The 13th International Conference on Fiber and Polymer Biotechnology

IFPB2026

Genova, Italy

August 26-28, 2026

Book of Abstracts



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Welcome to IFPB2026!

The organizing committee of IFPB2026, the 13th International Conference on Fiber and Polymer Biotechnology, is very pleased to welcome you at the University of Genova, Italy, during August 26-28, 2026 to discuss the most recent advances in textiles, fiber and polymer biotechnology.

The International Conference on Fiber and Polymer Biotechnology (IFPB) focuses on research and development of biotechnology, enzyme technology and bioprocesses applied to fibers and polymers. It is an internationally consolidated Congress, which is in its thirteenth Edition and has been carried out so far in nine countries and three continents.

The scope of the International Conference on Fiber and Polymer Biotechnology is to promote the scientific, professional and social exchange between researchers, students, research institutes, governmental entities and industries who are active in the field of textiles, fiber and polymer biotechnology. Its objective is to contribute to the growth and consolidation of the scientific community and the technological development in these fields through scientific education and formation of a critical mass of graduate and post-graduate students and future professionals in this area, by means of dissemination and publication of scientific academic and technological works.

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Programme overview

August 26th		August 27th		August 28th	
10.00	Registration	09.00	PL02	09.00	PL04
11.15	IFPB2026 opening	09.40	OC07	09.40	KN05
11.30	PL01	10.00	OC08	10.10	OC16
12.10	KN01	10.20	OC09	10.30	OC17
12.40	OC01	10.40	Coffee break	10.50	Coffee break
13.00	Lunch	11.10	PL03	11.20	OC18
14.20	KN02	11.50	OC10	11.40	OC19
14.50	OC02	12.10	OC11	12.00	OC20
15.10	CO01	12.30	OC12	12.20	CO03
15.30	IL01	12.50	Lunch	12.40	Lunch
15.50	Coffee break	14.10	KN03	14.00	OC21
16.20	OC03	14.40	IL02	14.20	OC22
16.40	OC04	15.00	OC13	14.40	Closing remarks
17.00	OC05	15.20	OC14	15.00	End of the event
17.20	OC06	15.40	Coffee break		
17.40	Poster session	16.10	KN04		
		16.40	OC15		
		17.00	CO02		
		17.20	Group photo		
		17.30	City tour		
		20.30	Dinner		

PL	Plenary Lecture	KN	Keynote Lecture	IL	Invited Lecture
CO	Company present.	OC	Oral Contribution	PS	Poster session

Conference programme

DAY 1 – Wednesday **August 26th**

Location: University of Genova, Palazzo dell'Ateneo, Via Balbi 5, main lecture hall

10.00	**Registration & Welcome coffee**
11.15	**IFPB2026 Conference opening**
Session 1 – Plastics biorefinery, depolymerization & recycling/upcycling **Chairs: Ale Pellis & Orietta Monticelli**	
11.30	**PL01 – Cristiano Varrone** **Aalborg University, Denmark** Techno-economic considerations on plastics biorefineries
12.10	**KN01 – Giacomo Damonte** **University of Genova, Italy** Enzymes as effective tools for the depolymerization of non-conventional polyester-based systems
12.40	**OC01 – Chiara Siracusa** **BOKU University, Austria** Selective enzymatic recycling to close the loop of novel synthetic polyesters blends
13.00	**Lunch**
14.20	**KN02 – Myleidi Vera Otero** **University of Concepcion, Chile** Enzymatic polymerization of biomass-derived polyphenols
14.50	**OC02 – Felice Quartinello** **BOKU University, Austria** Fantastic enzymes and where to apply them: selective polymer separation and biotechnological upcycling

15.10	**CO01 – Erika Tarro Genta** **BUCHI, Italy** BUCHI: integrated solutions for efficient and reproducible lab processes
15.30	**IL01 – Mario Bonaccorso** **SPRING, Italy** The circular bioeconomy for a competitive, innovative and resilient European Union
15.50	**Coffee break**
Session 2 – Enzymatic polymerization **Chair: Anamaria Todea**	
16.20	**OC03 – Ioana Cristina Benea** **Politehnica Timisoara, Romania** Biocatalytic synthesis of functional polyesters from dimethyl L-malate and aliphatic diols
16.40	**OC04 – Cicely May Warne** **University of Pisa, Italy** Sustainable enzymatic polycondensation of vanillin-based semi-aromatic polyesters in green solvents
17.00	**OC05 – Lena Graf** **Johannes Kepler University Linz, Austria** Investigation of sterically-demanding neopentyl glycol in enzyme catalyzed polyester synthesis
17.20	**OC06 – Francesco Papatola** **University of Genova, Italy** Thermostable polyester hydrolases as emerging CaLB alternatives for enzymatic synthesis
17.40	**Poster session & Welcome Aperitivo**

