança, Bragança, Portugal
[2] GICoS, Instituto Politécnico de Bragança, Bragança, Portugal
[3] Monteiro Fabrics, Porto, Portugal
[4] Centro Tecnológico do Calçado de Portugal (CTCP), S. João da Madeira, Portugal
(corresponding author: barreiro@ipb.pt)

The advancement of bio-based polymeric materials has become a key strategy to reduce the environmental footprint of the footwear industry[1]. This work explores the development and application of bio-based isocyanate-terminated polyurethane (PU) prepolymers for sustainable footwear coating formulations. The PU prepolymers were synthesised via polycondensation using commercial polyester polyols with 82-90% bio-based content, yielding systems with 5% free isocyanate (NCO) content. The use of aliphatic isocyanates was prioritised to minimise toxicity, hazardous by-products, and emissions of Volatile organic compounds (VOCs), without compromising performance. The stability of free NCO groups was assessed in accordance with ASTM D2572-97 and Fourier transform infrared spectroscopy (FTIR), confirming their suitability for industrial applications. Pilot-scale coatings, formulated with the bio-based PU prepolymers along with crosslinkers and pigments, demonstrated adhesion, durability, and structural integrity consistent with ISO 17698 standards over cotton surfaces. Overall, these results highlight not only the practical potential of bio-based PU prepolymers for sustainable footwear-coated fabrics but also their suitability at pilot-scale face to scalable industrial production.

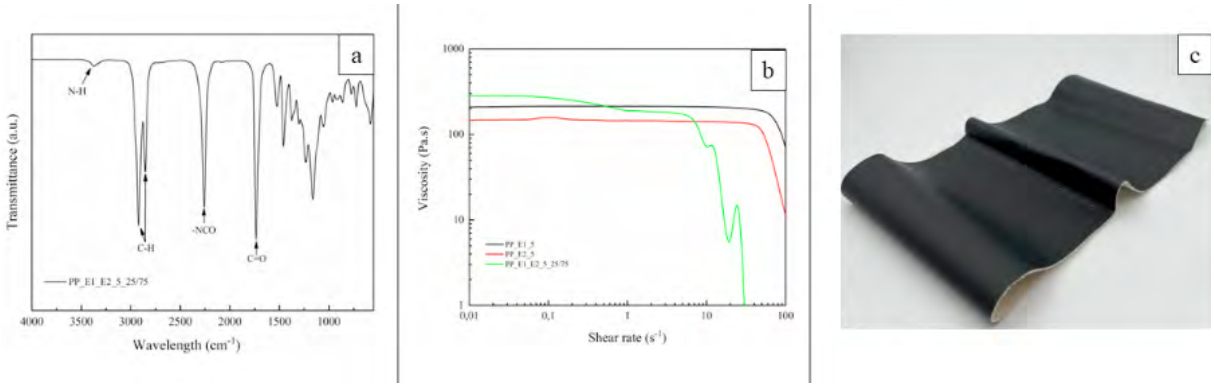

Figure 1

a) FTIR prepolymer, b) Rheological analysis, and c) PU-coated fabrics

Acknowledgments

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O-34

A New Modified Polypropylene to Replace PC/ABS Blend in the Production of Seat Covers

J. Smykowski[1,2], K. Mencel[1], A. Hejna[1], **M. Szostak**[1]

[1] Poznan University of Technology, Poznan, Poland
[2] KIEL Polska, Nowy Tomysl, Poland
(corresponding author: j.smykowski@kiel.com.pl; marek.szostak@put.poznan.pl)

As part of research conducted at the Poznan University of Technology's to select a polymer substitute for the PC/ABS blend used to manufacture the rear cover of a bus seat backrest, six grades of polypropylene were modified: TALCOPRENE C1016, MOPLEN EP548, INSPIRE TF1305 and 3 RESLEN grades: GF30, GF25 GF20. The PC/ABS blend CYCOLOY CX7240 was selected as the reference material, and its mechanical and flammability properties were considered as reference values. To modify the properties of selected polypropylenes, we used the following plasticizers: ENGAGE 8150 and KRATON; flame retardants: GRAFE 91-00220, Exolit AP 422 and AP 766; and fillers: basalt powder and EC9 glass fiber. Of the polypropylenes tested, the INSPIRE TF1305 grade was selected as the base due to its best combination of high stiffness while maintaining high impact strength and deformability. The ENGAGE modifier resulted in a polypropylene that absorbed impact energy during crash tests, deforming without visible cracking, and achieving nearly twice the initial notched impact strength (up to 14.6 kJ/m²). By introducing the Grafe 91-00220 flame retardant, the flammability properties of PP were significantly improved, coming very close to the values required in tests according to ECE R118.03 regulations. However, a side effect of modifying the impact strength and flammability of PP was a significant increase in its shrinkage. The reference nominal dimension of the molded part perpendicular to the flow direction for the PC/ABS blend was 400 mm, and for the PP with the addition of Engage and Grafe modifiers – 391 mm. The introduction of basalt, glass fiber, and the use of a mechanical pattern to limit shrinkage after removal from the injection mold ultimately resulted in a reduction to the reference dimension of 397 mm, which allowed for correct assembly of the molded part on the passenger seat frame. However, the biggest problem with using PP instead of the PC/ABS blend in the production of seat covers turned out to be scratch resistance, as the addition of the Engage modifier caused a significant deterioration of the PP properties in this regard. To improve this surface property, the product was hardened by using siloxanes, which significantly improved this feature of the product. The research ultimately led to the development of a polypropylene-based polymer composition that can successfully replace the PC/ABS blend currently used in the production of rear bus seat backrest covers.

Acknowledgments

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O-35

Viscoelastic Polyurethane Foams Obtained from Renewable Raw Materials – Laboratory Scale *vs.* Continuous Process

M. Kucała[1,2], E. Malewska[1], M. Kurańska[1], A. Prociak[1]

[1] Cracow University of Technology, Faculty of Chemical Engineering and Technology, Department of Polymer Chemistry and Technology, Kraków, Poland
[2] Cracow University of Technology, CUT Doctoral School, Department of Polymer Chemistry and Technology, Kraków, Poland
(corresponding author: michal.kucala@doktorant.pk.edu.pl)

Viscoelastic polyurethane foams are primarily used in the furniture and automotive industries[1]. These materials are characterized by their ability to conform to the shape of a deforming element, such as the human body. Generally, polyurethane foams are produced from polyols and isocyanates. These raw materials are primarily derived from refined petroleum products. To achieve more environmentally friendly products, conventional petrochemical polyols in the polyurethane system were replaced with biopolyol derived from rapeseed oil and repolyols derived from the chemical recycling of waste polyurethane materials. Foams with different mass fractions of renewable raw materials were obtained traditionally – in laboratories during free foam expansion and on a continuous polyurethane foaming line (Figure 1). Differences in the physicomechanical properties of foams with the same composition but obtained using different batch and continuous production methods were observed. The differences depend on the type of properties and average: apparent density 4%, hardness 36%, hysteresis 5%, comfort factor 26%, and resilience 20%. Viscoelastic polyurethane foams modified with biopolyols and repolyols can be a promising alternative to foam materials produced solely from petrochemical raw materials.

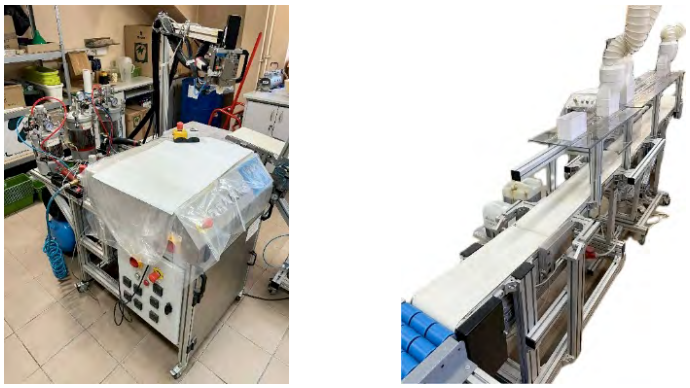

Figure 1

Line for continuous foaming of polyurethanes

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O-36

Degradable Polymers by Radical Ring Opening Copolymerization of CKAs

A. Barquero[1], A. Marchand[1,2], H. Sardon[2], J. R. Leiza[1]

[1] POLYMAT, Kimika Aplikatua Saila, Kimika Fakultatea,
University of the Basque Country, UPV/EHU, Joxe Mari Korta Zentroa,
Tolosa Hiribidea 72, 20018 Donostia / San Sebastián, Spain
[2] POLYMAT, Polimero eta Material Aurreratuak:
Fisika, Kimika eta Teknologia Saila, Kimika Fakultatea,
University of the Basque Country, UPV/EHU, Paseo Manuel de Lardizabal 3,
20018 Donostia / San Sebastián, Spain
(corresponding author: aitor.barquero@ehu.eus)

Polymers are versatile materials used in a many applications and are now everywhere in modern society. However, their widespread use has also created significant environmental challenges. For many applications, recycling represents the most appropriate strategy to reduce environmental impact; nevertheless, in certain cases material recovery is impractical or economically unfeasible.

Many of the applications in which polymer recovery is extremely challenging involve single-use or very short-use products. Examples include cosmetic formulations and food packaging. In cosmetics in particular, polymeric additives can be applied to the skin but are rinsed off into wastewater shortly after use. For such applications, the development of (bio)degradable polymers represents a promising strategy to mitigate environmental accumulation.

A major limitation in the degradability of conventional polymers is the presence of carbon–carbon bonds in the polymer backbone, which are highly resistant to chemical or biological degradation. To address this issue, heteroatoms can be incorporated into the polymer backbone, introducing cleavable linkages that enable degradation. One particularly attractive approach involves the use of cyclic ketene acetals (CKAs). These monomers can undergo radical ring-opening polymerization (rROP), introducing degradable ester bonds into otherwise non-degradable vinyl polymer backbones[1].

Despite their potential, CKAs are often difficult to polymerize efficiently due to their relatively low reactivity. Herein, we demonstrate that the effective incorporation of 2-methylene-1,3-dioxepane (MDO) can be achieved when it is combined with crotonic acid esters. Copolymerization of these monomers results in the formation of highly alternating copolymers with enhanced degradability[2]. Furthermore, when a third monomer is introduced, the crotonate units promote the incorporation of MDO into the polymer chain, providing an effective strategy to introduce degradable ester linkages into vinyl polymer systems[3].

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O-37

Development of Bio-Based Covalent Adaptable Network Fiber-Reinforced Composite Battery Casing

A. Maokhamphiou[1], L. de Paoli[2], S. Rolère[1], P. Piluso[1]

[1] Univ. Grenoble Alpes, CEA, Liten, DTNM, 38000 Grenoble, France
[2] Univ. Grenoble Alpes, CEA, Liten, DEHT, 38000 Grenoble, France
(corresponding author: alex.maokhamphiou@cea.fr)

In an effort to reduce greenhouse gas emissions, the current transition occurring in transport sector from fuel-powered to electric vehicles has led to the development of a new generation of batteries. With this sustainable transition, the end-of-life of the developed materials became a critical issue with stricter recycling targets.[1] Thus, many studies have been conducted on finding efficient strategies to recover critical materials from the electrochemical cells to the battery casings.[2] The latter one can represent up to 20 wt% of the total battery mass, deserving specific attention. Fiber-reinforced composites have emerged as a promising alternative to conventional metal-based casings regarding their outstanding strength-to-weight ratio[3], but remain non-recyclable.

In this work, we aim to develop a siloxane-based covalent adaptable network that could mitigate the recyclability limitation of these thermosets.[4] To carry this out, the formulations comprise vanillin-based epoxy precursors obtained through multi-step syntheses, leading to various structures including glycidyl ether of vanillyl alcohol and divanillyl alcohol. As the epoxidation involves the base-catalyzed reaction of hydroxyl groups with epichlorohydrin, the resulting methylolates can further react with glycidyl groups already formed, leading to oligomer formation through epoxy ring-opening reactions. In the case of divanillyl alcohol epoxidation, column chromatography coupled with NMR analyses revealed a complex mixture of species, including di-, tri-, and tetra-glycidyl ether monomers as well as oligomeric species such as multi-functional dimeric structures derived from divanillyl alcohol. Then, by varying both the aromatic content and the functionality of the monomers, together with the epoxy-amine ratio, the thermo-mechanical properties of the resulting material could be tailored. Overall, these results demonstrate the potential of this vanillin-based system for the preparation of recyclable high-performance composites using resin infusion processes for battery casing applications.

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O-38

Poly(Vinylogous Urethane) Foams from Acetoacetate-Functionalized Vegetable Oils

K. Polaczek[1], P. de Souza Lima[1], O. Gotkiewicz[1], O. Kopilec[2], O. Sedláček[2], M. Kirpluks[3], H. Beneš[1]

[1] Institute of Macromolecular Chemistry, Czech Academy of Sciences, Heyrovského nám. 2, Prague 6, 162 00, Czech Republic, polaczek@imc.cas.cz
[2] Department of Physical and Macromolecular Chemistry, Faculty of Science, Charles University, 128 40, Prague 2, Czech Republic
[3] Polymer Department, Latvian State Institute of Wood Chemistry, 27 Dzerbenes Str., LV-1006 Riga, Latvia
(corresponding author: polaczek@imc.cas.cz)

Conventional polyurethane (PUR) foams are used in numerous applications, such as thermal insulation, furniture, automotive components, and packaging, owing to their low density and tunable properties. However, their production depends on toxic aromatic isocyanates, and their permanently crosslinked structure makes recycling difficult. As a non-isocyanate alternative, vinylogous urethanes (VUs) are attractive because they can be synthesized without isocyanates and reprocessed through dynamic covalent bond exchange[1,2].

In this work, bio-based VU foams were synthesized from acetoacetate-functionalized vegetable oils, selected amines, and a physical blowing agent. The influence of formulation on reactivity, the foaming process, and cellular structure was studied. The foams were characterized in terms of thermal stability and mechanical performance. Network rearrangement in the VU materials was evaluated by stress-relaxation analysis, while reprocessability was demonstrated by converting ground foams into pressed bulk samples through catalyst-free transamination. The results demonstrate that bio-based VU foams are promising sustainable alternatives to conventional PUR foams.

Acknowledgments

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O-39

Opportunities and Challenges of Acrylates and Methacrylates in Epoxy-Amine Covalent Adaptable Networks

J. Lang, C. Slugovc
Graz University of Technology, Graz, Austria
(corresponding author: slugovc@tugraz.at)

Epoxy thermosets are essential for high-demand composite applications due to their outstanding thermal and mechanical performance. The incorporation of dynamic covalent bonds into the network facilitates reprocessing, making the materials more sustainable. This can be achieved by the addition of (meth)acrylates, which form β-amino ester bonds within the network via the aza-Michael reaction.[1]

Since methacrylates are less toxic than acrylates, it is advantageous to substitute the latter whenever possible.[2] However, as they are also less reactive, the methacrylate under study has an additional hydroxyl group to increase the amount of proton donors in the system. Therefore, this research combines the epoxy-amine, Aza-Michael and epoxy-alcohol reactions to obtain a low viscous formulation with covalent adaptable network (CAN) properties once cured.

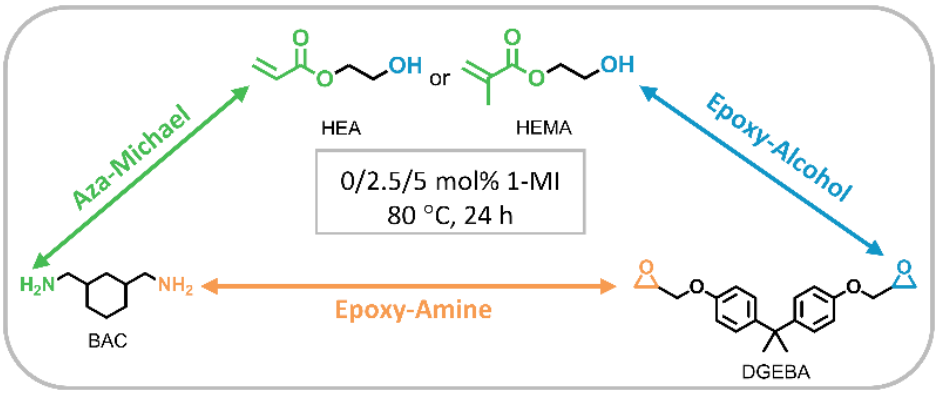

Figure 1

Monomers and curing conditions for epoxy-amine-(meth)acrylate CANs

The importance of 1-methylimidazole (1-MI) as a catalyst for the epoxy-alcohol reaction is demonstrated. ATR-IR reaction monitoring of the Aza-Michael reaction between 1,3-Bis(aminomethyl)cyclohexan (BAC) and 2-hydroxyethyl acrylate (HEA) or 2-hydroxyethyl methacrylate (HEMA) confirmed that the methacrylate reacted more slowly than its acrylic counterpart, which resulted in a lack of reworkability. In contrast, acrylate-based networks were remouldable, with glass transition temperatures above 75 °C. The stress relaxation behavior and changes in the material during rheological investigations were examined. Finally, the thermal stability and decomposition products showed potential limitations of the material.

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O-40

Biobased Levulinates for Imine Covalent Adaptive Networks in Rubber Materials

L. Lenzi[1], J. C. Chicharro[2], M. Degli Esposti[1], D. Morselli[1], M. H.Santana[2], P. Fabbri[1]

[1] Department of Civil, Chemical, Environmental, and Materials Engineering (DICAM), Università di Bologna, Bologna, Italy
[2] Institute of Polymer Science and Technology (ICTP), CSIC, Madrid, Spain
(corresponding author: luca.lenzi15@unibo.it)

Covalent adaptive networks (CANs) are attracting increasing interest as a strategy to overcome the intrinsic limitations of conventional crosslinked rubbers, enabling the production of materials that can be reprocessed, repaired, and recycled. Among the dynamic covalent chemistries used to produce CANs, imine bonds have been widely investigated. However, most studies rely on aldehyde-based systems, while imines derived from ketones remain largely unexplored. In this work, glycerol trilevulinate (GT), originally designed as bioplasticizer[1], was employed as component for the formation of dynamic bonds in the rubber network. GT, obtained from the solvent-free esterification of glycerol and levulinic acid, was combined with hexamethylene diamine (HMDA) to introduce reversible imine bonds in epoxidized natural rubber (ENR). This approach enabled the generation of hybrid networks where covalent imine bonds coexist with hydrogen bonds within the elastomer matrix. The resulting materials showed the ability to reconstruct their network during thermal reprocessing, leading to recyclable rubber systems showing the potential of levulinic-acid-derived building blocks as versatile components for the design of sustainable and adaptive elastomeric materials.[2]

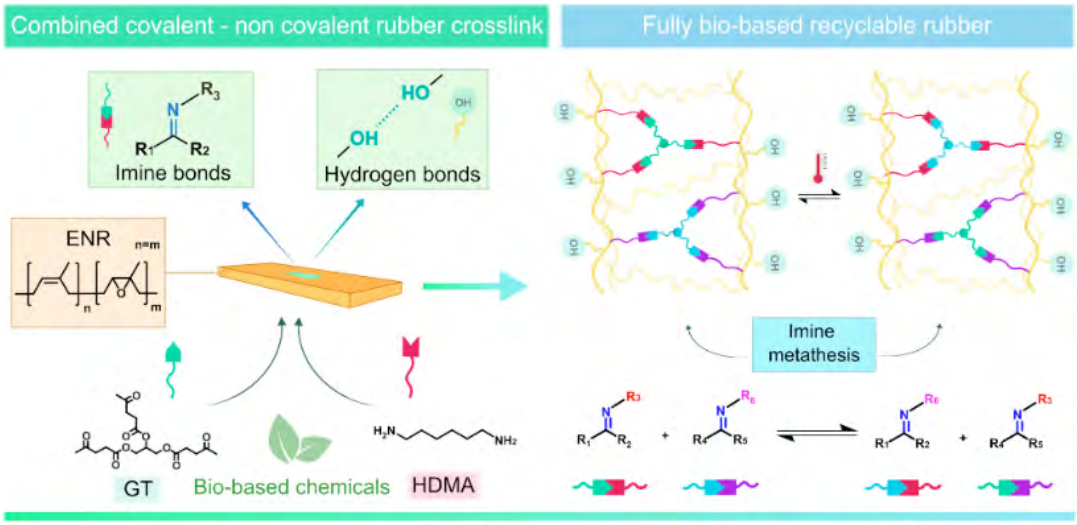

Figure 1

Schematic representation of the dynamic crosslinking in the rubber network and the imine metathesis mechanism

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O-41

Biodegradable Polyesters Deeply Remodelthe Soil Microbiome

J. Šerá, V. Kučabová, K. Lipovská, **M. Koutný**

Department of Environmental Protection Engineering, Faculty of Technology, Tomas Bata University in Zlín, Nad Ovčírnou 3685, 760 01, Zlín, Czech Republic
(corresponding author: mkoutny@utb.cz)

Biodegradable plastics (BPs) are increasingly presented as sustainable alternatives to conventional plastics. BPs can alter soil microbiomes, nutrient cycling, and soil organic matter (SOM). Our laboratory primarily works with three BPs: poly-3-hydroxybutyrate (PHB), poly(butylene succinate-co-adipate) (PBSA), and polybutylene adipate terephthalate (PBAT). Metagenomics, scanning electron microscopy, and fluorescent microscopy are valuable tools to explore changes in the soil microbiome. Structured plastispheres were formed, significantly altering microbial communities and SOM. Each polymer hosted a distinct plastisphere, with bacterial communities more strongly divergent between polymers, while fungi were shaped more strongly by the soil context. Functional profiling revealed shifts in nitrogen metabolism and ecological strategies at BP surfaces, including decreases in nitrifiers and increases in parasitic/pathogenic fungi. Interesting effects were observed depending on soil texture and water content. The plastisphere extended up to 1.25 mm for bacteria and 2.75 mm for fungi. PHB plastispheres were enriched by some specific taxa, and their composition changed over time. BP exposure reduced SOM, most strongly for PHB and PBSA, and to a lesser extent for PBAT, suggesting a positive priming effect. Overall, BP degradation promoted nitrogen-limited conditions and host-dependent microbial strategies. Although plastisphere communities showed signs of stabilization after about one year, full recovery of microbial composition and SOM may require longer.

Acknowledgments

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O-42

Crystallization of Biopolyesters within Graphene-Based Nanopapers

A. Fina[1], H. Zhao[1], R. A. Pérez-Camargo[2], G. Liu[3,4], A. J. Müller[2,5]

[1] Dipartimento di Scienza Applicata e Tecnologia, Politecnico di Torino, Alessandria, Italy
[2] POLYMAT and Department of Polymers and Advanced Materials, University of the Basque Country, Donostia / San Sebastián, Spain
[3] CAS Key Laboratory of Engineering Plastics, Beijing National Laboratory for Molecular Sciences, Institute of Chemistry, Chinese Academy of Sciences, Beijing, China
[4] University of Chinese Academy of Sciences, Beijing, China
[5] IKERBASQUE, Basque Foundation for Science, Bilbao, Spain
(corresponding author: alberto.fina@polito.it)

The control and design of the semicrystalline structure of polymer binders within nanopapers based on graphene-related materials (GRM) may have a significant impact on the nanopapers' physical properties, including thermomechanical resistance and thermal conductivity. Indeed, the controlled formation of polymer crystals on the surface of nanoparticles may contribute to the enhancement of load transfer and phonon transfer within percolative networks of inorganic nanoparticles.

With this aim, several polymers have been used as (semi)crystalline binders within GRM nanopapers, to investigate their crystallization and correlations with thermophysical properties. Among these, biopolyesters differing in methylene chain length between ester groups were extensively studied, specifically using poly(ε-caprolactone) (PCL), poly-4-hydroxybutyrate (P4HB) and polyglycolic acid (PGA)[1,2]. The crystallization behavior and crystalline structure of the polymers embedded in GRM nanopapers were studied by differential scanning calorimetry and wide-angle X-ray scattering (WAXS). In particular, high melting point crystals originating from strong nucleation and strong molecular interactions with the GRM were observed, with thermal stability dependent on the chemical structure of the polymer. The crystals having the highest melting temperatures, well above the equilibrium melting points of PCL and P4HB, are of particular interest. Besides their high thermal stability, these crystals cannot be fractionated through successive self-nucleation and annealing. At the same time, WAXS revealed distinct crystal diffraction reflections and relatively broad rings, suggesting the formation of crystals stabilized up to high-temperatures by their interfacial adsorption onto GRM.

In this presentation, the recent results obtained on both the fundamental aspects of polymer crystallization and the correlation with the physical properties of GRM/polymer nanopapers will be presented and discussed.

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O-43

Catalyst-to-Feed Ratio Effects in the Thermo-Catalytic Upgrading of Fibre-Reinforced Composite Pyrolysis Volatiles

H. Gomez-Llona, E. Lancho-Alonso, **E. Acha**, A. Lopez-Urionabarrenechea, B. M. Caballero

Engineering School of Bilbao, University of the Basque country (EHU), Bilbao, Spain
(corresponding author: esther.acha@ehu.eus)

The growing use of fibre-reinforced plastic composites (FRPC) in fields as diverse as wind energy, marine, automotive, aeronautics and aerospace, is leading to a rapid increase of FRPC waste. The durable thermoset–fibre architectures hinder mechanical recycling and often result in incineration or cement kiln co-processing with high CO_2 emissions. In parallel, national and EU strategies highlight the need for technologies capable of recovering materials and generating renewable hydrogen from waste streams. In this context, catalytic pyrolysis and thermo-catalytic reforming emerge as promising routes to valorise FRPC waste while producing hydrogen and circular raw materials. This work presents an ongoing experimental study focused on catalyst screening and optimisation for upgrading pyrolysis volatiles derived from real plastic composite waste.

This study focuses on maximizing hydrogen production and valuable base chemicals from a recreational nautical pre-preg FRPC waste. The workflow begins with reference pyrolysis at the minimum temperature required for complete decomposition of the polymer matrix. Cracking and reforming catalysts are evaluated at a catalyst to feed ratio of 1/14. The best-performing catalysts are selected and are then subjected to stress testing under more demanding conditions (C/F = 1/40).

The comparison of C/F ratios revealed clear differences in the upgrading performance of the evaluated cracking and reforming catalysts. Increasing the C/F ratio enhanced volatile conversion and shifted product distributions toward higher hydrogen yields and lighter chemical fractions, with each catalyst family exhibiting distinct selectivity patterns. Lower C/F ratio enabled a clearer differentiation of catalytic behaviour under more demanding conditions, highlighting materials capable of maintaining activity and selectivity with reduced catalyst loading.

Environmental performance criteria confirmed the alignment between catalytic behaviour and sustainability targets, identifying the combinations of catalyst type and operating conditions that best balance hydrogen production, chemical recovery and reduced environmental impact. Together, these findings provide a robust basis for selecting optimal catalysts and operating windows and support the subsequent reactor modelling and scale-up of thermo-catalytic upgrading routes for composite waste valorisation.

Acknowledgments

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O-44

Cellulose Nanofibers as Multifunctional Nano-Carriers for Nanoparticle Dispersion and Green Porosity Generation in PLA

J. M. Luque[1], P. Ortega-Columbrans[2,3], G. Estrella[1], A. Lucena[1], B. Ferrari[2,3], A. Rodríguez[1], Z. González[1,3]

[1] BioPrEn Group (RNM-940), Chemical Engineering Department, Instituto Químico para la Energía y el Medioambiente (IQUEMA), Faculty of Science, Universidad de Córdoba, Córdoba 14014, Spain
[2] Instituto de Cerámica y Vidrio, CSIC, Campus de Cantoblanco, c/ Kelsen 5, Madrid, 28049, Spain
[3] COLFEED4Print S.L. Avenida de los Encuartes, 19, Tres Cantos, Madrid, 28760, Spain
(corresponding author: q92luloj@uco.es)

The development of sustainable polymer nanocomposites has attracted increasing attention as a strategy to combine renewable resources with advanced material functionalities. However, the incorporation of functional nanoparticles into bio-based polymer matrices remains challenging due to aggregation phenomena and poor interfacial compatibility, often resulting in limited dispersion and reduced performance[1].

Cellulose nanofibers (CNF) have emerged as promising bio-derived nanomaterials owing to their attractive properties, including their capacity to be functionalized with functional materials such as nanoparticles[2]. These features make them suitable platforms for the incorporation and dispersion of nanophases within polymer matrices.

In this work, CNF were explored as multifunctional nano-carriers for the preparation of hierarchical polylactic acid (PLA)-based nanocomposites. The CNF network enabled the homogeneous incorporation of CuO nanoparticles while simultaneously inducing porosity during melt processing through the evaporation of bound water, eliminating the need for additional porogenic agents and generating structures with increased surface area. The resulting materials were characterized by SEM-EDS, TGA-DTA, melt rheology, swelling index, water contact angle, and mechanical tests to evaluate the effects of CNF incorporation. Antibacterial activity was finally assessed to demonstrate the functional potential of the developed nanocomposites.

Acknowledgments

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O-45

Deep Investigation on Novel Dialdehyde-Based Superabsorbent for Agricultural Applications

M. Bezbiz[1,2], A. Y. Boussif[1,2], S. Errahali[1], M. Latifi[1,3], L. Belachemi[1], C. Moreau[2], H. Benyoucef[3], B. Cathala[2], **H. Kaddami**[1,4]

[1] Cadi Ayyad University, IMED-Lab, Faculty of Sciences and Techniques, Avenue Abdelkrim Elkhattabi, Marrakech, Morocco
[2] UR1268 BIA (Biopolymers Interactions Assemblies), INRAE, Rue de la Géraudière, CS 71627, F-44316 Nantes Cedex 3, France
[3] Mohammed 6 Polytechnic University, HTMR -Lab, UM6P, Lot 660, Hay Moulay Rachid Ben Guerir, 43150, Bengrir, Morocco
[4] Mohammed 6 Polytechnic University, SUSMAT – Lab, Lot 660, Hay Moulay Rachid Ben Guerir, 43150, Bengrir, Morocco
(corresponding author: h.kaddami@uca.ac.ma)

This study explores the valorization of agriculture by-products (fibers) through the extraction, chemical modification, and incorporation of cellulose into superabsorbent polymer (SAP) formulations with high water absorption capacity. The extracted cellulose was subjected to controlled oxidation using sodium periodate to produce cellulose dialdehyde (DAC) with tunable aldehyde content. DAC was further modified through chemical reactions such as, but not only, Horner-Wadsworth-Emmons (HWE) olefination with triethyl phosphonoacetate, yielding cellulose containing sodium propenoate units forming dialdehyde cellulose acrylate (DACAcr). The modified cellulose served as both a grafting agent and a crosslink-enhancing copolymer for the synthesis of hybrid BioSAPs (DACAcr-g-poly(AA-co-IA)) via radical polymerization in water using acrylic acid (AA) and itaconic acid (IA) as monomers, with N,N′-methylenebisacrylamide (MBA) as a cross-linker and potassium persulfate (KPS) as an initiator. The incorporation, after oxidation, of a double bond at the C2 and C3 positions of β-D-glucose units enhanced the copolymerization with acrylic acid and increased the number of hydrophilic carboxylate groups. Pore orientation was also performed to assess this effect on the properties of the superabsorbent properties, especially the absorption properties. This resulted in a robust, flexible polymeric network with improved swelling and water retention properties which leads to a good compromise between the formation of pores in polymer networks and the mechanical stability of the hydrogel. Comprehensive characterization of the synthesized SAPs was conducted using Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), and rheological analysis. Kinetic studies revealed that the hybrid BioSAPs exhibited exceptional water absorption capacities, with the SAP-DACAcr0.5eq composite achieving up to 1441 ± 59 $g \cdot g^{-1}$ in distilled water. The results demonstrate the potential of DACAcr and its derivatives as sustainable, high-performance materials for water retention and management applications, providing an eco-friendly alternative to conventional SAPs. These findings pave the way for the development of cost-effective and environmentally conscious solutions utilizing agricultural waste.

Abstracts of Posters

P-1

Development of Bio-Based Polyurethane Prepolymers for Sustainable Cork Composite Insoles

G. C. S. Adão[1], T. B. Schreiner[1,2], A. Zanella[1], S. Nunes[3], I. P. Lima[4], M. J. Ferreira[5], A. Santamaria-Echart[1], M. F. Barreiro[1]

[1] CIMO, LA SusTEC, Instituto Politécnico de Bragança, Bragança, Portugal
[2] GICoS, Instituto Politécnico de Bragança, Bragança, Portugal
[3] 3DCork, Paços de Brandão, Portugal
[4] CIPADE - Indústria e Investigação de Produtos Adesivos, S. João da Madeira, Portugal
[5] Centro Tecnológico do Calçado de Portugal (CTCP), S. João da Madeira, Portugal
(corresponding author: barreiro@ipb.pt)

The footwear industry increasingly demands sustainable processes, promoting the replacement of fossil-based raw materials with bio-based alternatives[1]. This work investigates the development and application of bio-based isocyanate-terminated polyurethane (PU) prepolymers as binders for cork-based composites for shoe insoles. Polyurethane prepolymers were synthesised via polycondensation using commercial polyester polyols with 75-90% bio-based content, yielding systems with 3-5% free isocyanate (NCO) content. Aliphatic isocyanates were used to replace aromatic counterparts to lower toxicity and emissions of volatile organic compounds (VOCs) while maintaining performance. The stability of free NCO groups was assessed in accordance with ASTM D2572-97 and Fourier transform infrared spectroscopy (FTIR), confirming their suitability for industrial applications. Despite their potential, the prepolymers exhibited high viscosity, limiting cork dispersion and processability in industrial tests. To address this, two independent strategies were evaluated and checked by rheological analysis. In the first, a bio-based plasticiser (castor oil) was incorporated to reduce viscosity (maintaining or increasing bio-based content). In the second, synthetic viscosity depressants were added at low concentrations to minimise their impact on the bio-based content. The performance of both approaches was tested and compared in industrial tests for viscosity, processability, and cork dispersion, including water absorption and desorption and maximum bending stress. The optimised formulations were processed with cork particles (0.2-1 mm) by compression moulding to produce insoles. Overall, the tested strategies can facilitate the consolidation of these sustainable solutions for next-generation footwear components.

Figure 1
Cork composite insoles

Acknowledgments

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P-2

Preparation and Characterization of Bio-Based Non-Isocyanate Polyurethanes (NIPUs) Using Terpenes and CO_2

L. Ahmetović, P. Cruza Rodelgo, M. J. Ramos, I. Gracia, M. T. García, J. F. Rodríguez, J. M. García Vargas

University of Castilla-La Mancha, Ciudad Real, Spain
(corresponding author: JesusManuel.Garcia@uclm.es)

Non-isocyanate polyurethanes (NIPUs) have gained considerable attention due to their sustainability advantages stemming from the elimination of toxic isocyanates used in conventional polyurethane (PU) synthesis. With alterations in their structural composition, NIPUs stand among promising alternatives to PUs, meaningfully supporting the principles of green chemistry[1,2]. Nevertheless, despite the growing interest in NIPUs, research on alternative synthesis routes and tailoring possibilities remains crucial for property-oriented green polymer design.

This work focuses on the preparation, functionalization, and characterization of terpene-derived NIPUs by using limonene diepoxide (LDO) as the key precursor. The initial stage focuses on the partial carbonation of the epoxide groups in LDO to form cyclic carbonates, assisted by a potassium iodide-impregnated heterogeneous catalyst. To optimize the conversion under 24 h, catalyst ratios of 20, 40, 50, and 60 wt % relative to LDO were tested at 120 °C and 100 bar, with 10 mL of LDO used in each experiment.

Preliminary Fourier-transform infrared spectroscopy and nuclear magnetic resonance spectroscopy analyses confirmed the successful partial conversion of epoxide groups to cyclic carbonates, with the 40 wt % catalyst-to-LDO ratio achieving the highest conversion of 57.12% in 24 h. The obtained monomer will be further investigated with the tailoring of the remaining epoxide group with different polyols, specifically polyethylene glycol, polypropylene glycol, and bio-based polyether. The final synthesis stage will address the formation of NIPUs with the polyaddition reaction in the presence of a commercial amine, Priamine, followed by analysis of their mechanical, thermal, and morphological properties.

Table 1

Conversion of epoxide groups in limonene diepoxide to cyclic carbonates at different catalyst-to-LDO ratios in 24 h at 120 °C and 100 bar

Catalyst/LDO Ratio (wt %)	Conversion (%)
20	31.20
40	57.12
50	56.45
60	53.57

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P-3

Biobased and Biodegradable Copolyesters for Packaging Applications

M. S. Alam, M. Elorza Romero, A. Sangroniz

POLYMAT and Department of Polymers and Advanced Materials: Physics, Chemistry and Technology, Faculty of Chemistry, University of the Basque Country UPV/EHU, 20018 Donostia / San Sebastian, Spain
(corresponding author: ainara.sangroniz@ehu.eus)

Plastic packaging plays an important role in protecting food and maintaining its quality and safety. However, most plastics currently used in the market are not sustainable, as they are derived from petroleum resources and are difficult to recycle or biodegrade. once disposed of, they significantly contribute to the growing problem of plastic waste. Considering this challenge, this work focuses on the synthesis of bio-based polyesters with high potential for applications in the packaging sector. In this study, copolymers based on renewable 1,5-pentanediol (1,5-PDO), succinic acid (SA), and 2,5-furandicarboxylic acid (FDCA) are synthetized. The main objective of the project is the development of a bio-based and potentially biodegradable polymer that could serve as a sustainable alternative to conventional petroleum-based packaging materials. The polymers were synthesized through polycondensation reactions, and several copolymers were prepared in order to investigate the structure-property relationship. The obtained materials were thoroughly characterized using different analytical techniques. To evaluate the suitability of these materials for packaging applications, their barrier properties were assessed by measuring oxygen permeability and water vapour permeability. In addition, enzymatic biodegradation studies were carried out to investigate the degradability of the synthesized copolyesters and to assess their potential environmental impact after disposal. These results provide valuable insights into the feasibility of using the developed bio-based copolyesters as sustainable alternatives for food packaging materials.[1,2]

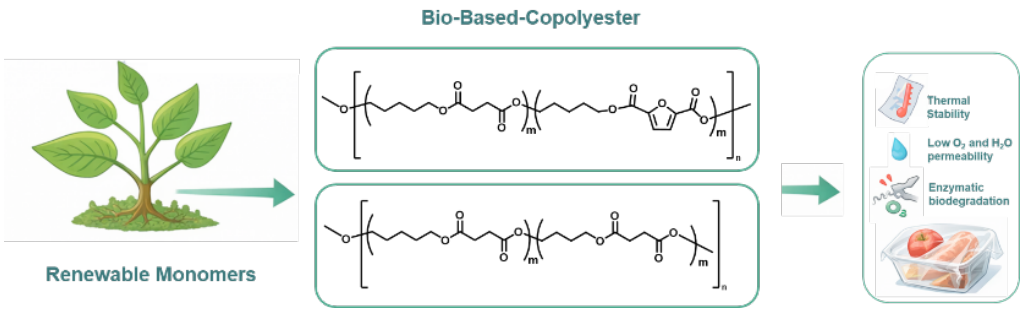

Figure 1

Scheme of the copolymers synthetized and the key properties

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P-4

Elucidating the Role of Ionic Liquids in Biodegradable Aliphatic Polyester Blends and Nanocomposites

N. Aranburu, I. Otaegi, G. Guerrica-Echevarría

POLYMAT and Department of Advanced Polymers and Materials: Physics, Chemistry, and Technology.
University of the Basque Country (UPV/EHU), Donostia, Spain
(corresponding author: nora.aramburu@ehu.eus)

The widespread use of single-use plastics is a major source of environmental pollution, motivating the development of sustainable alternatives. Aliphatic polyesters are a prominent family of biodegradable polymers, among which poly(lactic acid) (PLA) stands out due to its ease of processing, high strength and stiffness, and excellent transparency and barrier properties. However, the intrinsic brittleness of PLA limits its use in many applications.

Blending PLA with ductile biodegradable polyesters such as poly(butylene succinate-co-adipate) (PBSA) is an effective strategy to improve mechanical performance. PBSA offers excellent processability, high crystallization rate, and good barrier properties. However, as with most polymer pairs, PLA and PBSA are immiscible and incompatible, and identifying effective compatibilization techniques that do not compromise the sustainability of the blend remains challenging.

Aliphatic polyesters are also attractive matrices for functional nanocomposites. The incorporation of carbon nanotubes (CNTs) can impart electrical conductivity; however, nanotube agglomeration increases the percolation threshold and reduces ductility.

Ionic liquids (ILs), salts with melting points below 100 °C, exhibit low vapor pressure, ionic conductivity, and high thermal and chemical stability. They have been widely employed in polymer science for diverse applications, including as crosslinking agents for epoxy resins[1], dispersing agents in CNT-based nanocomposites [2], and compatibilizers for immiscible polymer blends [3].

This work investigates the role of nine ionic liquids in PLA/PBSA blends and PLA- and PBSA-based nanocomposites. The aim is to establish relationships between IL molecular structure and their effectiveness in compatibilizing PLA/PBSA blends and dispersing CNTs. Blends and nanocomposites were prepared by extrusion and injection molding, and their mechanical and electrical properties were evaluated.

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P-5

Sustainable Production of Polyhydroxyalkanoates from Local Waste and their Potential in Film Applications

I. Nafarrate, J. Berganza, M. J. Suárez, P. Valiente, L. Urbina

Gaiker Technology Centre, Basque Research and Technology Alliance (BRTA), Parque Tecnológico de Bizkaia, Edificio 202, 48170 Zamudio, Spain
(corresponding author: nafarrate@gaiker,es; urbina@gaiker.es)

Microbial plastics, known as polyhydroxyalkanoates (PHAs) are biodegradable polyesters synthesized by numerous microorganisms as intracellular carbon and energy storage compounds which can be considered as an alternative to synthetic plastics. These biopolyesters show promising perspectives in wide range of applications, specially in the development of compostable films and packaging. However, bacterium-derived polymer technology has to face some challenges to boost their commercial dissemination, such as the production of tailored copolymers, the final properties of the biopolymers and the use of suitable carbon sources as cheap substrates[1]. Hereby, the use of a cheap carbon source is crucial, and recent studies are focused on unconventional carbon sources (sugars, fatty acids) based on alternative substrates. In the present work, the effective culture method to produce PHAs using nonconventional sources was investigated i.e., by-products of the winery industry which are composed of vine shoots, steams/stalks and grape pomace. These components are considered lignocellulosic biomass because their structure is primarily made of cellulose, hemicellulose, and lignin. Different natural deep eutectic solvents (NaDES) were used (acid and basic) to "unlock" the lignocellulosic structure and remove the lignin, making the cellulose more accessible for cellulase enzymes which break the long polymer chains down into simple fermentable sugars like glucose and xylose. In addition, the inhibitory effects of different commercial sugar combinations were analyzed along with the monomeric composition and polymer production. In parallel, the application of these biopolymers in blown film extrusion was evaluated by developing improved formulations to overcome current drawbacks, such as melt strength and blocking effect.

Figure 1

Local biomass used in the present work and blown film of PHA-based material

Acknowledgments

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P-6

Sustainable Processing of Mechanically Enhanced PLGA Scaffolds Foaming via Supercritical CO_2

F. Carrascosa, I. Gracia, J. M. García-Vargas, M. J. Ramos, J. F. Rodríguez, M. T. García

Faculty of Chemical Sciences and Technologies,
University of Castilla-La Mancha, Ciudad Real, 13071, Spain
(corresponding author: Fernando.Carrascosa@uclm.es)

Bone regeneration remains a major challenge in regenerative medicine, particularly in the treatment of large defects that require substitutes capable of providing mechanical support while gradually degrading in the biological environment. Conventional solutions such as metallic implants or allografts are widely used; however, their long-term performance may be limited by complications including infection, immune reactions, and mechanical mismatch with surrounding tissue. These limitations have promoted the development of bone tissue engineering strategies based on porous scaffolds designed to mimic the structural and functional characteristics of native bone. Biodegradable polymers are attractive candidates for this purpose because their properties can be tailored through polymer composition and processing conditions[1]. Among them, poly(lactic-co-glycolic acid) (PLGA) has been extensively studied due to its biocompatibility and tunable degradation behaviour. However, achieving sufficient mechanical performance while maintaining a highly porous structure remains challenging.