DAY 2 – Thursday **August 27th**

Location: University of Genova, Palazzo dell'Ateneo, Via Balbi 5, main lecture hall

Session 3 – Enzymes for textile processing **Chair: Felice Quartinello**	
09.00	**PL02 – Sonja Salmon** **North Carolina State University, USA** Enzymatic refining of textile cotton waste
09.40	**OC07 – Jinsong Shen** **De Montfort University, United Kingdom** Enzymatic biotechnology for recovery and reuse of wool blended textile waste
10.00	**OC08 – Jeannie Egan** **JRC ReSTex, Austria** Exploring the effects of agitation on cellulase performance for cotton fiber hydrolysis in textile substrates
10.20	**OC09 – Clemence Belbeoch** **De Montfort University, United Kingdom** Selective enzymatic extraction of wool fibres' regions and fabrication of regenerated wool composites
10.40	**Coffee break**
Session 4 – Biotechnology for medical and cosmetic applications **Chair: Georg M. Guebitz**	
11.10	**PL03 – Manfred Zinn** **HES-SO Valais, Switzerland** Nature's PHA tailor-made for medical applications
11.50	**OC10 – Madalena Martins** **Solfarcos LDA, Portugal** Enzymatic polymerization for hair styling

12.10	**OC11 – Kenzo Koike** **Kobe Shoin Wemen University, Japan** Observation of hair structure using a simple digital microscope and its application to hair care
12.30	**OC12 – Camilla Mazzanti** **National Research Council, Italy** Advanced enzymatic and ionic crosslinked hydrogel as a tailored natural bioink for chronic wound management
12.50	**Lunch**
Session 5 – Biotechnological valorization of the lignocellulosic feedstock **Chair: Artur Cavaco-Paulo**	
14.10	**KN03 – Matteo Gigli** **Ca' Foscari University of Venice, Italy** Tailoring lignin properties via biocatalytic approaches for advanced materials applications
14.40	**IL02 – Jun-Ichi Kadokawa** **Kagoshima University, Japan** Chemoenzymatic synthesis of polysaccharide-grafted functional polymeric materials
15.00	**OC13 – Chiara Danielli** **University of Trieste, Italy** Hydrophobization of cellulose materials by means of thermal infrared activation
15.20	**OC14 – Sebastian Mayr** **BOKU University, Austria** Biomodified technical lignin for high-value applications
15.40	**Coffee break**

Session 6 – Computational tools applied to fiber and polymer biotechnology Chair: Lucia Gardossi	
16.10	**KN04 – Anamaria Todea** **Politehnica Timisoara, Romania** Computational guided biocatalysis for sustainable polymer synthesis
16.40	**OC15 – Artur Manuel Cavaco-Paulo** **Solfarcos LDA, Portugal** Molecular dynamics and beyond: computational insights in cosmetics research
17.00	**CO02 – Miguel Angel Bayo Valero** **BASF, Germany** Molecular determinants of nylonase efficiency
17.20	**IFPB2026 Group photo**
17.30	**Genova city tour** Meeting point for the city tour: main entrance of the conference location.
20.30	**IFPB2026 Conference dinner** Ristorante I Tre Merli al Porto Antico Calata Cattaneo, 17 - 16128 Genova

DAY 3 – Friday August 28th

Location: University of Genova, Palazzo dell'Ateneo, Via Balbi 5, main lecture hall

Session 7 – BIO-session (biobased, biosynthesis, biochar, etc.) Chair: Manfred Zinn	
09.00	**PL04 – Per-Olof Syren** **KTH Royal Institute of Technology, Sweden** Circular bio-based materials by enzyme catalysis
09.40	**KN5 – Keiji Numata** **RIKEN and Kyoto University, Japan** Biosynthesis and molecular design of spider silk
10.10	**OC16 – Silvana Alfei** **University of Genova, Italy** Laccase-bamboo biochar-based column systems remove efficiently hazardous dyes from water by electrostatic absorption and O_2-supported bimodal oxidative degradation
10.30	**OC17 – Asja Feruglio** **Università Vanvitelli, Italy** Crosslinking of chitosan: bio-based alternatives to glutaraldehyde
10.50	**Coffee break**