In this work, reinforced porous PLGA scaffolds were fabricated using a two-step processing strategy combining melt extrusion and supercritical CO_2 foaming, this two-step process has recently been implemented by our group[2]. The aim was to obtain scaffolds with structural and mechanical properties comparable to trabecular bone. Mechanical testing showed that PLGA 85/15 exhibited the most favourable performance, while the incorporation of hydroxyapatite (HAp) and magnesium hydroxide ($Mg(OH)_2$) further enhanced compressive strength. The resulting materials were characterized in terms of morphology, porosity, and mechanical properties.

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P-7

Bio-Based Flexible Hydrophilic Foams for Ornamental Applications

C. Castaño, A. Gil Moreno, A. Candela Gil, M. V. Navarro

Technological Centre of Furniture and Wood (Yecla, Spain)
(corresponding author c.castano@cetem.es)

Flexible polyurethane foams (FPUFs) are widely used in a variety of applications. However, their conventional formulations depend heavily on petrochemical-based polyols and exhibit limited hydrophilic behaviour. The partial substitution of these components with bio-based alternatives represents a promising strategy to both reduce petrochemical dependence and tailor functional properties[1].

In this work, flexible polyurethane foams (FPUFs) were formulated by partially replacing a conventional polyol with a bio-based polyol at controlled incorporation levels of *25-50 wt.%*, and the foamed materials were obtained via a one-shot foaming process using toluene diisocyanate (TDI 80/20) as the second major component, along with the necessary additives and catalysts for the reaction. The resulting foams were chemically characterized by FTIR-ATR spectroscopy, thermally by DSC and TGA, and structurally by scanning electron and optical microscopy, while their water absorption properties were evaluated using standard test methods. This work aims to evaluate the influence of conventional polyol substitution on foam structure and particularly on its hydrophilic character and water absorption capacity. The results obtained demonstrate that the incorporation of bio-polyol allows the production of flexible foams while maintaining their structural integrity, although modifications in the cellular structure are observed. These changes are associated with variations in the polymer network, leading to an enhanced hydrophilic behaviour compared to the reference formulation. Therefore, the modified foams exhibit an increased capacity for water uptake.

This combination of reduced petrochemical content and improved water absorption properties highlights the potential of these materials as functional substrates. In particular, flexible PU foams incorporating bio-polyol show promising performance as water-retaining media for applications such as hydroponic cultivation systems and vertical gardening.

Acknowledgments

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P-8

Pilot-Scale Extraction of Tannins from *Eucalyptus Globulus* Bark: A Circular Bioeconomy Strategy for Sustainable Wood Protection

V. Ferrer[1,2], T. Oñate-Valdés[1], C. Fuentealba[1,2], V. Hernández[2,3], J. Santos[4,5], D. Escobar-Avello[1,2]

[1] Unidad de Desarrollo Tecnológico, Universidad de Concepción, Coronel, Chile
[2] Centro Nacional de Excelencia para la Industria de la Madera (CENAMAD) - ANID BASAL FB210015, Pontificia Universidad Católica de Chile, Santiago, Chile
[3] Facultad de Ciencias Forestales y Centro de Biotecnología, Universidad de Concepción, Chile
[4] Associação Rede de Competência em Polímeros (ARCP), Porto, Portugal
[5] LEPABE, Faculty of Engineering, University of Porto, Porto, Portugal
(corresponding author: d.escobar@udt.cl)

The use of tannins as an alternative to synthetic additives has increased due to the interest in sustainable materials. This study extracted tannins from *E. globulus* bark residue in Chile for sustainable wood protection. Alkaline extraction was performed using a low NaOH concentration (0.05% w/v) in a 100 L reactor to achieve a yield of 8.79%. Extracted samples were characterized using FTIR, MALDI-TOF-MS, and LC-LTQ-Orbitrap-MS, while TGA/DSC. Leaching, UV-weathering, and antifungal assays evaluated the functional performance after wood impregnation (2.5% w/v). FTIR analysis indicated the presence of condensed tannins, with characteristic bands at ~1600, 1515, and 1440 cm^{-1}. Alkaline extraction increased the intensity of aromatic bands and reduced signals relating to carbohydrate structures (~1030-1150 cm^{-1}), indicating structural changes of the tannins. MALDI-TOF–MS confirmed the presence of oligomeric proanthocyanidins, including procyanidin dimers, trimers, and tetramers, showing a wide molecular weight distribution. LC–Orbitrap analysis identified phenolic compounds and oligomeric tannins. Thermal analysis showed enhanced stability of the alkaline extract. Residual mass at 600 °C was around 50%, significantly higher than for water extraction systems. This confirms the formation of thermally more stable structures. DSC analysis revealed a Tg of 100-150 °C, consistent with modified tannin networks. Application tests showed high retention (20 kg/m^3) and reduced leachability (2.15%), showing tannin–wood interaction. UV-weathering (1000 h) showed reduced color variation. Biological assays confirmed antifungal performance: 90.9% inhibition of *D. seriata*, 100% of *T. viride*, and full protection against *P. placenta*. The results show that tannins extracted from *E. globulus* bark are promising, bio-based additives for sustainable wood protection, contributing to the circular bioeconomy in the forest sector.

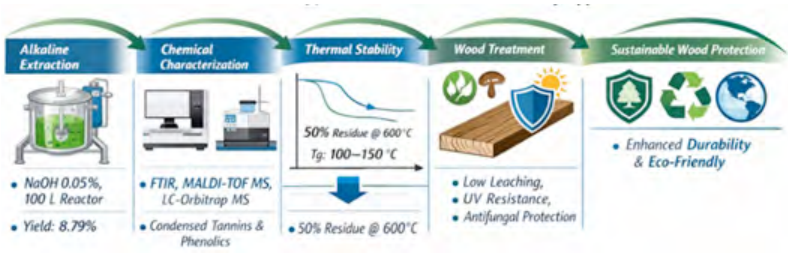

Figure 1

Graphical abstract of tannin extraction from *E. globulus* bark and its application in wood protection

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P-9

Pine Resin Terpenes as Renewable Additives for Chitosan-Based Functional Materials

X. Erdocia[1], A. Gálvez[2], A. Morales[3], J. Labidi[2], **R. Fernández-Marín**[2]

[1] Department of Applied Mathematics. University of the Basque Country UPV/EHU, Plaza Europa, 1, 20018, San Sebastian, Spain

[2] Chemical and Environmental Engineering Department, University of the Basque Country UPV/EHU, Plaza Europa 1, 20018 Donostia, Spain

[3] Chemical and Environmental Engineering Department, University of the Basque Country UPV/EHU, Nieves Cano 12, 01006 Vitoria-Gasteiz, Spain

(corresponding authors: xabier.erdocia@ehu.eus, rut.fernandez@ehu.eus)

Natural pine resins constitute a renewable and underexploited resource with significant potential for the development of high-value bio-based products. In the Basque Country, pine forests are widely distributed, offering an opportunity to valorize resin-derived compounds through their extraction and integration into advanced materials. This work focuses on the characterization and valorization of resins obtained from two relevant species in the region, *Pinus pinaster* and *Pinus radiata*, with particular attention to their terpene fraction.

Resin samples collected during the 2025 tapping campaign were obtained from different locations within the study areas, including *Pinus radiata* (R1LT, R2LT, R3LT and R4LT) and *Pinus pinaster* (P1LT, P2LT, P3LT and P4LT). The samples were initially separated into liquid and solid phases and characterized independently by GC-MS and FTIR in order to determine their chemical composition and functional groups. The results revealed a clear predominance of a-pinene as the major monoterpene in *Pinus pinaster* resins, with concentrations consistently higher than b-pinene in both fractions, confirming the characteristic terpene profile of this species.

To valorize this terpene fraction, resins were subjected to steam distillation, obtaining a turpentine distillate enriched in α- and β-pinene. The resulting turpentine was subsequently incorporated as a terpene phase into chitosan-based films prepared by solvent casting using glycerol as plasticizer and Tween 20 as surfactant.

The resulting films were characterized using FTIR spectroscopy, UV-Vis spectroscopy, opacity measurements and water contact angle analysis to evaluate their structural, optical and surface properties. This approach highlights the potential of pine resin-derived terpenes as functional additives in bio-based polymeric materials and contributes to the sustainable valorization of forest resources in the Basque Country.

P-10

Eutectic Systems Inspired Molecular Imprinted Polymers for Cancer Biomarkers Recognition

E. Gabirondo[1,2], L.C. Tomé[2]

[1] POLYMAT and Department of Polymers and Advanced Materials: Physics, Chemistry and Technology, Faculty of Chemistry, University of the Basque Country; Donostia, Spain
[2] CEMMPRE, ARISE, Department of Chemical Engineering, University of Coimbra, Coimbra, Portugal
(corresponding author: elena.gabirondo@ehu.eus)

Prostate cancer is one of the most common diagnosed malignancies in men and a leading cause of cancer-related mortality worldwide. Because the disease often progresses silently, early detection is crucial for improving clinical outcomes. Current diagnostic approaches, mainly prostate-specific antigen (PSA) blood tests, imaging, and biopsy, face limitations as low specificity and potential overdiagnosis, highlighting the need for complementary molecular detection strategies.[1]

Sarcosine is a metabolite associated with prostate cancer progression and its detection in biological fluids may enhance early diagnostic capabilities. In this work, we developed molecularly imprinted polymers (MIPs) synthesized from eutectic system–derived monomers,[2] to enable selective recognition of sarcosine.[3]

MIPs were prepared by polymerizing eutectic monomers in the presence of sarcosine as the template, generating specific binding sites through template–monomer interactions.[4] After template removal, cavity structures complementary to sarcosine remained within the polymer matrix. Non-imprinted polymers (NIPs) were also prepared under identical conditions to serve as controls.

The resulting materials were characterized by differential scanning calorimetry (DSC) and Fourier-transform infrared spectroscopy (FTIR), confirming polymer formation and functional group incorporation. Sarcosine adsorption capacity was evaluated through batch experiments monitored by UV-Vis spectroscopy. The MIPs exhibited higher sarcosine uptake compared to the corresponding NIPs, indicating successful imprinting and enhanced selectivity.

These findings indicate that eutectic–based MIPs offer a promising platform for the selective recognition of sarcosine and provide a foundation for developing simple, robust sensing strategies to support early prostate cancer diagnosis.

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P-11

Sustainable Supercritical CO_2 Route to Functionalizable Soybean Oil Monomers for Radiopaque NIPUs

F. González, J. M. García-Vargas, M. J. Ramos, J. F. Rodríguez, I. Gracia, M. T. García

University of Castilla-La Mancha, Department of Chemical Engineering,
Avda. Camilo José Cela, Ciudad Real 13071, Spain
(corresponding author: francisco.gonzalez@uclm.es)

Non-isocyanate polyurethanes (NIPUs), obtained by polyaddition between cyclic carbonates and amines, are attractive alternatives to conventional polyurethanes because they avoid isocyanates and phosgene[1]. In this context, the conversion of epoxidized vegetable oils into five-membered cyclic carbonates using CO_2 is appealing, since CO_2 can act as both reagent and medium. Supercritical CO_2 ($scCO_2$) is particularly suitable for highly viscous lipidic substrates, as it eliminates organic solvents and improves mass transfer, thus providing a greener processing route[2,3].

This work explores an $scCO_2$-based strategy to obtain partially carbonated soybean oil (CSBO) monomers with residual epoxide groups available for post-functionalization toward radiopaque NIPUs. Epoxidized soybean oil (ESBO) was carbonated for 16 h using tetrabutylammonium iodide (TBAI, 5 wt%). At 120 °C and 120 bar, a CSBO conversion of 47% was achieved, while 100 °C and 100 bar afforded 38% conversion. Formation of five-membered cyclic carbonates was confirmed by ^{1}H NMR and FTIR.

The CSBO sample with 47% conversion was further functionalized with aminobenzo-18-crown-6 (AB18C6) to introduce a chelating site for barium incorporation. Grafting conversions of 16% after 18 h and 25% after 24 h were determined by the decrease of epoxide signals in ^{1}H NMR. Current work focuses on improving AB18C6 grafting; subsequent Ba loading will be quantified by ICP, followed by polyaddition with diamines to obtain radiopaque NIPUs.

Acknowledgments

This work was supported by the Ministerio de Ciencia e Innovación Gobierno de España [PID2022-142198OB-100] and the Consejería de Educación, Cultura y Deportes de la Junta de Comunidades de Castilla-La Mancha. [SBPLY/23/180225/000130].

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P-12

Improving Bonding and Water Resistance Properties of Bio-Adhesives Derived from Grape Stalks

I. Barreto[1], R. A. Fernandes[1,2], N. Ferreira[1], M. Peixoto[3], J. M. Martins[2,4], L. H. Carvalho[2,4]

[1] ARCP – Associação Rede Competência em Polímeros, Porto, Portugal
[2] LEPABE, ALiCE – Faculty of Engineering, University of Porto, Porto, Portugal
[3] MOVECHO, S.A. Nelas, Portugal
[4] DEMad-Department of Wood Engineering, Instituto Politécnico de Viseu, Viseu, Portugal
(corresponding author: lhcarvalho@estgv.ipv.pt)

Grape stalks are a major by-product of the winery industry, representing c.a. 5-7% of the total residues generated annually.[1] Due to their high organic load and significant content of polyphenolic compounds, their disposal poses environmental challenges, requiring effective valorization strategies. In recent years, grape stalks have gained attention as a renewable source of naturally occurring polyphenols, which exhibit intrinsic reactivity and potential as adhesive for particleboard production.[2]

This work explores the development of bio-based resins derived from grape stalk polyphenolic extracts with improved performance. Several low-toxicity additives, including glyoxal, furfural, starch, citric acid, and chitosan, were investigated to promote cross-linking and enhance adhesive properties. The effect of curing temperature (120 °C and 160 °C) on network formation and water resistance was also evaluated.

FTIR analysis confirmed the occurrence of chemical interactions between the extract and additives, while HPLC enabled the identification of hydrolysable compounds. The results demonstrate that citric acid and chitosan significantly enhance cross-linking, leading to improved bonding and water resistance, highlighting the potential of grape stalks as a sustainable feedstock for natural polymer-based resins.

Acknowledgments

This work was supported by national funds through FCT/MCTES (PIDDAC): LEPABE, UIDB/00511/2020, UIDP/00511/2020 and ALiCE, LA/P/0045/2020. Additionally, it was also funded by Project EcoVinePanel (COMPETE2030-FEDER-01460800/18330) in the scope of Portugal 2030 co-funded by FEDER (Fundo Europeu de Desenvolvimento Regional) through COMPETE2030.

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P-13

Effect of Short-Fiber Fillers on Polymer Resins Synthesized via Michael 1,4-Addition

A. Ivdre[1], L. Vasilevska[1,2], D. L. Eihe[1], M. Kirpluks[1], R. Pomilovskis[1]

[1] Latvian State Institute of Wood Chemistry, Riga, Latvia
[2] Riga Technical University, Riga, Latvia
(corresponding author: aiga.ivdre@kki.lv)

The growing demand for sustainable materials has increased interest in polymers derived from renewable resources. In this study, polymer resins synthesized via Michael 1,4-addition from tall oil-derived components were reinforced with short fibers to increase the material's renewable content and evaluate their influence on the resulting composite properties.

The developed composites consisted of a polymer resin obtained via Michael 1,4-addition between a tall oil–based acetoacetate Michael donor and trimethylolpropane triacrylate as the Michael acceptor. The Michael donor was synthesized from tall oil derivatives obtained through either enzymatic epoxidation or epoxidation using an ion exchange resin. Subsequently, two types of composite matrices were used to produce a series of composites incorporating fillers of varying materials, shapes, sizes, and loadings. The thermal stability, mechanical properties, and morphology of all composites were systematically characterized.

The results indicated that the choice of tall oil epoxidation technique did not significantly affect the material properties. The incorporation of most fillers, including wood dust (WD) and sanding dust (SD), reduced tensile strength and modulus; however, nanoclay (Cl15A and Cl30B), microcellulose (MC), and carbon fibers (CF) increased the elastic modulus of the composites (Figure 1). A significant level of renewable material content was achieved, highlighting the potential of these composites as well-performing, bio-based materials, with the possibility of further increasing their renewable content.

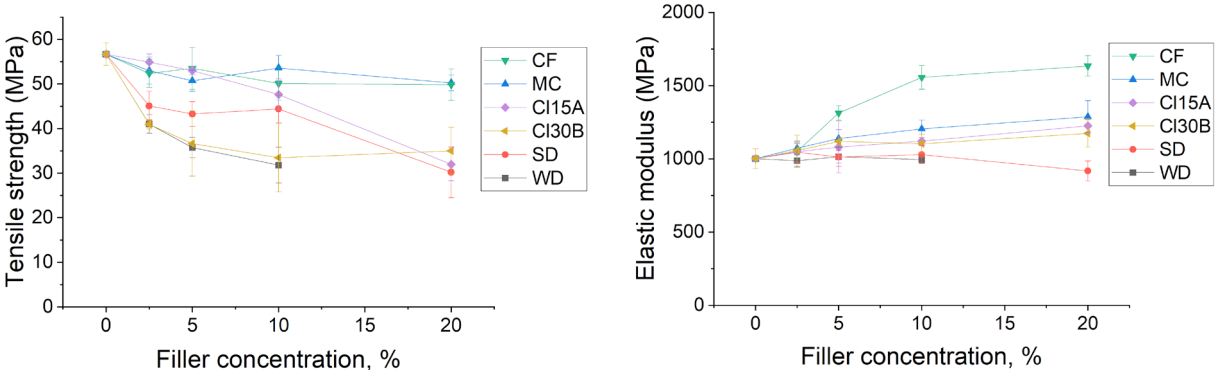

Figure 1

Tensile strength and elastic modulus of short-fiber composites

Acknowledgments

This research was funded by the project "Bio-based composite development from the fatty acid-based polymer resin reinforced with natural origin fibers (TOMPosite)", No. lzp-2024/1-0071.

P-14

Development of Sustainable Semicrystalline Polyesters

C. Jagtap, L. Sangroniz
POLYMAT and University of the Basque Country UPV/EHU, Donostia / San Sebastián Spain
(corresponding author: leire.sangroniz@ehu.eus)

Polymers are widely used in a wide range applications due to their tunable properties, easy processing, low density and inexpensive character. Among all the polymers employed in the market, the 70% are semicrystalline, with crystals providing excellent physical properties. However, most of them are obtained from oil and once that they reach their end of life they contribute to the plastic waste issue.[1] A sustainable polymer that has attracted much attention is poly(pentamethylene furanoate) (PPeF) due to its interesting properties.[2] However, due to the slow crystallization kinetic it remains usually amorphous which restricts its possible uses. In this work we add nucleating agents to promote crystallization and improve the final performance of the material. Specifically, we added talc and orotic acid, which are common nucleating agents used in the industry. We studied thermal properties, morphology and mechanical properties, analyzing the structure property relationships. The addition of nucleating agents improves the final performance of the material, widening its applications.

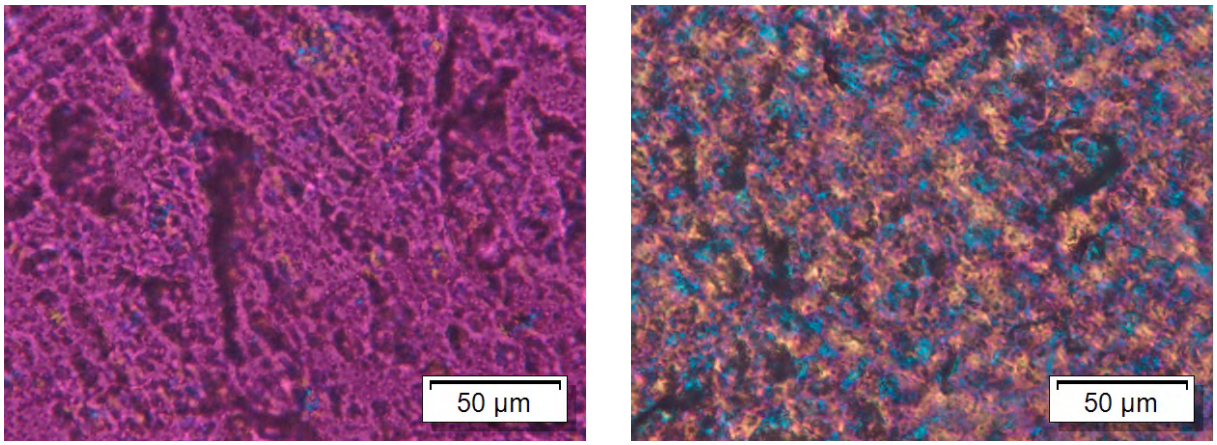

Figure 1

Polarized light optical microscope images of PPeF and PPeF/talc

Acknowledgments

Emakiker grant form POLYMAT and the fellowship from the "la Caixa" Foundation (ID 100010434) (code B006525) are acknowledged.

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P-15

Sustainable Functionalization of Chitosan via Mechanochemistry: A Comparative Study of Schiff Base Formation

L. López-Gómez[1,2], A. Pineda[1,2], A. García [1,2]

[1] FQM-383 research group, Organic Chemistry Department, University of Córdoba, Córdoba, Spain
[2] Faculty of Science, Instituto Químico Para la Energía y el Medioambiente (IQUEMA), University of Córdoba, Córdoba, Spain
(corresponding author: q92logol@uco.es; qo2ganua@uco.es)

Chitosan is a promising material for food, cosmetic, and pharmaceutical industries. However, it requires chemical modification to enhance its functionality and adapt it to specific demands. In this work, new routes of chitosan functionalization through the formation of Schiff bases with two aldehydes were designed/compared to increase hydrophobicity. We compared conventional impregnation with a more sustainable mechanochemical pathway, reducing solvent use and environment impact of the process. Functionalization conditions were optimized (Figure 1), with an evaluation of Liquid-Assisted Grinding (LAG), aging, and the impact of planetary (centrifugal) vs oscillating (vibratory) milling.

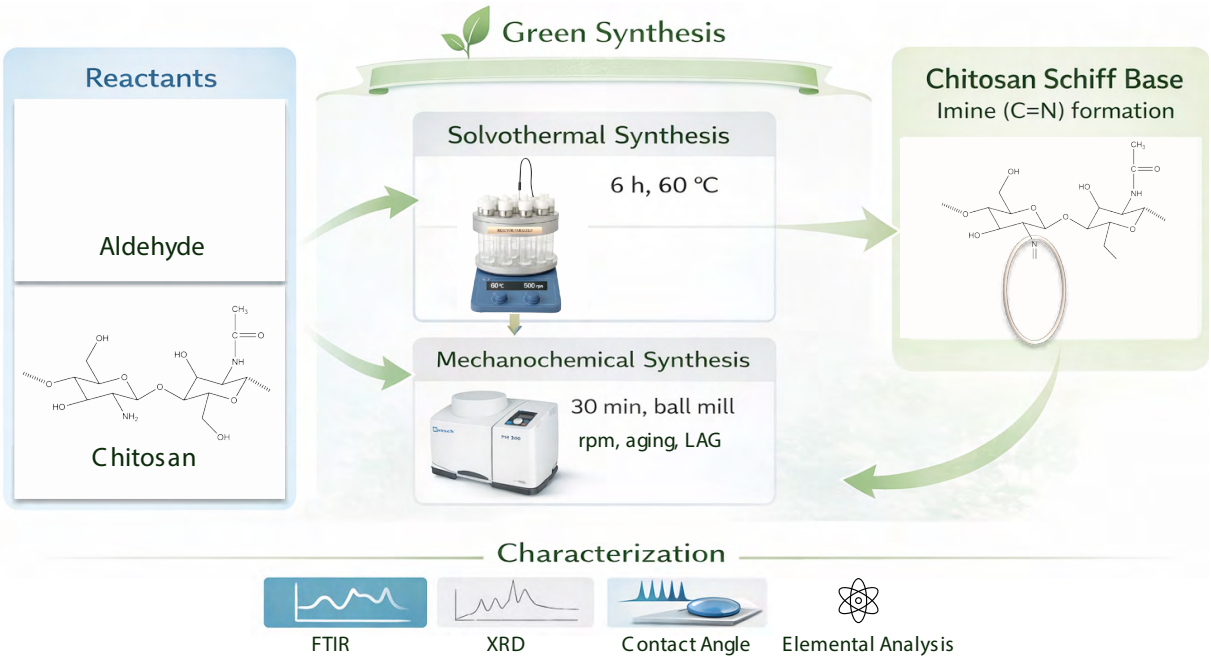

Figure 1

Graphical Abstract

FTIR confirmed Schiff base formation and purification yield; XRD monitored structural changes; contact angle assessed hydrophobicity variations and elemental calculated the degree of substitution. Results demonstrated that mechanochemistry offers a precise, greener alternative to conventional methods for tailoring biopolymer properties through specific milling parameters.

Acknowledgments

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P-16

Influence of Bio-Based Polyol and Chain Extender on the Structure and Performance of Viscoelastic Polyurethane Foams

E. Malewska[1,2], H. Benes[3], K. Polaczek[3], M. Kurańska[1,2], A. Prociak[1]

[1] Cracow University of Technology, Faculty of Chemical Engineering and Technology, Warszawska 24, 31-155 Cracow, Poland
[2] Cracow University of Technology, Interdisciplinary Center for Circular Economy, Warszawska 24, 31-155, Cracow, Poland
[3] Czech Academy of Sciences, Institute of Macromolecular Chemistry, Heyrovskeho nam. 2, Praha 6, 162 00, Czech Republic
(corresponding author: elabieta.malewska@pk.edu.pl)

Polyurethane foams are widely used in comfort applications due to their viscoelastic properties, governed by the balance between soft and hard segments and crosslink density. The incorporation of bio-based polyols increases process complexity because of their heterogeneous structures and varying functionalities, affecting network formation. Moreover, low-molecular-weight chain extenders, commonly used to modify hard segment content, may alter not only phase separation but also the overall architecture of the polymer network.

In this study, viscoelastic polyurethane foams were synthesized using a partially bio-based formulation, replacing petrochemical polyols with a transesterification-derived biopolyol. The effects of different chain extenders like ethylene glycol (EDO), 1,4-butanediol (BDO), and 1,6-hexanediol (HDO) were also examined. The introduction of biopolyol and diols increased apparent density while reducing hardness, especially in EDO-modified systems. Swelling and gel content analyses indicated a lower crosslink density, consistent with higher swelling and reduced insoluble fraction. Gel permeation chromatography confirmed the presence of linear oligomers and unreacted components, suggesting a more heterogeneous and less crosslinked network.

The biopolyol's complex composition further influenced the system, contributing to chain extension, termination, and limited crosslinking. Overall, combining biopolyol with difunctional chain extenders promotes a more linear, less crosslinked structure, resulting in softer foams despite higher apparent density. These findings support the design of sustainable polyurethane materials with tailored viscoelastic properties and will serve as a foundation for future studies on the incorporation of chain extenders containing dynamic covalent bonds.

Acknowledgments

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P-17

Collagen-Based Bio-Resins from Rabbit Skin Vermicelle for the Wood Industry

R. A. Fernandes[1,2], A. Sousa[3], **J. M. Martins**[2,4], L. H. Carvalho[2,4]

[1] ARCP – Associação Rede Competência em Polímeros, Porto, Portugal
[2] LEPABE, ALiCE – Faculty of Engineering, University of Porto, Porto, Portugal
[3] Cortadoria Nacional de Pêlo, S.A, S. João da Madeira, Portugal
[4] DEMad-Department of Wood Engineering, Instituto Politécnico de Viseu, Viseu, Portugal
(corresponding author: jmmartins@estgv.ipv.pt)

In Portugal, Cortadoria Nacional do Pêlo faces a significant challenge managing *vermicelle*, a collagen-rich rabbit skin by-product generated in large volumes during fur processing. As landfill disposal is not permitted, current management relies on some strategies as its conversion into low molecular proteins and/or amino acids for fertilizers, pet food and food industry. However, the high content of collagen turns it into a valuable raw material for the production of bio-based adhesives. These collagen-derived adhesives show strong potential for application in the wood industry, including plywood and particleboard production, offering a renewable alternative to synthetic resins and supporting circular economy strategies.[1,2]

The present work explores the extraction of collagen from *vermicelle*, to obtain a bio-adhesive with interesting characteristics for wood industry. A multi-stage extraction procedure was adopted, with degreasing step, followed by enzymatic and acid hydrolysis at optimized conditions. The kinetic of collagen extraction during both hydrolyses was evaluated in terms of solids and protein contents, adhesive capacity and molecular weight.

The results indicate a direct impact of hydrolysis degree, by affecting the molecular weight of protein fragments, on the bonding properties of collagen extract. Additionally, by tuning the conditions of hydrolysis it was possible to obtain a high performance collagen glue.

Acknowledgments

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P-18

A Novel Approach for Lignin Depolymerization via Iridium-Catalysis

N. Mel[1], I. Dávila[2], X. Erdocia[3], J. Labidi[1]

[1] Chemical and Environmental Engineering Department, University of the Basque Country UPV/EHU, Plaza Europa 1, 20018, San Sebastian, Spain
[2] Chemical and Environmental Engineering Department, University of the Basque Country UPV/EHU, Plaza Rafael Moreno "Pitxitxi" 2, 48013, Bilbao, Spain
[3] Department of Applied Mathematics, University of the Basque Country UPV/EHU, Plaza Europa 1, 20018, San Sebastian, Spain
(corresponding author: jalel.labidi@ehu.eus)

Unlike traditional methods that require higher conditions for lignin depolymerization and leads to undesired reactions[1]. Photocatalysis offers new technology for lignin valorization into low aromatic compounds. In this context. A novel approach for the depolymerization of native lignin utilizing an iridium-based catalytic system has been developed. This strategy achieves direct cleavage of the lignin through a Single Electron Transfer (SET) mechanism. Mechanistic investigations indicate that this reductive pathway facilitates the breaking of robust ether linkages, yielding value phenolic monomers such as vanillin, acetovanillone, guaiacylacetone, from pine organosolv with concentration around 6.07 mg/g. This method offers a streamlined, one-pot alternative for lignin valorization that preserves the structural integrity of the resulting phenolic products while bypassing the complexities of oxidative pretreatment.

To achieve this, pine-derived lignin was isolated via the organosolv process. A reaction mixture containing the lignin solution, an iridium catalyst was subjected to photocatalysis for 8 hours at 25 °C under constant stirring. The depolymerization progress was monitored using UV-vis spectroscopy, which identified 4 hours of light exposure as the optimal reaction time. The resulting products were characterized using FTIR, GPC, and GC-MS.

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P-19

From Marine Waste to Medicine: Extraction, Characterization, and Use of Alginate from the Basque Coast in Dermatological Therapies via 3D Printing

J. Mendizabal[1], K. Gonzalez[1,2], L. Ugarte[1,3], A. Eceiza[1], R. Fernandez[1]

[1] 'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering Gipuzkoa, University of the Basque Country (UPV/EHU), Plaza Europa 1, 20018 Donostia / San Sebastián, Spain
[2] Department of Graphic Design and Engineering Projects, Faculty of Engineering of Gipuzkoa, University of Basque Country (UPV/EHU), Plaza Europa 1, 20018 San Sebastian, Spain
[3] Department of Graphic Design and Engineering Projects, Faculty of Engineering of Gipuzkoa, Eibar section, University of Basque Country (UPV/EHU), Av. Otaola 29, 20600 Eibar, Spain
(corresponding author: jabier.mendizabal@ehu.eus)

The present work evaluates the valorization of sodium alginate extracted from algal waste collected along the Basque coast and its application in the development of 3D-printed therapeutic systems for the treatment of dermatitis. First, the physicochemical properties of the extracted polymer were thoroughly characterized using thermogravimetric analysis, Fourier-transform infrared spectroscopy, nuclear magnetic resonance, and capillary viscometry to assess its thermal stability, chemical structure, molecular weight and purity. Subsequently, 3D printing inks were prepared using the extracted biopolymer loaded with a combination of an anti-inflammatory agent (hydrocortisone) and an antibiotic (chloramphenicol). Their performance was directly compared with that of commercially available alginates. In this comparison, rheological tests were essential to evaluate the viscoelastic properties of the inks: all formulations exhibited shear-thinning behavior, facilitating material processing; they showed pronounced gel-like behavior; and they demonstrated adequate recovery capacity. Finally, UV-Vis spectroscopy was used to analize drug release profiles through *in vitro* assays, resulting in sustained release of the active compounds. Thus, a continuous and controlled release profile was achieved for the local treatment of dermatitis, thereby providing a bioengineering solution based on circular economy principles.

Acknowledgments

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P-20

UV-Curable Waterborne Polyurethane Acrylate Coatings with Reactive Diluents for Wood

M. G. Rodríguez, I. Olazabal, O. Gordobil, R. Herrera, A. Saralegi, A. Eceiza

'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering Gipuzkoa, University of the Basque Country (UPV/EHU), Plaza Europa 1, 20018 Donostia / San Sebastián, Spain
(corresponding author: mariagabriela.rodriguez@ehu.eus)

Wooden materials are often damaged due to exposure to environmental factors, such as changes in humidity, temperature fluctuations and ultraviolet radiation. This can result in surface ageing, deformation, and cracking[1,2]. In this context, the development of durable and sustainable protective coatings is essential. In this work, a UV-curable waterborne polyurethane acrylate (WBPUA) was synthesized and formulated with two reactive diluents: a commercial acrylic monomer and an acrylic modified lignin**.** The effect of the diluent nature on curing kinetics, network formation, and thermo-mechanical performance was evaluated. The photopolymerization process was monitored by in situ Fourier transform infrared spectroscopy (FTIR), while photorheology provided real-time insight into gelation and network development. The resulting crosslink density was analyzed by dynamic mechanical analysis (DMA), complemented by differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), and tensile testing. In addition, WBPUA coatings were applied onto wood substrates, to evaluate their resistance to UV-induced ageing. Results demonstrate that both reactive diluents enhance the mechanical strength and thermal stability of the coatings. Notably, the lignin-based diluent contributes to improved performance while increasing the bio-based content of the system. The coatings exhibit effective UV-protection on wood, confirming their potential as sustainable, high-performance materials for wood preservation applications.

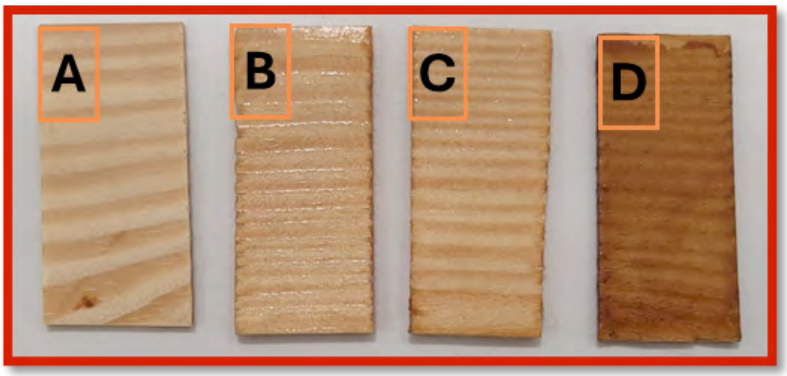

Figure 1

Wood surfaces with different reactive diluent coatings:
A) untreated wood, B) WBPUA coating, C) WBPUA with commercial reactive diluent, and D) WBPUA with modified lignin as reactive diluent

Acknowledgments

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P-21

Biodegradable TPS/PBAT-Based Systems Incorporating Collagen Waste for Controlled Nitrogen Release

I. A. dos S. Matusinho, P. P. Souza, **P. S. de O. Patricio**

Centro Federal de Educação Tecnológica de Minas Gerais (CEFET-MG), Belo Horizonte, Brazil
(corresponding author: patricia@cefetmg.br)

The increasing demand for sustainable and efficient agricultural practices has driven the development of fertilizers capable of optimizing nutrient uptake while minimizing environmental impacts, economic losses, and health risks associated with the excessive use of conventional fertilizers. In this context, biodegradable polymers such as starch have emerged as promising matrices for slow-release fertilizers (SRFs), acting as physical barriers and diffusion-controlling media in soil environments. This study proposes the development of fully biodegradable SRFs using treated leather industry waste, predominantly composed of Type I collagen, as an alternative nitrogen source. Polymeric systems based on thermoplastic starch (TPS) and TPS/Poly(butylene adipate-co-terephthalate) (PBAT) blends were produced by extrusion, incorporating nitrogen sources in different proportions, including collagen-based waste and granular urea, either individually or in combination. The materials were characterized by Fourier Transform Infrared Spectroscopy (FTIR), X-ray diffraction (XRD), wettability, and swelling analyses. Biodegradation under soil composting conditions was also evaluated to investigate nitrogen release kinetics. The results indicate that nutrient incorporation occurs mainly through physicochemical interactions, including hydrogen bonding with the starch matrix and physical encapsulation within the polymeric network, leading to changes in crystallinity, hydrophobicity, and swelling behavior. The biodegradation study demonstrated a direct correlation between

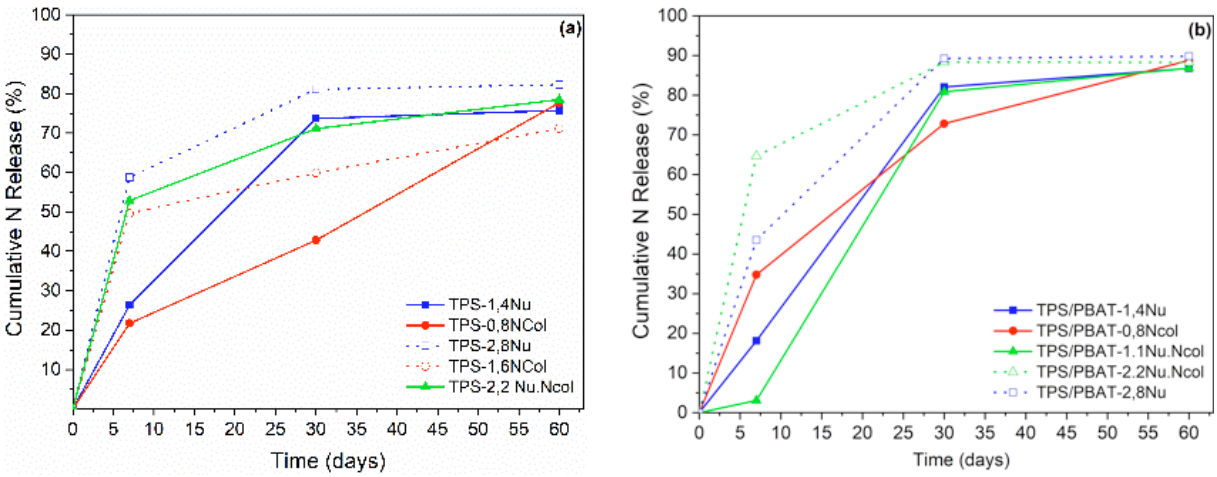

Figure 1

Cumulative nitrogen release (%) as a function of composting time
for (a) TPS and (b) TPS/PBAT systems with different nitrogen sources

matrix degradation and nitrogen release, suggesting a mechanism governed by initial diffusion followed by matrix erosion. TPS-based systems exhibited faster nutrient release due to their higher hydrophilicity and rapid degradation, particularly within the first 7 days (21-58%). In contrast, TPS/PBAT blends promoted a more controlled release profile, with gradual nutrient availability up to 30 days and residual nitrogen content of approximately 10% after 60 days. These results indicate that both systems of TPS and PBAT enable modulation of nutrient release kinetics, while the use of collagen waste contributes to sustainable nutrient sourcing.

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P-22

Development of 3D-Printable Mycelium-Based Biocomposites for Sustainable Material Applications

L. Ugarte[1,2], U. Ortega[1,3], N. Zaldua[4], K. González[1,3]

[1] 'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering Gipuzkoa, University of the Basque Country (UPV/EHU), Plaza Europa 1, 20018 Donostia / San Sebastián, Spain

[2] Dept. of Graphic Design and Engineering Projects, Faculty of Engineering of Gipuzkoa, Eibar section, University of Basque Country (UPV/EHU), Av. Otaola 29, 20600 Eibar, Spain

[3] Dept. of Graphic Design and Engineering Projects, Faculty of Engineering of Gipuzkoa, University of Basque Country (UPV/EHU), Plaza Europa 1, 20018 Donostia, Spain

[4] Dept. of Chemical and Environmental Engineering, Faculty of Engineering of Gipuzkoa, University of Basque Country (UPV/EHU), Plaza Europa 1, 20018 Donostia, Spain

(corresponding author: lorena.ugarte@ehu.eus)

The development of sustainable and bio-based materials is a key challenge in the transition toward more environmentally responsible production systems. In this context, mycelium-based biocomposites have gained increasing attention as renewable, biodegradable alternatives to conventional polymeric materials. Their ability to act as natural binders, combined with the use of low-value organic substrates, makes them particularly attractive within the framework of circular economy strategies.

This work focuses on the development of 3D-printable mycelium-based inks through direct ink writing (DIW), addressing both formulation and processability aspects. Two bio-based formulations were developed using coffee grounds, flour, water, agar-agar as a natural structuring agent, and grain-based mycelium. In addition, jute fibers were added in one of the formulations to enhance internal reinforcement and structural integrity.

The printability of the developed inks was evaluated using syringe-based extrusion systems with nozzle diameters of 4 mm and 7 mm. Both formulations exhibited suitable extrusion behavior, enabling continuous deposition and adequate shape fidelity. Following printing, the samples were incubated to promote mycelial growth, allowing the biological phase to consolidate the material. The results indicate that both formulation and processing parameters influence the development of the mycelial network. In particular, the presence of jute fibers contributes to improved cohesion and provides a reinforcing framework that supports mycelium colonization. Additionally, processing parameters such as nozzle diameter and infill percentage affect the growth conditions.

The developed materials show strong potential as alternatives to conventional polymeric foams or lightweight cores, particularly in applications requiring low density and biodegradability. This work demonstrates the feasibility of producing sustainable, 3D-printable polymer-like materials derived from natural resources.

Acknowledgments

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P-23

Bioactive Films Based on Collagen Derivatives

I. Degutytė, **V. Valeika**
Kaunas University of Technology, Lithuania
(corresponding author: virgilijus.valeika@ktu.lt)

Collagen and its derivatives are compatible with human skin, which is why they are often used in the medical industry. The research has been carried out to explore an application of collagen hydrolysate and gelatine in compositions with bioactive herbal extracts. The films were obtained using collagen derivatives and plasticizers such as polyethylene glycol (PEG) characterised by various molecular weight or glycerol. The organoleptic, mechanical and physical properties of films were evaluated.

It has been established that the most suitable composition of collagen derivatives in protein films is: collagen hydrolysate and gelatine in a 1:1 ratio, while the most suitable composition for plasticized films is a 2:3 ratio of protein to plasticizer, if the plasticizer added is polyethylene glycol (molecular weight 20,000 g/mol). This composition was employed to investigate the incorporation of bioactive materials into the films. Synthetic and natural biologically active substances were incorporated: the preservative Euxyl® 9010 PE, an extract obtained from fireweed (lot. *Chamaenerion angustifolium L.*) and extract obtained from St. John's wort (lot. *Hypericum perforatum L.*).

Mechanical, physical, and microbiological tests were performed on these films to compare how different biologically active substances change the properties of the film. The thermal stability and chemical composition of all films were also evaluated and compared: the addition of bioactive substances to the film resulted in greater changes in mass in the temperature range of 40-400 °C. Bioactive substances (preservative Euxyl® 9010 PE, fireweed extract and St. John's wort extract) had positive effect on the antibacterial properties of films (Figure 1).

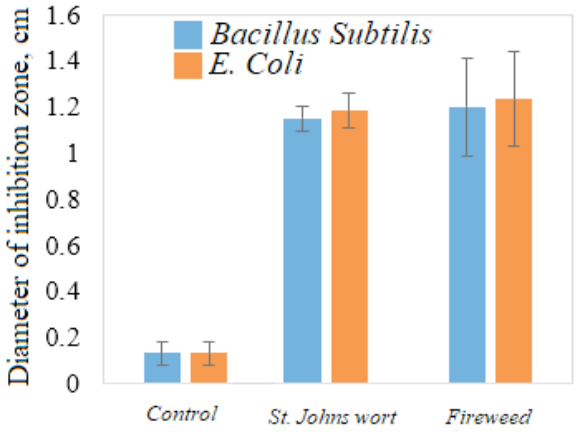

Figure 1

Evaluation of antibacterial properties of plasticized collagen derivatives' films with incorporated herbal extracts

P-24

Design of Innovative Polymer Materials from Eutectic Monomers

R. F. Cardoso[1], C.T. Paula[1,2], E. Gabirondo[3], L. C. Tomé[1]

[1] CEMMPRE, ARISE, Department of Chemical Engineering, University of Coimbra, Coimbra, Portugal
[2] Instituto Pedro Nunes (IPN), Coimbra, Portugal
[3] POLYMAT, University of the Basque Country, Donostia / San Sebastian, Spain
(corresponding author: liliana@eq.uc.pt)

The development of sustainable polymeric materials combining environmental compatibility with high performance remains a central challenge in materials science.[1] Eutectic solvents (ES) have attracted significant attention due to their simpler preparation, relatively low cost and potential biodegradability.[1] Beyond their use as liquid media, ESs can be converted into functional materials including eutectogels and poly(eutectic solvents) (PES).[2,3] Despite the recent advances in this field, epoxy-functionalities remain unexplored, although epoxy networks are widely recognized for their robustness and versatility.