Session 7 – BIO-session (biobased, biosynthesis, biomaterials, biochar, etc.) Chair: Giacomo Damonte	
11.20	**OC18 – Francesca Stella** **Politecnico di Torino, Italy** From post-consumer textiles to biobased polymers: step-wise conversion and life cycle impact
11.40	**OC19 – Loris Savino** **University of Bari Aldo Moro, Italy** Waste-to-Biomaterial: circular bioeconomy-driven bacterial cellulose production via SCOBY Kombucha fermentation
12.00	**OC20 – Giulia Fichera** **University of Naples "Federico II", Italy** Self-assembling fungal protein as functional building blocks for reinforced biopolymer fibres
12.20	**CO03 – Camilla Fantasia** **SRA Instruments, Italy** From pyrolysis to infrared spectroscopy: a multi-instrumental workflow for integrated analytical solutions in the characterization of biopolymers, fibers and biobased and/or biodegradable polymeric materials
12.40	**Lunch**

Session 7 – BIO-session (biobased, biosynthesis, biomaterials, biochar, etc.) Chair: Giacomo Damonte	
14.00	**OC21 - Mattia Colacicco** **University of Bari Aldo Moro, Italy** From lignocellulose to polylactic acid: an integrated second-generation biorefinery approach
14.20	**OC22 – Jürgen Andreaus** **Universidade Regional de Blumenau, Brasil** Lignin as sustainable colorant for textile dyeing
14.40	**Awards & Closing remarks**
15.00	**End of the event**


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List of the abstracts presented as oral communications

PL01 - Techno-economic considerations on Plastic Biorefineries

Cristiano Varrone[a]

[a] Aalborg University, Department of Chemistry and Bioscience. Fredrik Bayers Vej 7H, 9220 Aalborg, DK

E-mail: cva@bio.aau.dk

Plastic production has been increasing exponentially with a 20-fold increase in the last 60 years and predictions of a further 4-fold increase in the next 25 years. Yet, the End-of-Life of plastic waste shows a broadly inefficient system and still linear value-chain, with only 9% being recycled on a global scale[1]. Moreover, 99% of plastics are obtained from non-renewable feedstock and estimations suggest that we will be using up to 20% of all fossil resources just to produce plastics[2].

Plastic Biorefineries could in principle contribute to improving the sustainability of the plastic sector by 1) providing renewable plastics (obtained through fermentation technologies), 2) depolymerize currently challenging mixed plastic waste through enzymatic depolymerization, and 3) improve economic viability through bioupcycling[3]. Nonetheless, most of these technologies are still under development and often validated only in small-scale[4]. The EU Horizon projects UPLIFT and UPCYCLE have been addressing these issues, investigating the main technical and economic barriers for scalability of plastic biorefineries, aiming to scale up the best technology to TRL7. This will provide a unique opportunity to validate the viability of these approaches in industrially relevant conditions, while identifying the major economic and/or environmental challenges that need to be overcome to bring plastic biorefineries closer to the market. Techno-economic analysis digital twins will be used as a decision-making tool to decide which technology to scale up and identify the best integration of technologies for a plastic biorefinery able to handle real mixed plastic waste.

Acknowledgements

This work has been supported by the H2020 UPLIFT [Grant no 953073] and the Horizon Europe IA UPCYCLE project [Grant no 101178389].

References

[1] OECD, Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options, OECD Publishing, Paris, 2022, https://doi.org/10.1787/de747aef-en.
[2] European Environmental Agency. Plastics, the Circular Economy and Europe0s Environment—A Priority for Action; European Environmental Agency: Copenhagen, Denmark, 2021
[3] Lomwongsopon and Varrone. Critical review on the progress of plastic bioupcycling technology as a potential solution for sustainable plastic waste management. Polymers, 2022, 14(22):4996
[4] Roux and Varrone. Assessing the economic viability of the plastic biorefinery and its contribution to a more circular plastic sector. Polymers; 2021, 13, 3883.