In this communication, we will report the design of epoxy-based eutectic monomers and their conversion into crosslinked PES materials. Stable eutectic monomers were obtained by combining epoxide-containing hydrogen bond donors (HBDs) with different hydrogen bond acceptors (HBAs). Subsequently, polymerization was carried out via a dual UV-thermal curing strategy using a multifunctional epoxy crosslinker to produce transparent membranes. The efficiency of the crosslinking process and the resulting polymer network formation were monitored by FTIR. Rheological and thermal analyses were performed to assess the mechanical integrity and stability of the prepared crosslinked PES materials. Finally, their adhesive properties were tested using various substrates, including commodity polymers, aluminum, and wood.

In sum, this work shows that epoxy-based eutectic monomers are a versatile platform for the development of sustainable materials with tunable physicochemical properties.

Acknowledgments

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P-25

Polymer Networks Based on Renewable Vanillin

P. de Souza Lima[1], A. Hašpl[1], K. Polaczek[1], O. Kopilec[2], O. Sedláček[2], H. Beneš[1]

[1] Institute of Macromolecular Chemistry, Czech Academy of Sciences, Heyrovského nám. 2, Prague 6, 162 00, Czech Republic
[2] Department of Physical and Macromolecular Chemistry, Faculty of Science, Charles University, 128 40, Prague 2, Czech Republic
(corresponding author: desouza@imc.cas.cz)

Thermosetting polymers play an indispensable role in numerous engineering applications. However, increasing attention is being directed toward improving their sustainability, particularly by enhancing recyclability and incorporating renewable feedstocks. This work focuses on the synthesis of polymer networks derived from bio-based monomers. First, diglycidyl ether of divanillyl alcohol (GEDVA) was synthesized as a renewable precursor serving as an alternative to conventional fossil-based epoxy resins, notably diglycidyl ether of bisphenol A (DGEBA). GEDVA is obtained through the dimerization of vanillin followed by epoxidation, yielding a structure analogous to conventional epoxy monomers. As a curing agent, the bio-based diamine propane-2,2-diyldi(furan-5,2-diyl) dimethanamine (PDFA) was synthesized via an optimized procedure designed to facilitate scalable production. Then, both bio-based precursors, GEDVA and PDFA, were used for preparation of renewable epoxy networks. The incorporation of GEDVA into epoxy formulations led to improved thermomechanical properties due to higher network density and high content of aromatic structures, resulting in fabrication of rigid glassy networks with high tensile modulus and high tensile strength. Consequently, rigid glassy thermosets exhibiting high tensile modulus and tensile strength were obtained. Finally, cyclic carbonate derivatives of GEDVA were prepared via microwave-assisted cycloaddition with carbon dioxide and subsequently reacted with PDFA to produce non-isocyanate polyurethane (NIPU) networks. Stress-relaxation experiments revealed dynamic behavior within these materials, associated with transcarbamoylation exchange reactions activated at elevated temperatures. Overall, the results demonstrate that vanillin-derived monomers represent promising building blocks for the development of renewable thermosetting polymers with favorable mechanical properties and dynamic network behavior.

Acknowledgments

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P-26

Natural Soft Solid Materials Based on Pickering Emulsion-Filled Gels

A. C. Lima[1,2], T. Calvo-Correas[3,4], A. Eceiza[3], M. M. Dias[2], A. Santamaria-Echart[1], M. F. Barreiro[1]

[1] CIMO, LA SusTEC, Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
[2] LSRE-LCM, AliCE, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal
[3] 'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering Gipuzkoa, University of the Basque Country (UPV/EHU), Plaza Europa 1, 20018 Donostia / San Sebastián, Spain
[4] Department of Chemical and Environmental Engineering, Faculty of Engineering – Vitoria-Gasteiz, University of the Basque Country (UPV/EHU), Nieves Cano, 12, Vitoria-Gasteiz 01006, Araba, Spain
(corresponding author: asantamaria@ipb.pt; barreiro@ipb.pt)

Emulsion-filled gels (EFGs) are soft solid materials in which emulsion droplets act as dispersed fillers within a gel matrix, forming structured systems and tunable properties with potential applications in food and pharmaceutical fields[1]. In this work, EFGs were produced by incorporating high-internal phase Pickering emulsions (HIPPEs), stabilized by bio-based β-cyclodextrin/chitosan particles, into transglutaminase-enzymatically crosslinked gelatin/alginate matrices. The effect of emulsion content incorporation (5-50 wt%) on the rheological behavior and 3D printability after 24h of cold-set gelation was investigated. Increasing HIPPE content progressively enhanced the viscoelastic properties of the soft solid network, as evidenced by higher viscosity, elastic modulus, and yield stress, as well as improved structural recovery. These results indicate that emulsion droplets act as active fillers, restricting polymer chains mobility and promoting a more interconnected structure. Formulations with 35 and 50 wt% of emulsion exhibited enhanced shape fidelity and self-supporting capacity, associated with a more compact and reinforced polymeric network. The produced EFGs constitute a surfactant-free polymeric platform with tunable rheological and structural properties, relevant for functional food design and lipophilic bioactives' encapsulation.

Acknowledgments

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P-27

Versatility of Triphenylacetic Glyceroate as a Bio-Based Plasticizer for Bio- and Fossil-Based Polymers

L. Martellosio[1,2], M. Ferri[1,2], L. Lenzi[1,2], A.Tauro[2,3], A. Dorigato[2,3], M. Degli Esposti[1,2], D. Morselli[1,2] P. Fabbri[1,2]

[1] Department of Civil, Chemical, Environmental and Materials Engineering, Alma Mater Studiorum – Università di Bologna, Via Terracini 28, 40131 Bologna, Italy
[2] National Interuniversity Consortium of Materials Science and Technology (INSTM), Via Giusti 9, 50121 Firenze, Italy
[3] Department of Industrial Engineering, Università di Trento, Via Sommarive 9, 38123 Povo, Italy
(corresponding author: laura.martellosio2@unibo.it)

To support the transition from fossil-derived plastics to biopolymers, the development of efficient and versatile bio-based plasticizers is essential to enhance material performance while preserving biodegradability and safety.[1] In this context, the present work explores the versatility of the emerging triphenylacetic glyceroate (TPAG) bio-plasticizer[2], by incorporating it into a range of bio-based and conventional polymers. TPAG has been compounded at increasing concentrations, ranging from 5 to 20 parts per hundred of resin (phr), to polyhydroxybutyrate (PHB), polyhydroxybutyrate-*co*-valerate (PHBV), polyvinyl chloride (PVC) and polybutylene succinate (PBS), which are known for their difficult processability and/or limited mechanical properties as bare polymers. Differential scanning calorimetry reveals a clear reduction in glass-transition temperatures (T_g) for PHB, PHBV, and PVC, with the largest decrease observed for PVC (ΔT_g = −25 °C at 20 phr TPAG), confirming the plasticizing efficiency. Reduction in melting temperature is also observed for PHB and PBS, with PHB exhibiting β-crystalline phase formation at higher TPAG contents, likely promoted by increased chain mobility. Mechanical tests demonstrate that 10 phr TPAG effectively lowers Young's modulus in all tested polymers, substantially improving their flexibility. Furthermore, 20 phr of TPAG enhances the elongation at break of PVC and PHBV up to 349% and 22%, respectively. Volatility and migration studies confirm minimal plasticizer loss, with values well below safety thresholds. Moreover, TPAG addition also tailors both water contact angle and UV-blocking activity of the tested polymers, demonstrating its versatility and potential as a multifunctional additive for consumer-facing applications.

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P-28

Obtaining High-Value Bioactive Compounds from Agroindustrial Waste Using Green Technology

S. Alfaro Araya, M. Jarpa-Parra, Y. Rivas Tiznao, E. Castro Inostroza

Adventist University of Chile, Camino Las Mariposas 11771, Chillán, Ñuble
(corresponding author: susanaalfaro@unach.cl)

This study evaluated the extraction of total polyphenols (TP) and antioxidant activity (DPPH and ABTS) from maqui leaf extracts obtained from pruning using green solvents (NADES) and conventional solvents. Samples were collected at the Biociclo Orchard and processed at the Protein and Natural Resources Laboratory of the Universidad Adventista de Chile. The results demonstrated that NADES solvents with 20-30% water optimize the recovery of antioxidant compounds. Specifically, 20% lyophilized NADES (1664.08 ± 61.6), 30% lyophilized NADES (1540.38 ± 33.3), and 70% lyophilized ethanol (1760.69 ± 83.0) showed high and comparable values. HPLC-UV analysis confirmed greater compound complexity in NADES extracts from freeze-dried leaves, identifying phenolic acids (gallic, caffeic), flavonoids (rutin, myricetin), and possible quercetin derivatives with retention times between 12 and 15 min.

Conclusions: Statistical analysis showed significant differences ($p < 0.0001$) between treatments. An efficiency gradient was established: Met/Et < NADES 15-20 < NADES 30. The treatments with NADES 30% (dry and freeze-dried) showed the highest antioxidant activity, confirming its potential as a sustainable and high-performance alternative for the valorization of agroindustrial waste.

Acknowledgments

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P-29

Analysis of Microparticles Arising from Degradation of Nanofibrous Materials

K. Strnadová[1], J. Mikule[1], Š. Hauzerová[1], E. Chudobová[1], D. Chvátil[2], D. Lukáš[1]

[1] Technical University of Liberec, Liberec, Czech Republic
[2] Nuclear Physics Institute Czech Academy of Sciences, Prague, Czech Republic
(corresponding author: katerina.strnadova@tul.cz)

Concerns about the environmental and health impacts of polymeric microplastics, especially those derived from nanofibrous materials, are growing with the growing nanofiber industry. Although research is extensively investigating microplastic pollution[1,2], significant gaps remain in understanding the degradation mechanisms of nanofibers, the resulting particle properties, and their cytotoxicity and ecotoxicity. Microplastics have been found in human tissues[3], but the potential risks of degraded nanofibrous materials to human health and aquatic ecosystems remain largely unexplored. The aim of this research is to develop a new methodology for the production of defined nano- and microparticles through accelerated degradation using β-irradiation. In this work, we investigate the degradation processes of different types of nanofibrous materials and evaluate their properties and toxicity. The aim of this work is also to standardize testing protocols for these materials and provide insight into the degradation processes, environmental impacts, and health risks associated with polymeric nanofibers.

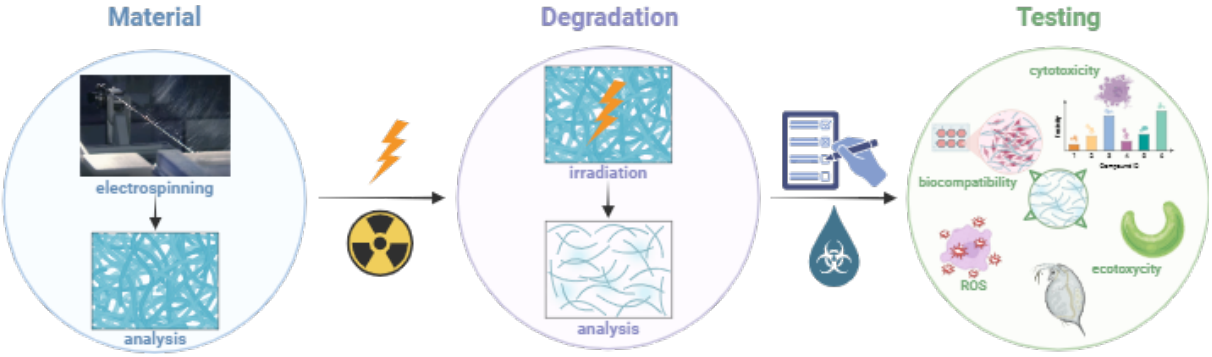

Figure 1

Scheme of the degradation experiments. Created in https://BioRender.com

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P-30

Coaxial and Multilayer Electrospun Systems for Encapsulating Waste Derived Bio-PCMs

T. Calvo-Correas[1,2], A. Barbosa[1], L. Vignau[1], I. Zalakain[3], M. Pinto[4], A. Eceiza[1]

[1] 'Material + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering of Gipuzkoa, UPV/EHU, Plaza Europa 1, 20018 San Sebastian, Spain
[2] Department of Chemical and Environmental Engineering, Faculty of Engineering of Vitoria-Gasteiz, UPV/EHU, Nieves Cano 12, 01006 Vitoria-Gasteiz, Spain
[3] Institute for Advanced Materials and Mathematics (INAMAT2) Arrosadia Campus, Avenida Cataluña s/n, 31006 Pamplona, Navarre, Spain
[4] Tecnalia Basque Institute for Agricultural Research and Development (NEIKER), Gasteiz-Vitoria, Spain
(corresponding author: tamara.calvo@ehu.eus)

In this work, coaxially electrospun nanofibrous membranes were developed for the encapsulation of phase-change materials derived from biomass residues (bio-PCMs). The resulting fibers consisted of a TPU shell obtained from discarded bovine ear tags and a core composed of bovine fat recovered from livestock waste and spent coffee grounds (SCG). SCG were incorporated as a shape stabilizer to prevent bio-PCM migration during the melting–solidification cycles involved in the thermal energy-storage process. For this purpose, formulations containing different amounts of SCG in the bio-PCM were prepared. The resulting membranes were subjected to thermal, mechanical, and morphological characterization, and bio-PCM migration from the nanofibers was evaluated during the energy-storage process. Furthermore, reference electrospun membranes containing a commercial bovine fat were prepared and characterized, and it was observed that the membranes produced with waste-derived fat were comparable to the commercial ones.

Additionally, an alternative strategy was developed to enhance bio-PCM retention: a multilayer sandwich-like configuration. This system consisted of a central coaxial layer containing the bio-PCM and SCG, confined between two conventional electrospun external layers of TPU waste. This configuration significantly improved structural integrity and reduced bio-PCM migration.

Overall, the results demonstrate that coaxial and multilayer electrospinning offer strong potential for the valorization of polymeric and biomass residues, enabling the fabrication of stable encapsulation systems for waste-derived bio-PCMs suitable for thermal energy-storage applications.

Acknowledgments

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P-31

Glycolysis of Riverine PET Waste via Magnetic Catalysts

P. Jutrzenka Trzebiatowska, O. Cavdar
University of Gdańsk, Faculty of Chemistry, Department of Environmental Technology
Wita Stwosza 63, 80-308 Gdańsk, Poland
(corresponding author: patrycja.jutrzenka-trzebiatowska@ug.edu.pl)

Poly(ethylene terephthalate) (PET) bottles recovered from aquatic environments represent a growing environmental concern due to their persistence and continuous accumulation in rivers and marine ecosystems. Mechanical recycling is limited due to partial degradation of material. As an alternative, chemical recycling offers an attractive route for valorizing such waste streams by recovering valuable monomers. One representative approach is the glycolysis of PET, a transesterification reaction between PET ester groups and a diol (e.g., ethylene glycol, EG) that produces bis(hydroxyethyl) terephthalate (BHET)[1]. This reaction typically requires catalysis, as transesterification with alcohol groups proceeds very slowly under mild conditions without catalysts. For PET recycling, both homogeneous (metal acetates, chlorides, carbonates) and heterogeneous catalysts (metal oxides, nanoparticles) have been widely investigated[2].

In this work, the glycolysis of PET bottles, collected from Motława river during EcoKayak action in Gdańsk, was investigated using heterogeneous magnetic catalysts based on cobalt spinel ferrite supported on ZSM-5 zeolite. The magnetic catalyst $CoFe_2O_4$/ZSM-5 was designed to combine high catalytic activity with facile recovery from the reaction mixture via magnetic separation.

Table 1

Efficiency of riverine PET bottles glycolysis

Catalyst	Conditions	BHET yield (%)
$Zn(OAc)_2$	EG:PET mol ratio: 24.17	76.9
$CoFe_2O_4$ (CFO)	PET:M mol ratio:~110	60.7
CFO/ZSM-5 (75/25)	T:197°C, t: 90 min	69.1

Acknowledgments

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P-32

Towards Zero-Waste BioInsulation: Circular Economy Approaches in Polyurethane BioFoam Technology

M. Kurańska[1,2], E. Malewska[1,2], M. Kucała[3], N. Kowalik[1], J. Sędzimir[1], A. Put[1], H. Ożóg[1], O. Matysik[1], E. Stanik[1], S. Michałowski[1], A. Prociak[1]

[1] Cracow University of Technology, Faculty of Chemical Engineering and Technology, Department of Chemistry and Technology of Polymers, Warszawska 24, 31-155, Cracow, Poland
[2] Cracow University of Technology, Interdisciplinary Center for Circular Economy, Warszawska 24, 31-155, Cracow, Poland
[3] Cracow University of Technology, CUT Doctoral School, Faculty of Chemical Engineering and Technology, Warszawska 24, 31-155 Cracow, Poland
(corresponding author: maria.kuranska@pk.edu.pl)

Rigid polyurethane foams are widely used as high-performance thermal insulation materials, however their production relies heavily on petrochemical resources, whereas their end-of-life management remains challenging. The circular economy (CE), aligned with sustainable development principles, provides a framework for reducing environmental impact through resource efficiency, waste minimization, and material recirculation.

In the case of polyurethane systems, CE implementation involves replacing fossil-based components with renewable and waste-derived raw materials, such as biopolyols obtained from plant oils, biomass, or recycled polymers. The use of waste-derived fillers further supports the valorization of by-products and reduces the consumption of primary resources. Additionally, recycling approaches (particularly chemical methods such as glycolysis) enable the recovery of polyol fractions that can be reused in the synthesis of new materials, contributing to closed material loops.

In the in conducted research, special attention was given to the recycling of bio-based polyurethane foams produced from biopolyols with different chemical structures, as well as to the potential for their multiple recycling cycles. These aspects are crucial for evaluating the durability and circularity of bio-based systems.

Despite growing progress, challenges remain, including variability in waste-derived raw materials, the need for process standardization, and maintaining material performance. Addressing these issues is essential for the wider implementation of circular solutions in polyurethane insulation materials.

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P-33

Esterification of Lignocellulose Nanofibers from Construction and Demolition Waste Wood

M. M. Osama, P. L. de Hoyos-Martínez, I. Egues, J. Labidi

Chemical and Environmental Engineering Department, Faculty of Engineering of Gipuzkoa, University of the Basque Country (UPV/EHU), Donostia, Spain
(corresponding author: mahmoud.youssf@address.eus)

Lignocellulosic nanofibers (LCNF) isolated from construction-and-demolition waste (CDW) wood were chemically upgraded via fatty acid esterification to convert inherently hydrophilic fibrils into durably hydrophobic, interface-active nanomaterials. CDW wood, as a high-volume post-consumer stream, offers a circular feedstock but presents heterogeneity and residual additives[1]. The LCNF precursor was produced from delignified CDW wood under neutral catalyst-free organosolv condition. Fourier Transform Infrared spectroscopy and ^{13}C Nuclear Magnetic Resonance confirmed covalent ester formation through the emergence of ester carbonyl bands and carbonyl carbons while preserving the cellulose backbone, indicating surface-grafting without scission of the polysaccharide framework. Thermal analysis revealed a two-stage degradation profile in the esterified LCNF, evidencing earlier volatilization of grafted aliphatic moieties superimposed on the native cellulose decomposition as observed from Differential Scanning Calorimetry and Thermogravimetric analyses. Wettability measurements showed a 446% increase in water contact angles, with values stable over the observation window, demonstrating a robust hydrophobic transition that resists rapid rewetting. Fibrillar integrity was retained after esterification, enabling dispersion as individualized, hydrophobized nanofibers. The combined spectroscopic, thermal, and interfacial signatures establish a chemically and functionally coherent transformation from hydrophilic LCNF to moisture-resistant, polymer-compatible nano-reinforcements. These outcomes directly support applications in barrier coatings, moisture-stable papers, and bio-composite interfaces, while leveraging CDW wood as a circular feedstock and a neutral-organosolv platform that aligns chemical performance with process sustainability.

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P-34

Depolymerisation of PU and PIR Foams with Diehtylene Glycol and Tall Oil-Based Polyols

B. Sture-Skela, D. L. Eihe, R. Pomilovskis, U. Cabulis

Polymer laboratory, Latvian State Institute of Wood Chemistry, Riga, Latvia
(corresponding author: beatrise.stureskela@kki.lv)

Polyurethane (PU) foams have been widely used for decades in various applications – thermal insulation, aerospace industry, furniture, automotive industry, and many other both domestic and industrial fields. This high demand for PU products, naturally, increases the waste amount, therefore effective recycling methods must be explored. Depolymerisation of PU foams by glycolysis is already being performed on industrial level, but novel recycling methods should be investigated since several industrial methods might be limited in the future due to petrochemical reagents' negative impact on the environment. Addition of polyols based on tall oil fatty acids (TOFA) and epoxidized tall oil fatty acids (ETOFA) can be equally effective in depolymerisation process, also emphasizing renewable product utilization for such actions.

In this study we performed depolymerisation of four different PU and polyisocyanurate (PIR) foams which were produced from both bio-based and petrochemical polyols with different isocyanate indexes. Firstly, recycled polyols were obtained through glycolysis with diethylene glycol (DEG), and further achieved to depolymerise foams with addition of TOFA- and ETOFA-based polyols. Depolymerisation process with DEG occured at the following conditions: temperatures 160, 170 and 180°C, mass ratio of foam:DEG as 1:1.5 and 1:2, catalysts potassium hydroxide KOH and zinc acetate $Zn(Ac)_2$. Depolymerisation with TOFA- and ETOFA-based polyols took place at 160°C, using the same catalysts, ratio of foam:DEG:TOFA-/ETOFA-polyols as 1:0.75:0.75, so that total foam:DEG mass ratio would make 1:1.5. The results showed that, for example, recycled polyols from foam 110bio (made from bio-based polyols with isocyanate index of 110) with $Zn(Ac)_2$ as catalyst had OH value of 607 mgKOH/g and viscosity 2309 mPa·s, but recycled polyol obtained by partially substituting DEG with ETOFA-based polyol had OH value 450 mgKOH/g and viscosity above 35000 mPa·s. Separation into two phases was observed for several recycled polyols depolymerised with TOFA-based polyols.

Our results demonstrate that depolymerisation of PU foams could be done by substituting DEG with ETOFA-based polyols, thus making the process and the final product more attractive to both industrial and domestic level the resulting end-products have higher viscosity, which must be taken into account when using it for further applications.

Acknowledgments

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P-35

Natural Antioxidants as Thermal Stabilizers for Recycled Soft PVC

S. Wilczewski[1], K. Skórczewska[1], M. Osial[2], R. Yanar[3], J. Szulc[1]

[1] Bydgoszcz University of Science and Technology, Bydgoszcz, Poland
[2] Institute of Fundamental Technological Research, Polish Academy of Sciences Warsaw, Poland
[3] Pamukkale University, Denizli, Türkiye
(corresponding author: slawomir.wilczewski@pbs.edu.pl)

Recycling of plasticized poly(vinyl chloride) (PVC) remains challenging due to its complex formulation and the presence of various additives such as plasticizers and stabilizers, which negatively affect reprocessing and material performance. Thermo-oxidative degradation during recycling leads to chain scission, discoloration, and deterioration of mechanical properties, limiting the reuse of recycled soft PVC[1].

Natural antioxidants have recently gained attention as sustainable alternatives to conventional stabilizers. Bio-based compounds such as polyphenols and flavonoids can effectively inhibit oxidative degradation and improve thermal stability of polymer systems, while reducing environmental impact and toxicity[2]. Their use aligns with the principles of green chemistry and circular economy, promoting more sustainable polymer processing.

From a sustainability perspective, incorporating natural additives into recycled PVC may enhance material durability and enable multiple recycling cycles. However, challenges related to compatibility, dispersion, and long-term stability still require further investigation[3].

In this study, calendula extract was used as a natural stabilizer. The materials were prepared by the solvent casting method, in which the extract was incorporated in amounts ranging from 0.5 to 5 wt.% relative to the polymer mass into solutions obtained from aged, plasticized poly(vinyl chloride).

Thermal analysis (TGA and the Congo red method) demonstrated a significant improvement in the thermal stability of the materials after the addition of the extract. At the same time, no deterioration in mechanical properties was observed. Particularly promising is the increase in the thermal stability time of PVC, determined using the Congo red method, which indicates that the application of the extract may facilitate the thermal processing of recycled soft poly(vinyl chloride).

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P-36

Bio-Circular Composites: Recycled Polypropylene Reinforced with Lignocellulosic Fibers and Biochar

W. Wyderkiewicz, J. Miedzianowska-Masłowska, M. Masłowski
Lodz University Of Technology, Institute of Polymer and Dye Technology, Łódź, Poland
(corresponding author: wiktor.wyderkiewicz@dokt.p.lodz.pl)

Recycling of plastics within a circular economy increasingly requires efficient routes to valorise both post-consumer and post-industrial waste streams. Recent European analyses indicate that, although the availability of post-consumer recycled plastics has grown substantially in the last years, overall circularity levels for plastics remain low and additional measures are needed to increase the use of recyclates and to reduce packaging waste generation[1,2]. In this context, recycling of polypropylene (PP) packaging waste into composites containing lignocellulosic fibers and biochar obtained by pyrolysis of the same biomass is presented. The PP waste was shredded and processed by extrusion with the addition of lignocellulosic fillers and lignocellulose-derived biochar, and the resulting material was used to prepare injection-moulded specimens. A comprehensive characterization of the obtained materials was performed, including mechanical tests (tensile, flexural and impact), thermal analysis (DSC and TGA), rheological measurements in the molten state and evaluation of surface properties, in order to assess the influence of both the type and loading level of the fillers on the behaviour of the composites. Additionally, the morphology of the composites and the structural differences between the lignocellulosic fibers and the resulting biochar were examined by microscopic analysis. Particular attention was paid to the possibility of reducing the use of conventional mineral and synthetic fillers in favour of low-emission, bio-based fillers produced from accumulated lignocellulosic biomass, in line with the principles of the circular economy. The results indicate the potential of PP composites containing lignocellulose fibers and lignocellulose-derived biochar for applications in the field of sustainable materials, including packaging and technical components.

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P-37

Use of Biological Waste for the Production of Thermal Systems

I. Zalakain[1,2], M. Ibarrola[1], A. Claver[1,2], I. Alfonso[1,2], T. Calvo-Correas[3,4], A. Eceiza[3]

[1] Public University of Navarra (UPNA/NUP), Engineering Department, Arrosadia Campus, Avenida Cataluña s/n, 31006 Pamplona, Navarre, Spain
[2] Institute for Advanced Materials and Mathematics (INAMAT2) Arrosadia Campus, Avenida Cataluña s/n, 31006 Pamplona, Navarre, Spain
[3] 'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering Gipuzkoa, University of the Basque Country (UPV/EHU), Plaza Europa 1, 20018 Donostia / San Sebastián, Spain
[4] Department of Chemical and Environmental Engineering, Faculty of Engineering of Vitoria-Gasteiz (UPV/EHU), Nieves Cano 12, 01006 Vitoria-Gasteiz, Spain
(corresponding author: inaki.zalakain@unavarra.es)

The global warming crisis and dependence on fossil fuels as an energy source have led to the search for renewable and sustainable energy sources. For applications that consider using thermal energy from the sun or other sources, materials can be used as thermal energy storage devices.

Phase-change materials (PCMs) are capable of storing heat through the latent heat released during a phase change. The energy supplied to a material to cause a phase change is called the enthalpy of phase change; this energy supplied to the material for the phase change can be recovered when the phase change is reversed (the material returns to its physical state prior to the energy input). Therefore, PCMs can be used to regulate thermal contrast within a defined temperature range, for example, in building walls or thermal clothing where heating-cooling cycles occur. One of the problems with these materials is the change in shape and volume they undergo when transitioning from one phase to another, which requires them to be encapsulated for most applications. As a solution to this problem, the encapsulation of PCMs in coaxial fibers using electrospinning is proposed. The material used as PCM in the fiber core will be biomass waste materials with melting points close to room temperature, and the matrix material will be recycled polyurethane derived from ear tags.

Acknowledgments

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P-38

When Ethylene Meets Sulfur

J. Henrotte[1], F. Zaccaria[2], A. Ginzburg[1]

[1] Catholic University of Leuven, Leuven, Belgium
[2] Institut de Química Computacional i Catàlisi (IQCC) and Departament de Química, Universitat de Girona, Girona, Catalonia E-17071, Spain
(corresponding author: jules.henrotte@kuleuven.be)

Ethylene is the most widely used monomer in the chemical industry, underpinning the production of polymers and intermediates ranging from polyethylene to solvents and surfactants. In parallel, elemental sulfur is an abundant and underutilized byproduct of petroleum refining and natural gas desulfurization. The growing accumulation of sulfur, driven by stringent fuel desulfurization regulations, has created both an environmental challenge and an opportunity for valorization through new chemical transformations and materials applications. Despite significant progress in inverse vulcanization chemistry[1], most systems rely on multifunctional unsaturated crosslinkers. In contrast, simple olefins such as ethylene have been largely overlooked as comonomers, representing a key knowledge gap. We report a material based on ethylene-sulfur copolymers synthesized through the reaction of gaseous ethylene at mild pressures with elemental sulfur via an inverse vulcanization approach. The resulting materials are sulfur-rich, reprocessable dynamic covalent networks exhibiting sheet-like morphology, dual wetting behavior, high electrical conductivity, and exceptional permittivity. This approach provides a straightforward route to value-added polymers from conventional feedstocks, enabling access to a new class of functionally differentiated polyolefins and broadening the scope of inverse vulcanization chemistry.

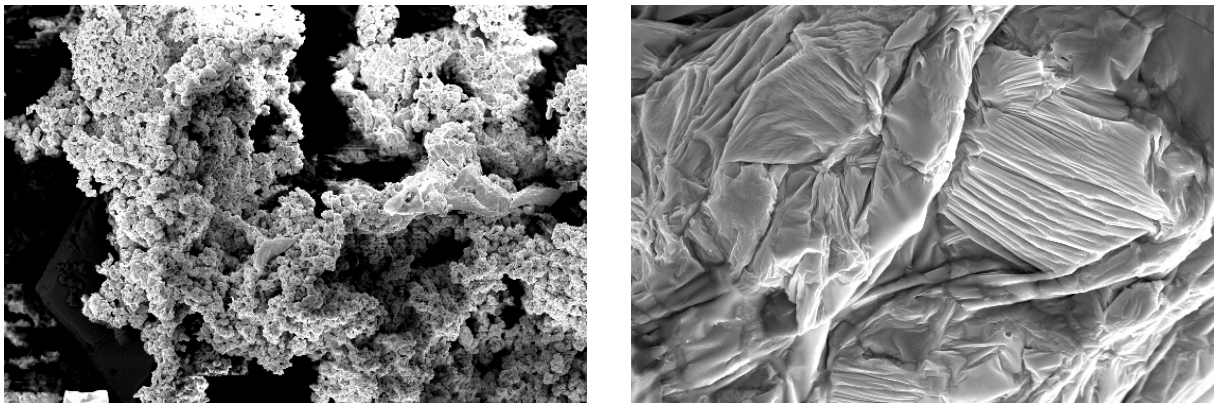

Figure 1

a) elemental sulphur b) the synthesized ethylene-sulphur copolymer

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P-39

UV-Curable Resins Based on Bio-Derived Precursors

M. L. Auad[1,2], L. Carias[1,2], J. Graneros[1,2], C. Mandurai[1], D. Hartmann[3], M. Sakhaharmy[3], S. Adhikari[3]

[1] Center for Polymers and Advanced Composites, Gavin Engineering Research Laboratory, Auburn University, 311 West Magnolia Avenue, Auburn, Alabama 36849, United States
[2] Department of Chemical Engineering, Ross Hall, Auburn University, 222 Foy Union Circle, Auburn, Alabama 36849, United States
[3] Department of Biosystems Engineering, Auburn University, 209 Tom E. Corley Building, Auburn, AL, 36849, United States
(corresponding author: auad@auburn.edu)

The development of sustainable UV-curable resins has gained increasing attention as an alternative to petroleum-based thermosetting systems. In this work, two distinct resin platforms were designed and comparatively analyzed: a model resin derived from a well-defined phenolic compound (gallic acid) and a complex resin synthesized from bio-oil. Acrylation was carried out using acryloyl chloride under controlled low-temperature conditions to preserve functional integrity and maximize substitution efficiency. Both systems were subsequently formulated with acrylated epoxidized soybean oil (AESO) to tailor crosslink density and rheological behavior. Cure kinetics and network formation were evaluated using Fourier Transform Infrared Spectroscopy (FTIR) and ^{1}H and ^{13}C nuclear magnetic resonance (NMR), with particular attention to the consumption of vinyl groups and the evolution of carbonyl functionalities. The model system enabled direct structure–property correlations, while the bio-oil-based resin captured the complexity of lignin-derived feedstocks, including heterogeneous functionality and molecular weight distribution. UV curing at 405 nm resulted in rapid polymerization, although limitations in light penetration and network heterogeneity were observed in the bio-oil system. These challenges were partially mitigated through dual-curing strategies combining photopolymerization and thermal post-curing. The results highlight the trade-off between chemical tunability and sustainability, demonstrating that while model compounds offer mechanistic clarity, bio-oil-derived systems provide a viable pathway toward scalable, renewable UV-curable materials for coatings, adhesives, and additive manufacturing applications.

P-40

Sustainable Thermoplastic Polyurethanes for Footwear Applications: From Laboratory to Pilot Scale

T. B. Schreiner[1,2], J. R. Manhique[1,3], L. L. Aquino[1], M. S. C. A. Brito[3], Y. A. Manrique[3], R. J. Santos[3], L. M. R. Mesquita[2], C. Coelho[4], J. Meireles[4], M. J. Ferreira[5], A. Santamaria-Echart[1], **M. F. Barreiro**[1]

[1] CIMO, LA SusTEC, Instituto Politécnico de Bragança, Bragança, Portugal
[2] GICoS, Instituto Politécnico de Bragança, Bragança, Portugal
[3] LSRE-LCM, ALiCE, Faculty of Engineering, University of Porto, Porto, Portugal
[4] Atlanta Steps, Lixa, Portugal
[5] Centro Tecnológico do Calçado de Portugal (CTCP), São João da Madeira, Portugal
(corresponding author: barreiro@ipb.pt)

Thermoplastic polyurethanes (TPUs) are versatile materials widely used in industrial applications, namely in the footwear sector. In line with green chemistry principles and the growing bioeconomy, the transition from petroleum-based materials to sustainable, bio-based alternatives remains a major challenge. This work demonstrates the feasibility of scaling up bio-based TPU formulations, from laboratory- to pilot-scale production via reactive extrusion. Based on prior optimisation studies, a formulation containing 20% 1,4-butanediol (BDO) as hard segment, and 80% polyol, as soft segment, was selected for its balanced mechanical performance. To bridge laboratory development and industrial processing, pilot-scale trials were conducted with a biodegradable synthetic polyol (PCL2000), enabling process validation prior to implementing fully bio-based systems. The selected formulation was successfully processed using reactive extrusion, followed by pelletising and injection moulding. Different processing conditions were evaluated to optimise filament formation, revealing that moderate thermal profiles (60-90 °C), combined with low screw rotation speeds (25-30 rpm), favour production of continuous filaments. The obtained materials were structurally characterised by Fourier-Transform Infrared Spectroscopy, confirming characteristic urethane linkages and absence of significant chemical degradation during processing. Additional analyses, including Differential

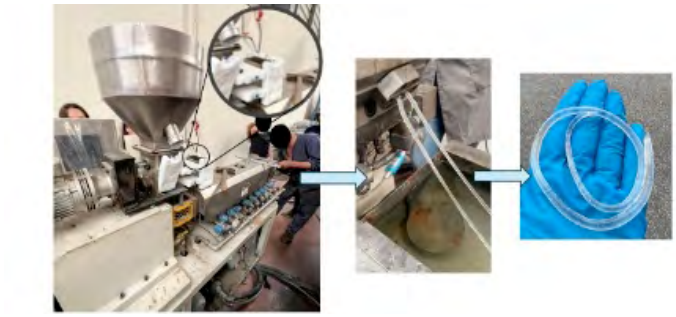

Figure 1

Pilot-scale reactive extrusion of TPU
(material feeding, filament formation, and final extrudate)

Scanning Calorimetry, and Gel Permeation Chromatography, indicated results comparable with laboratory-scale counterparts. Overall, the results pointed out the successful translation of TPU formulations from lab to pilot scale, meeting industrial processing and performance requirements. This work reinforces the potential of bio-based TPUs as viable, sustainable substitutes for conventional petroleum-based materials in the footwear sector. Future work will focus on pilot-scale validation of the bio-based formulation developed at laboratory scale, aiming to confirm its processability and performance under industrially relevant conditions.

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P-41

Numerical Study and Research of Composite Structure with Rigid Polyurethane Foam

U. Cabulis[1], V. Dhalivala[1], V. Yakushin[1], A. Kovalovs[2]

[1] Latvian State Institute of Wood Chemistry, Riga, Latvia
[2] Institute of High-Performance Materials and Structures, Riga Technical University, Riha, Latvia
(corresponding author: ugis.cabulis@kki.lv)

The aim of this study is based on the hypothesis that incorporating functionally graded (FG) foam materials into the rotor blades or wings of an unmanned aerial vehicle can enable stiffness variation, thereby alter vibrations and improve aerodynamic performance.

This study serves as a preliminary investigation to understand the behaviour of a simplified finite element model before analysing a realistic rotor blade containing functionally graded polymer foam. A simplified model of a full-size helicopter blade is presented in a composite box-plate configuration. The cross-section of the composite structure examined in this study corresponds to the overall dimensions of a full-scale helicopter blade. The graded properties of the core vary across the structure's width. The influence of the distribution law of functionally graded foam on the stiffness characteristics of composite structures was calculated using ANSYS software. To model the graded foam as the rotor blade core, the foam's density and mechanical properties of rigid polyurethane (PUR) foam were tested.

PUR foam is produced from renewable resources, using environmentally friendly catalysts and foaming agents, and is available in different densities. Specimens of PUR foam were manufactured with nominal densities of 30, 40, 50, 60, and 70 kg/m³ and were experimentally investigated under tension. The Young's modulus of PUR foam ranges from 3.9 to 17.4 MPa, while the density ranges from 30 to 70 kg/m³. These properties were then used to define the variation in material properties within the composite box plate using a power-law function.

The parametric study of the composite box plate shows that the use of graded foam based on PUR foam properties has the greatest influence on the model's mass, centre of gravity location, and torsion stiffness as the power-law index p increases. The influence of graded polymer foam on the elastic axis location and lag- and flap-bending stiffness characteristics of composite structures is negligible. However, preliminary results suggest that increasing the power-law index p may lead to a larger twist angle.

Acknowledgments

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P-42

Oxidised Starch Additive for Polyurethane Coatings and Foams: Influence of the Extraction Route

A. Gil Moreno, A. Candela Gil, C. M. Muñoz Martí, M. V. Navarro Bañón

Technology Centre of Furniture and Wood of the Region of Murcia (CETEM),
C/ Perales, 30510 Yecla, Murcia, Spain
(corresponding author: a.gil@cetem.es)

Oxidised Starch (OS), due to its reactivity and compatibility with polyurethane matrices, has emerged as a promising bio-based additive in the development of more sustainable polymeric materials. This work explores both the extraction and application of oxidized starch in polyurethane-based systems, highlighting how the extraction method influences its physicochemical properties and performance in different formulations[1,2].

Potato starch was oxidised using hydrogen peroxide 30 v/v% and extracted through two routes: lyophilization and precipitation in ethanol. The resulting oxidised starch (OS) was characterised by FTIR spectroscopy and thermogravimetric analysis (TGA). The OS was then applied as an additive in two different polyurethane systems: coatings and flexible foams. For coatings, the OS was incorporated into a polyurethane dispersion at concentrations ranging from 1% to 5% under controlled mechanical agitation. Stable formulations were obtained up to a concentration of 3%, whereas higher concentrations (4-5%) led to visible particle sedimentation and inhomogeneity. Colour changes were already significant at 1% loading ($\Delta E = 7.98$), which may be relevant for aesthetic or protective applications. Despite the observed low viscosity, the coatings showed acceptable surface appearance and adhesion performance at lower additive levels.

In the case of foams, reference formulations were compared to samples containing 1% oxidized starch from both lyophilization and ethanol precipitation processes. The use of lyophilized starch required a 20% increase in catalyst concentration to maintain foam stability. Mechanical tests showed poor recovery performance (permanent deformation).

It is noteworthy that the lyophilized OS exhibited high hygroscopicity, which had a detrimental effect on the foam production process and the final properties of the product. In contrast, the ethanol-precipitated starch demonstrated enhanced stability and compatibility with foam formulations. This distinction underscores the necessity to select the most appropriate of starch derivative to the target application.

Acknowledgments

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P-43

Study of the Biodegradation Process of PBAT and PBAT/Latxa Wool Fiber Composites under Composting and Marine Conditions

A. Larruscain, C. Peña-Rodriguez, A. Arbelaiz

'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering Gipuzkoa, University of the Basque Country (UPV/EHU), Plaza Europa 1, 20018 Donostia / San Sebastián, Spain
(corresponding author: ander.larruscain@ehu.eus)

Poly(butylene adipate-co-terephthalate) (PBAT) is a biodegradable copolyester, which is a promising alternative to conventional plastics, particularly in applications where material recovery is challenging. Although its compostability under controlled conditions is well established, its behavior in less favorable environments, such as marine conditions, still requires further investigation[1].

This work focuses on the biodegradation of PBAT and PBAT/Latxa wool fibercomposites Latxa wool is a locally available waste stream. Furthermore, tannins extracted from pine bark are introduced as bio-based additives. The incorporation of natural fibers as well as tannins, may influence degradation mechanisms by modifying the composite structure, water uptake, and microbial accessibility. Tannins exhibit antifungal and antimicrobial properties[2] which may affect composite degradation process.

The materials were processed using conventional techniques and evaluated under composting and marine conditions. Key parameters such as disintegration, loss of properties, and structural changes were analyzed in order to better understand degradation pathways.

The results provide relevant insight into how wool fibers and bio-based additives influence PBAT biodegradation, supporting the development of materials with reduced environmental persistence for agricultural and marine applications[3].

Acknowledgments

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P-44

Hybrid Biodegradable Polymer Composites Filled with Wood Flour and Talc

K. Lewandowski[1], P. Altmajer[1,2], J. Mirowski[1], Z. Altmajer[1]

[1] Bydgoszcz University of Science and Technology, Bydgoszcz, Poland
[2] Kazimierz Wielki University, Bydgoszcz, Poland
(corresponding author: krzysztof.lewandowski@pbs.edu.pl)

In response to increasing environmental challenges and restrictive polymer waste regulations, biodegradable materials such as polylactide (PLA) and poly(butylene adipate-co-terephthalate) (PBAT) are gaining significance. PLA is characterized by high stiffness, while PBAT offers high flexibility and impact strength[1]. This study investigates Wood Polymer Composites (WPC) based on these matrices, exploring the hybrid modification with talc - a mineral filler known for improving the performance of conventional polyolefins by acting as a nucleating agent[2,3]. The objective was to verify if the synergistic combination of wood flour (WF) and talc yields similar benefits in fully biodegradable systems.

The research involved hybrid composites produced via twin-screw extrusion and injection moulding, with wood flour content at 10, 30, and 50 wt.% and talc levels at 1, 3, and 5 wt.%. The materials underwent comprehensive analysis, including Shore hardness, density, and water absorption. Mechanical properties were assessed through static tensile testing (Young's modulus, tensile strength, elongation at break) and Charpy impact testing, while a capillary rheometer was used for rheological evaluation. Additionally, accelerated environmental aging was performed to assess durability.