KN01 - Enzymes as effective tools for the depolymerization of non-conventional polyester-based systems

Giacomo Damonte[a], Martina Cozzani[a], Alessandro Fortunato[a], Leonardo Giribaldi[a], Maria Jose Calandri[a], Alessandro Pellis[a], Orietta Monticelli[a]

[a] Università degli Studi di Genova, Dipartimento di Chimica e Chimica Industriale, Via Dodecaneso 31, 16146, Genova, Italy

E-mail: giacomo.damonte@edu.unige.it

Despite the growing use of bioplastics as sustainable alternatives to oil-based polymers, their end-of-life management still represents a major challenge [1]. Although some of them, such as poly(lactic acid) (PLA) and poly(hydroxyalkanoates) (PHAs), are often considered biodegradable, many of their derivatives still fail to degrade sufficiently under conventional composting conditions. Moreover, their recovery through mechanical recycling is often hindered by significant drops in thermal and mechanical performance, while alternative approaches such as pyrolysis or reactive extrusion typically rely on energy-intensive or hazardous processes. In this scenario, chemoenzymatic depolymerization has emerged as a promising strategy for the circular recovery of value-added monomers and oligomers under mild conditions. This contribution discusses the application of hydrolase enzymes, with a specific focus on *Humicola insolens* cutinase (HiC), to the degradation of structurally diverse bio-based polymer systems, including linear, star-shaped, crosslinked materials derived from bio-based polymers [2]. Particular attention is also given to how polymer architecture affects enzymatic accessibility and degradation behavior in relation to crosslinking density, hydrophobicity, and network structure. The presented results show how relatively simple enzymatic degradation experiments can provide useful information on the degradability of polymer systems with very different structural organizations, while also enabling the recovery of functional oligomers and monomers.

References

[1] V. Jašek, S. Figalla, R. Přikryl, Upcycling of Commercial Biobased Polyester Bioplastics—turning used or spoiled materials into added-value products, ACS Polym. Au (2026).

[2] G. Damonte, M. Cozzani, M. Ozenda, C. Siracusa, M.J. Calandri, A. Pellis, G.M. Guebitz, O. Monticelli, Environmentally friendly upcycling of PHA-based copolymers, Int. J. Biol. Macromol. 319 (2025) 145457.

OC01 - Selective enzymatic recycling to close the loop of novel synthetic polyesters blends

Chiara Siracusa[a], Felice Quartinello[a,b], Michelina Soccio[c], Nadia Lotti[c], Georg M. Guebitz[a,b], Alessandro Pellis[d]

[a] Institute of Environmental Biotechnology, Department of Agricultural Sciences, BOKU University Konrad-Lorenz-Strasse 20, 3430 Tulln an der Donau, Austria.
[b] acib GmbH, Konrad-Lorenz-Strasse 20, 3430 Tulln an der Donau, Austria.
[c] Department of Civil, Chemical, Environmental and Materials Engineering (DICAM), University of Bologna, Italy
[d] Department of Chemistry and Industrial Chemistry, Università degli Studi di Genova, Via Dodecaneso 31, 16146 Genova, Italy

E-mail: chiara.siracusa@boku.ac.at

Packaging leads European plastics market, accounting for about 39% of total production [1]. To meet performance and cost-effectiveness while advancing biobased content and biodegradability, researchers efforts focus on novel materials based on polymer blends [2]. Among next-generation polyesters, those derived from 2,5-furandicarboxylic acid (FDCA), renewable counterpart to fossil-derived terephthalic acid (TPA), are promising competitors for packaging applications. As an example, combining poly(pentamethylene 2,5-furandicarboxylate) (PPeF) with poly(lactic acid) (PLA) in physical blends and block copolymers reduces PLA brittleness and improves biodegradability, while retaining biocompatibility and fully biobased derivation [3]. Nevertheless, blended materials complicate end-of-life recycling due to component separation and monomer recovery challenges.
We suggest an enzymatic route to enable selective depolymerization and scalable monomer recovery from both FDCA- and TPA-based polyesters. Using the cutinase from *Thermobifida cellulosilytica* (Thc_Cut1) [3], the furan component in PPeF/PLA blends was preferentially hydrolysed. FDCA was recovered from the hydrolysate *via* a straightforward workflow namely stepwise acidification and solid/liquid separation. Extending the approach to TPA-based materials, TPA from PET and PBAT hydrolysates was 80–95% pure. Also when applied to mixed waste streams, TPA was recovered in high yield, ~20–25% of the initial mass. Both FDCA and TPA obtained enzymatically were successfully used to resynthesize their respective polymers [4].
Collectively, these results demonstrate that enzyme-enabled hydrolysis can deliver selective, high-yield depolymerization and high-purity monomer recovery across complex polyester matrices, including blends and contaminated waste without extensive pretreatments.