The analysis of the results demonstrated that the introduction of wood flour leads to a increase in hardness and elastic modulus for both matrices, which, however, occurs at the expense of a drastic decrease in relative elongation and impact strength. PLA-based composites exhibited higher water resistance compared to PBAT systems, resulting from the differing hydrophobicity of the polymers themselves. Regarding rheological properties, it was observed that the addition of talc to systems containing wood flour did not cause significant changes in the flow curves that could substantially affect processing parameters. Despite the observed changes in mechanical parameters, they should be considered minor. The research results lead to the conclusion that in the investigated PLA and PBAT systems, talc did not fully meet expectations as a modifier significantly enhancing performance properties or facilitating processing to a degree comparable to PP or PE-based systems. This indicates the necessity for further research into the compatibilization of hybrid systems based on biodegradable polymers.

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P-45

Valorization of Coffee Waste for the Production of Bacterial Cellulose-Reinforced PHBV Biocomposites

L. Vignau[1], I. Berasarte[1], T. Calvo-Correas[1,2], A. Retegi[1], A. Eceiza[1], N. Gabilondo[1]

[1]'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering Gipuzkoa, University of the Basque Country (UPV/EHU), Plaza Europa 1, 20018 Donostia / San Sebastián, Spain
[2]Department of Environmental Engineering, Faculty of Engineering of Vitoria-Gasteiz, University of the Basque Country (UPV/EHU), Nieves Cano 12, 01006 Vitoria-Gasteiz, Spain
(corresponding author: laura.vignau@ehu.eus)

Bacterial cellulose (BC) is a promising sustainable biopolymer due to its high purity, crystallinity, and nanofibrillar structure. However, its conventional production requires high glucose concentrations, increasing costs and limiting sustainability. In this work, 50% of the glucose in a standard culture medium was replaced with the liquid fraction obtained from hydrolyzed coffee waste as an alternative carbon source for BC production. The resulting BC was incorporated into poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV) to develop biocomposites with 1, 3, and 5 wt % BC, processed by injection and compression molding. Mechanical, thermal, and morphological properties were evaluated as a function of BC content. This approach reduces glucose consumption while valorizing coffee waste, contributing to more sustainable production of fully bio-based biocomposites.

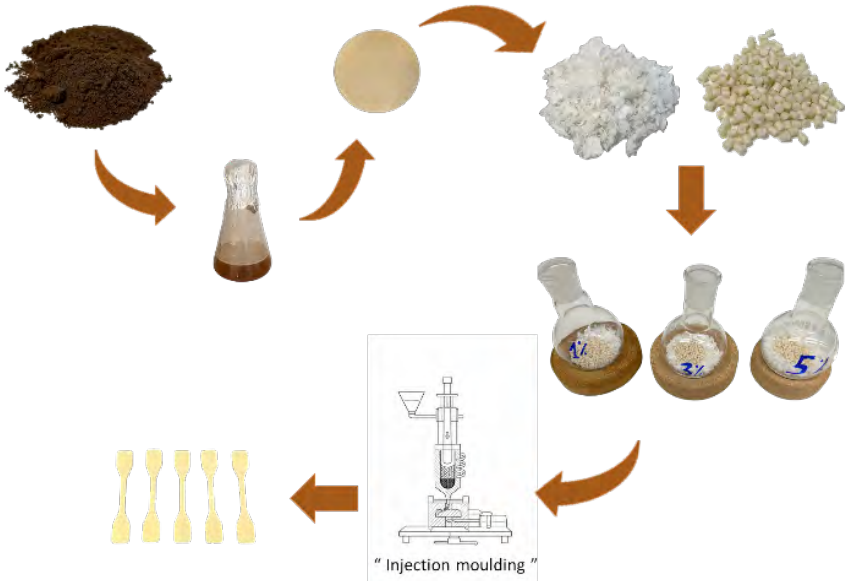

Figure 1

Manufacturing of PHBV/BC biocomposites

Acknowledgments

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P-46

Obtaining Membranes Composed of Polyurethane and Phase Change Materials (PCM)

M. Ibarrola[1], T. Calvo-Correas[2,3], A. Eceiza[2], A. Claver[1,4], I. Alfonso[1,4], I. Zalakain[1,4]

[1] Public University of Navarra (UPNA/NUP), Engineering Department, Arrosadia Campus, Avenida Cataluña s/n, 31006 Pamplona, Navarre, Spain

[2] 'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering Gipuzkoa, University of the Basque Country (UPV/EHU), Plaza Europa 1, 20018 Donostia / San Sebastián, Spain

[3] Department of Environmental Engineering, Faculty of Engineering of Vitoria-Gasteiz, University of the Basque Country (UPV/EHU), Nieves Cano 12, 01006 Vitoria-Gasteiz, Spain

[4] Institute for Advanced Materials and Mathematics (INAMAT2) Arrosadia Campus, Avenida Cataluña s/n, 31006 Pamplona, Navarre, Spain

(corresponding author: muskilda.ibarrola@unavarra.es)

Phase Change Materials (PCMs) offer a clean and efficient way to store energy; however, their practical application requires proper encapsulation to prevent leakage or degradation. In this context, electrospinning is a highly suitable technique for incorporating PCMs into stable and functional structures, as it enables the production of continuous, small-diameter coaxial fibers. Furthermore, the materials used in this study were selected with the aim of promoting reusability and sustainability by valorizing natural resources and waste materials. This research analyzes the characteristics and behavior of coaxial fibers produced via electrospinning. To this end, Thermoplastic Polyurethane (TPU) sourced from cattle ear tags was used as the encapsulating material (shell), while PCMs such as fly wax, hemp oil, and beef tallow were incorporated into the core. The objective was to analyze the compatibility, morphological structure, and thermal behavior of these materials, as well as to evaluate their phase-change efficiency and energy storage capacity. The results indicate that the different PCMs exhibit distinct behaviors, which in turn affect the thermal and mechanical properties of the fibers. Overall, this study demonstrates that coaxial fibers produced via electrospinning can serve as effective systems for PCM encapsulation, making them suitable for thermal energy storage applications, such as passive temperature control in buildings.

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P-47

Structural Characterization and Solvent Resistance Assessment of Enzymatically Functionalized Tropical Wood Extractives from Industrial Residues

A. Selmanović[1,2], I. Olazabal[3], A. Kutnar[1,2], R. A. Herrera Diaz[3]

[1] InnoRenew CoE, UP IAM & UP FAMNIT, University of Primorska, Koper, Slovenia
[2] Doctoral School, University of the Basque Country (EHU), Donostia / San Sebastian, Spain
[3] 'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering Gipuzkoa, University of the Basque Country (UPV/EHU), Plaza Europa 1, 20018 Donostia / San Sebastián, Spain
(corresponding author: amina.selmanovic@iam.upr.si)

Wood extractives from industrial residues represent a chemically diverse and renewable source of bioactive compounds with potential applications. Their practical application and long-term performance are limited by low molecular weight, high solubility and susceptibility to leaching. To address these limitations, extractives, recovered from merbau (*Intsia spp.*) and jatoba (*Hymenaea spp.*) wood residues by ultrasound-assisted extraction in ethanol-water system, were used to evaluate whether laccase from *Trametes versicolor*, as green and sustainable approach, could promote oxidative modification and improve their properties. The extraction process was evaluated through basic green metrics, showing low unit energy consumption and favorable material performance under selected conditions. The recovered extractives were characterized by gel permeation chromatography (GPC) and attenuated total reflectance fourier transform infrared (ATR-FTIR) spectroscopy, confirming predominantly low molecular weight and soluble constituents prior to the treatment. Following the enzymatic treatment, obtained products exhibited increased solvent resistance to five different solvents, and could no longer be analyzed by GPC. ATR-FTIR spectral changes showed decreased intensity in the hydroxyl stretching region and redistribution of bands associated with aromatic structures, indicating modification of the initial phenolic extractive profile. The observed changes suggest that enzymatic treatment alters the structural organization of the extracts and may lead to the formation of less soluble and more structurally complex products. While the nature of these changes requires further research using solid state analytical approaches, such as Raman spectroscopy, solid-state nuclear magnetic resonance (ssNMR), X-ray diffraction, the reduced solvent solubility and corresponding changes observed in FTIR spectra indicate that enzymatic modification is relevant for further investigation of enzymatically modified extractives as candidates for bio-based wood protection strategies, particularly where reduced solubility could favor improved retention and lower leaching.

Acknowledgments

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P-48

Development and Evaluation of Non-Isocyanate Polyurethanes Using Different Amines for Footwear Applications

J. R. Manhique[1,3], **S. S. Bernardoni**[1], L. L. Aquino1, T. B. Schreiner[1,2], R. J. Santos[3], M. J. Ferreira[4], M. F. Barreiro[1], A. Santamaria-Echart[1]

[1] CIMO, LA SusTEC, Instituto Politécnico de Bragança, Bragança, Portugal
[2] GICoS, Instituto Politécnico de Bragança, Bragança, Portugal
[3] LSRE-LCM, ALiCE, Faculty of Engineering, University of Porto, Porto, Portugal
[4] CTCP- Centro Tecnológico do Calçado de Portugal, S. João da Madeira, Portugal
(corresponding author: asantamaria@ipb.pt)

The footwear industry faces growing pressure to adopt more sustainable materials, as conventional polyurethanes, widely used in soles, adhesives, and coatings, rely on toxic isocyanate-based chemistry. Non-isocyanate polyurethanes (NIPUs) emerge as a green alternative, enabling the use of bio-based feedstocks while avoiding the use of isocyanates. In this work, NIPUs were synthesised via polyaddition of a five-membered bis(cyclic carbonate) (CC)[1], from diglycerol and dimethyl carbonate (K_2CO_3 catalyst), with 1,4-diaminobutane (BDA), a bio-based fatty diamine (PRI), and their mixtures (25/75, 50/50, 75/25), aiming to evaluate how the BDA/PRI ratio governs the final properties. Fourier transform infrared (FTIR) confirmed urethane bonds formation (CC band disappearance at 1790 cm^{-1}; urethane carbonyl formation at 1705 cm^{-1}), with all formulations achieving >90% conversion. The resulting NIPUs were characterised by rheological analysis, differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), and gel permeation chromatography (GPC). Their potential as adhesives for footwear applications was further assessed through T-peel tests on leather substrates using dynamic mechanical analyses (DMA). These findings confirm that the PRI-BDA ratio enables tuning of NIPU properties.

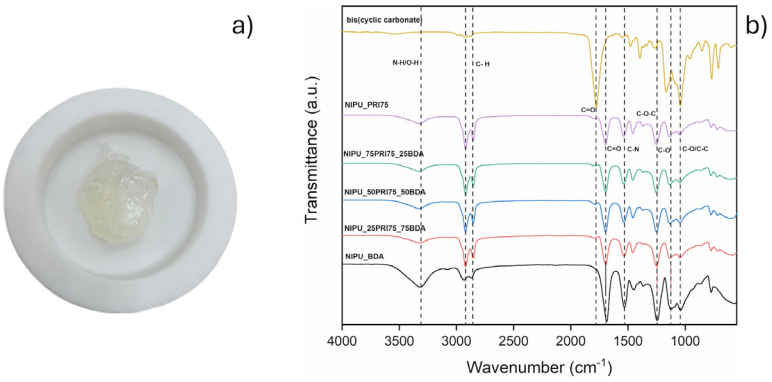

Figure 1

a) NIPU_BDA sample b) FTIR spectrum of NIPUs samples

Acknowledgments

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P-49

Active Ester Curing of Epoxides Producing Low Dielectric Thermosets

P. Weiss[1,2], D. Schuster[1,2], C. Slugovc[1,2]

[1] Institue for Chemistry and Technology of Mat., Graz University of Technology, Graz, Austria
[2] Christian Doppler Laboratory for Organocatalysis in Polymerization, Graz, Austria
(corresponding author: slugovc@tugraz.at)

Epoxy resins are important materials used in a variety of applications due to their excellent mechanical, thermal, and electrical properties. The curing process, whereby the resin is transformed into a solid material, is an important processing step in which curing agents react with the epoxides and influence their properties. For use in composites, castings and encapsulations, good thermal properties, like a high glass transition temperature, stability for mechanical processing and electrical properties, enabling insulation, are needed. The most commonly used curing agents for this purpose are anhydrides, bearing some ecological drawbacks, such as long curing cycles at high temperatures.[1] Additionally, anhydrides entail certain hazards, making them the focus of potential prohibition measures and regulatory provisions. To overcome these issues active esters can be used as curing agents to produce epoxy thermosets. Model reactions to determine the mechanism of these reactions delivered promising results, particularly with regard to the modification of the polymer backbone by the type of active ester used.[2]

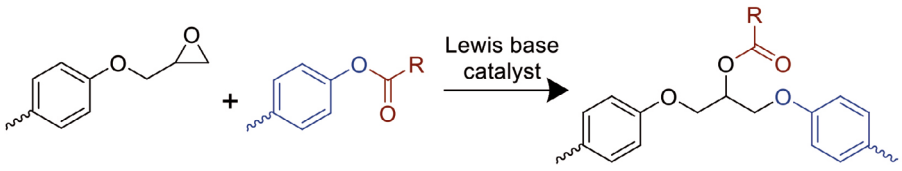

Figure 1

Scheme for the epoxy ester curing reaction

In this work we present results that contribute to identifying influences on dielectric and thermal properties of epoxy materials. As epoxide we focused on DGEBA, the most commonly used epoxide in industry. The selection of curing agents significantly influences the curing kinetics and final properties of the epoxy resin. Additionally, varying the ratio of epoxide to curing agent results in different products obtained from the same starting materials. Comparing the two organic Lewis base catalysts, 1-methylimidazole (1-MI) and 4-dimethylaminopyridine (DMAP), we observed an influence on the effectiveness of the curing process and the dielectric properties of the products. These properties are also heavily influenced by the amount of catalyst used in the reaction.

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P-50

Synthesis of Biobased Vitrimers from Renewable D-Isosorbide

O. Kopilec[1], O. Sedláček[1], H. Beneš[2]

[1] Department of Physical and Macromolecular Chemistry, Faculty of Science, Charles University, Prague, Czech Republic

[2] Institute of Macromolecular Chemistry, Czech Academy of Sciences, Prague, Czech Republic

(corresponding author: kopileco@natur.cuni.cz)

In this work, we have developed novel vitrimer networks based on the renewable monomer *D*-isosorbide. Isosorbide bis(acetylacetonate) was synthesized via a green synthetic route and subsequently cross-linked with several multifunctional amines to form networks containing vinylogous urethane linkages. In addition, a new bio-based cross-linker derived from furfurylamine was developed as a potential alternative to the petroleum-based xylylenediamine cross-linker.

In total, four bi- and trifunctional amines with varying bio-based carbon content were investigated as vitrimer cross-linkers. Different combinations of amines, together with varying isosorbide/amine ratios, were explored in order to tailor the final vitrimer properties. All resulting networks exhibited a stiff character while remaining readily processable and recyclable at elevated temperatures (>120 °C).

The thermomechanical properties of the prepared vitrimers were characterized using DSC, TGA, DMTA, and tensile testing. Stress-relaxation experiments were performed to determine the topology transition temperature of the materials. The networks were further analysed through swelling experiments. The same characterization techniques were also applied to reprocessed (recycled) samples.

The physicochemical properties of the prepared networks were found to strongly depend on the structure of the amines used for cross-linking. Overall, the developed isosorbide-based vitrimer systems demonstrate promising potential for high-performance applications with reduced environmental impact.

Acknowledgments

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P-51

Enabling Circularity in Bio-Based PU Foams through Diels–Alder Chemistry

F. Recupido[1], **K. Polaczek**[1,2], F. Orabona[3,4], L. Tammaro[5], G. C. Lama[1], Z. Wang[6], L, Verdolotti[1], M. Lavorgna[1] , H.Xia[6]

[1] Institute for Polymers, Composites and Biomaterials, National Research Council of Italy (IPCB-CNR), Piazzale E. Fermi 1, 80055 Portici (Italy)
[2] Institute of Macromolecular Chemistry, Czech Academy of Sciences, Heyrovského nám. 2, Prague 6, 162 00, Czech Republic
[3] Åbo Academy University, Laboratory of Industrial Chemistry and Reaction Engineering, Henrikinkatu 2, FI-20500, Turku/Åbo, Finland
[4] Chemical Sciences Department, University of Naples Federico II, Via Cinthia 26, 80126 Naples, Italy
[5] Nanomaterials and Devices Laboratory (SSPT-PROMAS-NANO), ENEA—Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Piazzale E. Fermi, 1, 80055 Portici (Naples), Italy
[6] State Key Laboratory of Advanced Polymer Materials, Polymer Research Institute, Sichuan University, Chengdu 610065, China
(corresponding author: federica.recupido@cnr.it)

In recent years, Covalent Adaptable Networks (CANs) have attracted noticeable interest for their ability to enable the reprocessing and reshaping of thermoset polymers. They are capable of reversible exchange reactions under external stimuli, such as thermal or mechanical ones, combining thermoset stability with thermoplastic-like properties, such as self-healing, shape memory, and recyclability[1]. The present study explores the potential of a Diels-Alder (DA) compound to enhance the reprocessability of open cell-like bio-based polyurethane (PU) foams. Bio-based 1,5-pentanediisocyanate (PDI) is functionalized with varying DA content ratios to yield isocyanate-terminated prepolymers. These latter ones are employed, by replacing PDI and combining with PU precursors and additives, to synthesize foams. To evaluate their recyclability, the foams are mechanically milled and subjected to controlled thermal-mechanical treatments at 130°C for 1 hour and at 3 MPa, turning them into thermoplastic films. Such films exhibit promising mechanical properties and significant self-healing capabilities, with a notable recovery in mechanical strength upon two reprocessing routes. This study provides insights into the potential of DA in enhancing the sustainability and reprocessability of PU foams.

Acknowledgments

This study was founded by the Horizon EU project GREen ENdeavor in Art ResToration (Green Art) Grant Agreement no. 101060941 and Horizon EU project INTEGRANO-G.A. 101138414 (Multidimensional Integrated 623 Quantitative Approach To Assess Safety And Sustainability Of Nanomaterials In Real Case Life Cycle Scenarios Using Nanospecific Impact Categories).

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P-52

Degradation-Controlled Release of Curcumin from PCL Nanofibrous Scaffolds

K. Havlíčková[1], N. Marousková[1], Š. Hauzerová[1], Jana Müllerová[1], Vít Novotný[2], D. Lukáš[1], V. Jenčová[1]

[1] Technical University of Liberec, Faculty of Science, Humanities and Education, Department of Chemistry, Liberec, Liberec 461 17, Czech Republic
[2] Institute for Nanomaterials, Advanced Technology and Innovation, Department of Environmental Chemistry, Technical University of Liberec, Liberec 461 17, Czech Republic
(corresponding author: kristyna.havlickova@tul.cz)

Curcumin is a natural bioactive compound with strong antioxidant and anti-inflammatory activity[1,2]; however, its broader application is limited by pronounced hydrophobicity and extremely low solubility in aqueous environments[3]. Biodegradable nanofibrous scaffolds based on poly(ε-caprolactone) (PCL) represent a promising platform for the encapsulation and controlled delivery of such poorly soluble compounds[4]. In this study, PCL nanofibrous materials incorporating curcumin were prepared, while lecithin was introduced as an amphiphilic additive to promote curcumin release from the hydrophobic polymer matrix.

The degradation behavior of the materials was investigated using lipase-catalyzed enzymatic degradation, and the degradation kinetics were evaluated with respect to curcumin loading and the presence of lecithin. Curcumin release was examined under two conditions: (i) enzymatic degradation in the presence of lipase and (ii) release in phosphate-buffered saline (PBS) governed only by simple diffusion. The results demonstrate that simple diffusion contributes negligibly to curcumin release from the hydrophobic PCL nanofiber matrix. Instead, the release process is predominantly governed by enzymatic degradation of the scaffold. The presence of lecithin appears to facilitate curcumin release, which may be related to its amphiphilic character and its influence on curcumin distribution within the nanofibrous matrix. Interestingly, higher curcumin loading resulted in slower degradation compared with pristine PCL nanofibers, suggesting intermolecular interactions between PCL, curcumin, and lecithin that may form supramolecular aggregates limiting enzyme accessibility and slowing matrix degradation[5].

Acknowledgments

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P-53

Synthesis of Zwitterionic Poly(Terphenyl Piperidinium) Copolymers for Fuel Cells

F. Panagiotou, I. Abdel Aziz, D. Mantione, D. Mecerreyes, E. Gabirondo

POLYMAT, University of the Basque Country UPV/EHU, Avenida Tolosa 72, Donostia / San Sebastián, 20018, Gipuzkoa, Spain
(corresponding author: elena.gabirondo@ehu.eus)

High temperature proton exchange membrane fuel cells (HT-PEMFCs) are considered one of the most promising technologies for the transition from a fossil-fuel economy to a green-hydrogen economy. State-of-the-art phosphoric acid-doped polybenzimidazole (PA/PBI) membranes offer high proton conductivities (70-150 mS cm^{-1} at 160-200 °C), along with good thermal, and chemical resistance[1]. However, the phosphoric acid leaching, the low mechanical strengths at high doping levels, the difficult synthesis and the toxicity of the diaminobenzidine monomer, pose significant challenges to their application[1,2]. In recent years the development of polyarylenes synthesized by Friedel-Crafts hydroxyalkylation polymerization has offered an easier way to prepare high molecular weight polymers with an "all-carbon" polymer backbone, that exhibit excellent thermal and mechanical properties, and good proton conductivities[2,3]. However, the tradeoff between phosphoric acid doping and the tensile strength is still a limiting factor[2,3]. In this work we prepared polyarylene copolymers from para-terphenyl, methyl piperidone and a quaternized methyl piperidone zwitterion (Figure 1), with the aim to mitigate this tradeoff by the zwitterionic interactions between the polymer chains. The polymers are characterized by ^{1}H NMR, ATR-FTIR, and TGA while the membranes properties are investigated by acid doping and swelling measurements, electrochemical impedance spectroscopy (EIS), and tensile measurements.

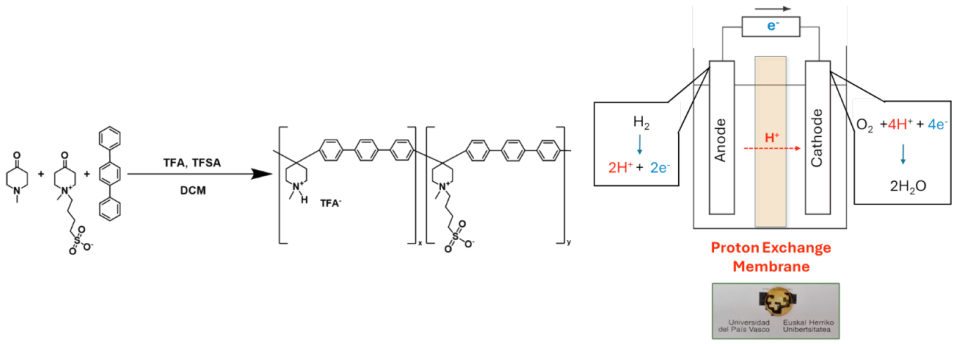

Figure 1

Synthesis of zwitterionic poly(terphenyl piperidinium) copolymers along with the corresponding membrane after doping with 85% PA at 60 °C for 72h

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P-54

Waste-Valorized Bacterial Nanocellulose in Edible Coatings for Longer-Lasting Cherry Tomatoes

M. Peña-Ortiz[1,2], A. García[1], S. Marqués[3], **L. Serrano**[2]

[1] Organic Chemistry Department, Nanoval FQM-383 Research Group, University of Córdoba, Córdoba, Spain
[2] Inorganic Chemistry and Chemical Engineering Department, BioPrEn RNM 940 Research Group, University of Córdoba, Córdoba, Spain
[3] Department of Biotechnology and Environmental Protection, Estación Experimental del Zaidín CSIC, Granada, Spain
(corresponding author: iq3secal@uco.es)

Postharvest losses considerably affect the quality and availability of fresh produce. Sustainable strategies based on bio-based materials are therefore attracting growing interest for food preservation[1]. This study presents easy-to-prepare carboxymethyl cellulose (CMC) edible coatings reinforced with bacterial nanocellulose (BNC) that can extend cherry tomato shelf life under room-temperature storage (Figure 1). The nanofibers were produced from residual crude glycerol via *Ancylobacter* sp. STN1A fermentation, thus supporting a circular economy approach through waste valorization. Microscopy analyses (SEM and AFM) of this BNC revealed a narrow width (≈54 nm) and a remarkable nanofiber length (micrometer scale), indicating a high aspect ratio. X-ray diffraction (XRD) showed a crystallinity index (CrI) of 57%. These nanofibers were then incorporated into CMC matrices at 0-10 wt. % to evaluate how BNC loading influences key physicochemical and functional properties of the resulting composites, including water-related barrier performance, mechanical and dynamic thermomechanical behavior, optical features, and thermal stability. Based on the obtained characterization results, cherry tomatoes were dip-coated with CMC-BNC formulations containing 0, 2.5, 5, and 7.5 wt. % nanofiller, and changes in weight, visual appearance, and microbial loads were monitored under controlled room-temperature storage. Coatings with higher BNC contents limited fruit weight variations over storage and helped maintain overall visual quality. Furthermore, these coatings restricted microbial proliferation, likely associated with the barrier effect formed on the fruit surface. Overall, these findings highlight the potential of the designed CMC-BNC edible coatings as a sustainable postharvest alternative to improve cherry tomato shelf life at room temperature.

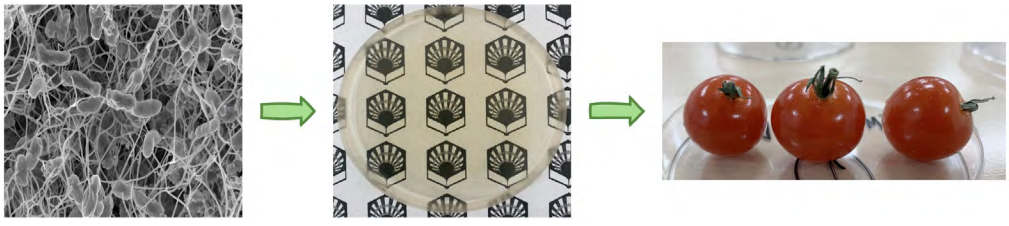

Figure 1

Study overview showing BNC, a CMC-BNC film, and coated cherry tomatoes

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P-55

Phytotoxicity Assessment of Lignin Nanoparticles Using Eruca Sativa Seeds as a Biological Model

W. F. Silva[1], C. B. Ferreira[1], P. H. F. C. Barros[1], C. H. M. Ribeiro[1], R. S. Goulart[1], P. C. Silva[1], J. Labidi[2], M. L. Bianchi[1]

[1] Federal University of Lavras, Lavras, Brazil
[2] University of the Basque Country (UPV/EHU), San Sebastián, Spain
(corresponding author: wanderleia.silva3@estudante.ufla.br)

Lignin nanoparticles have emerged as promising sustainable materials for agricultural applications, particularly as carriers for controlled release systems. However, their environmental safety must be evaluated prior to large-scale use. In this study, the phytotoxicity of eucalyptus kraft lignin nanoparticles (KLNP) was assessed through seed germination assays using *Eruca sativa*, a widely recognized bioindicator due to its sensitivity and rapid physiological response[1]. Seeds were exposed to aqueous dispersions of NPLK at different concentrations (0.004-0.08 mg/mL) for 2 hours, followed by incubation under controlled conditions. Germination rate (G7), seedling height, diameter, and fresh mass were evaluated after 7 days. Statistical analysis was performed using ANOVA followed by Tukey's test ($p < 0.05$). All treatments exhibited germination rates above 95%, with no statistically significant differences compared to the control, indicating that KLNP did not negatively affect seed germination. Morphological parameters, including seedling height and diameter, also showed no significant variation among treatments. Although a slight reduction in fresh mass was observed in treated samples, this effect was not statistically significant and may be attributed to natural variability or osmotic effects rather than toxicity[2]. These findings are consistent with previous studies reporting low phytotoxicity of lignin-based nanomaterials in plant systems[1,2]. Overall, the results demonstrate that KLNP exhibit good biocompatibility with plant systems, supporting their potential application in sustainable agriculture, particularly in the development of eco-friendly delivery systems for bioactive compounds.

Acknowledgments

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P-56

Cellulose Nanofibers as a Strategy for Microstructural Control in Rigid Polyurethane Foam

P. A. Silveira da Silva[1], P. H. G. Cademartori[1], R. A. Delucis[2], A. P. Acosta[1], J. Labidi[3]

[1] Federal University of Paraná (UFPR), Curitiba, Brazil
[2] Federal University of Pelotas (UFPel), Pelotas, Brazil
[3] University of Basque Country, San Sebastián, Spain
(corresponding author: paulo.alexandre@ufpr.br)

This study investigates the use of cellulose nanofibrils (CNF) as a strategic tool for microstructural control in bio-based rigid polyurethane (RPUF) foams, aiming to overcome the mechanical and thermal limitations of sustainable polymer matrices. In this context, incorporating nanocellulose into PU matrices has proven to be an effective strategy for improving material performance while adding a sustainability aspect to the product[1].Two distinct CNF processing methods were compared: solvent exchange (liquid dispersion) and spray-drying (SD-CNF). The nanocomposites were synthesized with CNF loadings of 0.1%, 0.5%, and 1.0% wt. Scanning electron microscopy (SEM) revealed that CNF acts as a potent nucleating agent, significantly refining the cellular architecture. While solvent-exchanged CNF promoted highly uniform, smaller closed cells with nanofibers seamlessly integrated into the cell walls (struts), the SD-CNF samples exhibited micro-agglomerates that acted as structural defects, leading to a less homogeneous pore distribution. FTIR analysis confirmed the formation of urethane linkages (1730 cm^{-1}) and suggested stronger chemical anchoring between the individualized CNF and the isocyanate groups. Statistically, the solvent-exchange method proved superior: the 0.1% CNF nanocomposite exhibited significant increase in compressive strength compared to neat RPUF, significantly outperforming the SD-CNF samples, which suffered from stress concentration due to fiber cornification. Thermogravimetric analysis (TGA/DTG), showing that the incorporation of CNF promotes a slight improvement in the thermal stability of PU, attributed to restriction of the mobility of the polymer chains. DTG curves reveal changes in the degradation mechanisms, indicating interaction between the polymer phase and the nanofibers. Samples with SD-CNF show more pronounced changes in the degradation profiles, suggesting greater structural heterogeneity. These results demonstrate that the effectiveness of nanocellulose as a reinforcement depends strictly on the processing-induced dispersion, positioning the solvent-exchange strategy as the most viable route for high-performance, bio-based structural insulation materials.

Acknowledgments

We thank UFPR, UPV, PIPE, CAPES, as well as our colleagues and advising professors.

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P-57

Controlled Microfluidic Synthesis of Lignin Nanocarriers for Lipophilic Active Encapsulation

T. Tanisha, A. Eceiza, O. Gordobil

'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering Gipuzkoa, University of the Basque Country (UPV/EHU), Plaza Europa 1, 20018 Donostia / San Sebastián, Spain
(corresponding author: oihana.gordobil@ehu.eus)

The field of lignin nanotechnology has gained increasing attention due to the growing demand for sustainable, biobased, and safe materials for industrial and cosmetic applications. Lignin, one of the primary structural constituents of wood, is a highly abundant natural aromatic polymer with intrinsic multifunctional protective properties, including antioxidant and UV-absorbing potential[1,2].The physicochemical properties of lignin nanomaterials strongly depend on lignin origin, structure and the fabrication process. This work aims to synthesize lignin nanoparticles (LNPs) from various lignin sources using microfluidic technology to achieve controlled particle formation, suitable for topical applications.The effect of lignin molecular structure, concentration, solvent system, and flow-rate ratios on particle size, surface charge, and morphology is investigated using DLS and TEM. Controlled mixing under optimized process conditions resulted in spherical and well-defined LNPs, which are appropriate for skin-related applications. Preliminary cosmetic-relevant evaluations, including antioxidant activity, photoprotective potential, thermal stability, and encapsulation capacity of lipophilic vitamins are performed. Overall, this work provides a versatile platform for the design and optimization of lignin-based nanoparticles using microfluidic technology for cosmetic applications, supporting the development of eco-friendly, functional, and high-performance nanocarriers for next-generation skin care products.

Acknowledgments

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P-58

Technical Pathways in Lithium-Ion Battery Recycling: A Comparative Analysis of Pyrometallurgy, Hydrometallurgy, and Direct Regeneration

N. Zabalegui[1], A. Retegui[1], S. Torresi[2], A. Eceiza[1], R. Fernández[1]

[1] 'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering Gipuzkoa, University of the Basque Country (UPV/EHU), Plaza Europa 1, 20018 Donostia / San Sebastián, Spain

[2] BioTeam/ICPEES-ECPM, UMR CNRS 7515, Université de Strasbourg, 25 Rue Becquerel, 67087 Strasbourg Cedex 2, France

(corresponding author: nzabalegui002@ikasle.ehu.eus)

The rapid growth of electric mobility and energy storage has driven up demand for lithium-ion batteries, generating a critical volume of end-of-life waste[1-3]. Given the severe socio-environmental impacts of primary extraction in the "Lithium Triangle," the concept of urban mining has emerged as a mitigating alternative. However, the core of this transition lies in the development of recovery and recycling technologies. This study analyzes the three main approaches currently in use. Pyrometallurgy, based on melting at over 1000°C to obtain Ni-Co-Cu alloys, is robust but requires high energy input and generates emissions. Hydrometallurgy involves acid leaching and selective precipitation, successfully recovering pure Li, Ni, Co, and Mn salts with efficiencies exceeding 90% and lower environmental impact. Finally, direct recycling is highlighted as a trend that restores cathode materials without dissolving them, drastically minimizing the energy required and waste generated. Optimizing these methods is essential for consolidating the circular economy.

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Enzymatic Surface Nanostructuring of Biopolymer-Silica Hybrid Materials

A. Etchecopar[1,2], C. Courreges[1], S. Nolivos[1], R. Grimaud[1], J. Allouche[1], N. Gabilondo[2]

[1] IPREM, University of Pau and Pays de l'Adour, CNRS, Pau, France
[2] University of the Basque Country, GMT, Faculty of Engineering, San Sebastian, Spain
(corresponding author: al.etchecopar@univ-pau.fr)

Sustainable polymer engineering requires low-impact strategies to tailor surface properties at the nanoscale. Conventional strategies to generate porosity often rely on energy and chemical-intensive template removal steps. In this context, enzymatic processes could offer a selective and environmentally friendly alternative, yet their role in structuring hybrid polymer materials remains insufficiently understood[1].

Here, we investigate the enzymatic nanostructuring of gelatin-silica hybrid thin films, combining a bio-based polymer phase with an inorganic network. Films were prepared by dip-coating using gelatin and tetraethyl orthosilicate, and treated with extracellular proteases from the marine bacterium Alteromonas macleodii, enabling selective degradation of the organic phase under mild conditions[2].

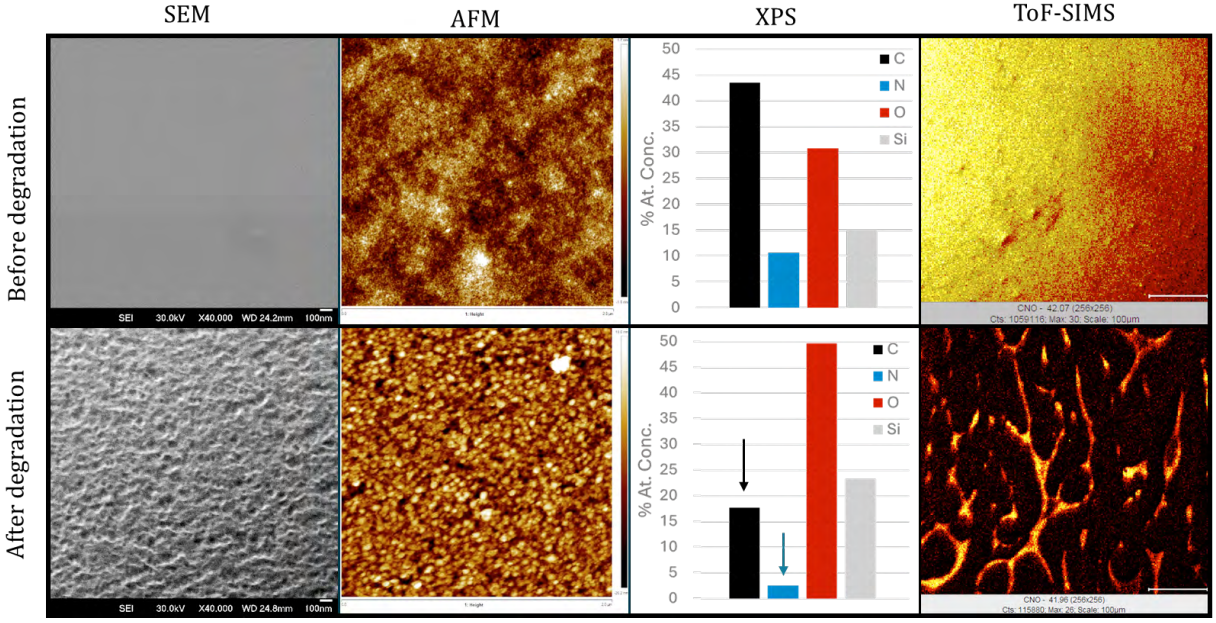

Figure 1

SEM, AFM, XPS, and ToF-SIMS characterization of gelatin-silica hybrid films before and after enzymatic degradation

A correlative surface analysis approach combining electron microscopy, atomic force microscopy, X-ray photoelectron spectroscopy, and Time of Flight-Sencondary Ions Mass Spectrometry revealed the progressive formation of nanoscale porosity, along with a depletion of organic components and a relative enrichment of silica at the outer surface.

These results show that enzymatic treatment can induce nanostructuring of hybrid polymer interfaces and highlight its potential as a sustainable strategy for designing functional polymer surfaces.

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Evaluating Biodegradable Polyemrs as a Marine Safe Materials Using LCA Methodology

M. Iturrondobeitia[1,2], E. Rodriguez-Hortelano[1,2], H. Afonso[1], C. Alfaro[1], J. Ibarretxe[1,2]

[1] Life Cycle Thinking Group, Department of Graphic Design and Engineering Projects, Faculty of Engineering in Bilbao, University of the Basque Country (UPV/EHU), Bilbao 48013, Spain
[2] Research Centre for Experimental Marine Biology and Biotechnology, Plentziako Itsas Estazioa (PIE), University of the Basque Country (UPV/EHU), Plentzia, Spain
(corresponding author: maider.iturrondobeitia@ehu.eus)

The accumulation of persistent plastics in marine environments highlights the need for materials with reduced ecological burdens. This study evaluates biobased and biodegradable polymers and their blends (polylactic acid, PLA; polyhydroxybutyrate PHB, polyethylene, HDPE, etc) as a bio based, biodegradable alternative to petrochemical polymers for marine applications. Components were manufactured via compression and injection molding. Then, Life cycle assessment (LCA), conducted according to state of the art Product Category Rules, shows that PHB offers substantially lower eco costs (2.02 €/kg) and an exceptionally low impact in Physical Effect on Biota (13,511 PAF · m³ · day/kg emitted) compared with petrochemical polymer based materials, such as PA and PP. These results indicate a markedly reduced potential for physical harm to marine organisms. End of life analysis under real marine conditions is also performed. Overall, PHB emerges as a technically viable and environmentally superior material for marine related applications compared to other biobased and biodegradable polymers and their composites.

Figure 1

Flow char of the conducted research

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Development of Sustainable Biocomposites Using Bio-Based Polyesters and Natural Fibres

H. G. Saraiva[1], J. Braz[1], A. I. C. Romeiro[1], M. A. F. F. Reis[1], R. C. Rebelo[1], R. Moreira[2], A. C. Fonseca[1]

[1] CEMMPRE, ARISE, Department of Chemical Engineering, University of Coimbra, Rua Sílvio Lima-Pólo II, 3030-790 Coimbra, Portugal
[2] CERES, Department of Chemical Engineering, University of Coimbra, Rua Sílvio Lima-Polo II, 3030-790 Coimbra, Portugal
(corresponding author: henriquesaraiva4@gmail.com)

Due to the growing demand for sustainable materials and stricter environmental regulations, the development of renewable solutions for the automotive industry is gaining attention. In this context, the valorisation of agro-industrial residues represents an attractive strategy to produce bio-based reinforcement materials. In Portugal, rice husk and corn cob are widely available residues, particularly in the central and Alentejo regions, and represent valuable sources of cellulose[1]. The aim of this work was to extract cellulose fibres from these residues and incorporate them into biodegradable polyester matrices to produce sustainable biocomposites. Cellulose was extracted by conventional methods and incorporated into poly(butylene adipate terephthalate) (PBAT), poly(butylene succinate) (PBS) and poly(lactic acid) (PLA), processed by micro-extrusion followed by injection moulding[2,3]. Morphological analysis confirmed adequate dispersion of cellulose fibres within the polymer matrices. Mechanical testing showed improved properties for composites containing extracted cellulose compared with untreated residues or unreinforced materials. PBS composites containing 30 wt% cellulose derived from rice husk exhibited mechanical behaviour comparable to some fossil-based materials (E = 1098 ± 62.49 MPa, σ_{max} = 24.07 ± 3.33 MPa, ε_b = 4.43 ± 0.37). These results highlight the potential of extracted cellulose from agro-industrial residues as reinforcement for biodegradable polyester composites, contributing to circular economy strategies and sustainable automotive materials.

Acknowledgments

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Bio-Based Crosslinked Nipus from Epoxidized Soybean Oil with Diels-Alder Reversible Networks

L. Ezquerra Riega, M. d. M. Cammarata, A. C. Restrepo Montoya, A. Saralegi, A. Eceiza

'Materials + Technologies' Group (GMT), Department of Chemical and Environmental Engineering, Faculty of Engineering Gipuzkoa, University of the Basque Country (UPV/EHU), Plaza Europa 1, 20018 Donostia / San Sebastián, Spain
(corresponding author: lucasnicolas.ezquerra@ehu.eus)

Vegetable oil-based non-isocyanate polyurethanes (NIPUs)[1,2] incorporating reversible Diels–Alder linkages[3] are promising sustainable and recyclable materials. This work presents the development of three crosslinked soybean oil-based NIPUs with dynamic furan–maleimide networks. Furfuryl glycidyl ether was carbonated with CO_2 and reacted with a trismaleimide to obtain a furan–maleimide crosslinker. Carbonated epoxidized soybean oil was then mixed with the crosslinker at different ratios (100/0, 70/30, 50/50, and 30/70) and subsequently polycondensed with a triamine at 100 °C and 50 bar for 24-48 h (Figure 1).

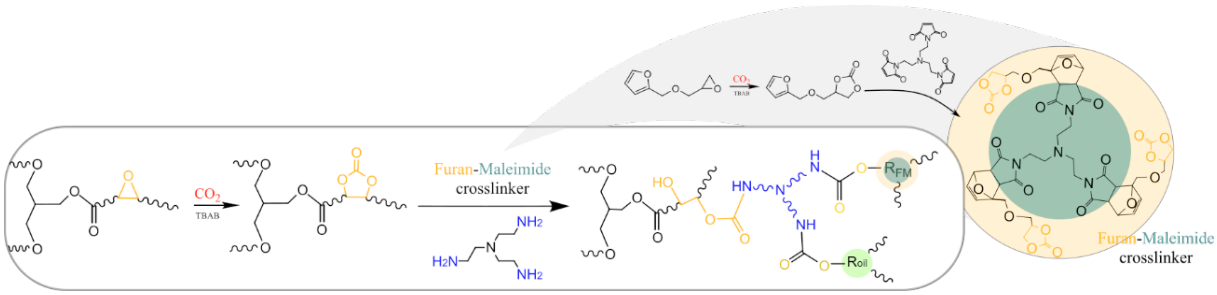

Figure 1

Summary of the synthetic pathway. R_{FM} = Furan-Maleimide adduct; R_{oil} = soybean oil structure

NIPUs cured at 100 °C for 48 h showed higher stiffness and lower elongation with increasing crosslinker content. However, DSC revealed the loss of the retro-Diels–Alder transition for the 50/50 and 30/70 formulations, indicating irreversible side reactions during curing, whereas the 70/30 formulation retained network reversibility. These results highlight the need to optimize curing conditions to balance mechanical performance and recyclability.

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