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[2] Parameswaranpillai, Jyotishkumar & Thomas, Sabu & Grohens, Yves. (2014). Polymer Blends: State of the Art, New Challenges, and Opportunities. 10.1002/9783527645602.ch01.
[3] Siracusa, C. et al. On the Selective Enzymatic Recycling of Poly(pentamethylene 2,5-furanoate)/Poly(lactic acid) Blends and Multiblock Copolymers. ACS Sustain. Chem. Eng. 11, 9751–9760 (2023). https://doi.org/10.1021/acssuschemeng.3c01796
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KN02 - Enzymatic polymerization of biomass-derived polyphenols

Myleidi Vera[a], Edison Monrroy[a], Lisette Lagos[a], Romina Romero[b]

[a] Universidad de Concepción, Department of Polymers, Edmundo Larenas 129, 4070371, Chile
[b] Universidad de Concepción, Department of Analytical and Inorganic Chemistry, Edmundo Larenas 129, 4070371, Chile

E-mail: mylevera@udec.cl

Sustainable polymer science requires the convergence of renewable feedstocks and environmentally benign catalytic processes. Biomass-derived polyphenols constitute a versatile molecular platform capable of generating functional materials with inherent antioxidant and photoprotective properties. Yet, unlocking their full potential demands controlled polymerization strategies compatible with green chemistry principles.
This contribution explores enzymatic polymerization as a green strategy for transforming natural polyphenols into functional polymer networks, together with a critical discussion of structure–property relationships, biomass heterogeneity, and current scalability challenges. Laccase-mediated oxidative coupling reactions enable polymer formation under mild, aqueous, and oxygen-driven conditions, avoiding toxic reagents and reducing energy consumption. Enzymatic grafting and copolymerization with biopolymers such as chitosan enable the fabrication of bio-based films with enhanced mechanical strength, improved thermal stability, and retained antioxidant functionality.
The resulting materials demonstrate significant potential for sustainable applications, including active packaging, greywater treatment, removal of emerging contaminants, and protective coatings. These findings highlight enzymatic catalysis as a key enabling technology for integrating biomass valorization with circular polymer design.

Acknowledgments
Myleidi Vera thanks ANID Fondecyt Iniciación 11251670 for the financial support.

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[2] M. Vera, C. Mella, Y. García, V.A. Jiménez, B.F. Urbano, Recent advances in tannin-containing food biopackaging, Trends Food Sci. Technol. 133 (2023) 28–36.

OC02 - Fantastic enzymes and where to apply them: selective polymer separation and biotechnological upcycling

Felice Quartinello[a], Chiara Siracusa[a], Florent Pruvost[a] and Georg Guebitz[a]

[a] Institute of Environmental Biotechnology, Department of Agricultural Sciences, BOKU University, Vienna, Konrad Lorenz-Strasse 20, 3430 Tulln an Der Donau, Austria

E-mail: felice.quartinello@boku.ac.at

The increasing accumulation of heterogeneous polymer-based waste streams presents significant environmental and technological challenges, particularly when materials consist of blends, that are difficult to separate using conventional recycling methods. This work shows biotechnological approaches for the selective separation, depolymerization, and valorization of mixed polymer materials, with a focus on enzymatic processing and subsequent biopolymer production.

Natural polymers such as cellulose-based materials differ in chemical structure from synthetic polymers such as polyesters and polyamides, enabling selective enzymatic degradation. Enzymes including cellulases, amylases and proteases can hydrolyze natural polymer components under mild process conditions without damaging second polymer fractions. Compared to mechanical and chemical recycling methods, enzymatic processes operate at lower temperatures, require fewer hazardous chemicals, and preserve the quality and mechanical properties of recovered synthetic polymers[1].

The hydrolysis products, containing the various building blocks and oligomers, will be further utilized as substrates in microbial fermentation processes. These biotechnological conversion pathways enable the production of value-added bio-based materials such as polylactic acid, polyhydroxyalkanoates, bacterial cellulose and chemicals for bio plasticizer formulations[2]. This integrated approach links polymer separation with biotechnological upcycling and supports the development of circular material systems. Overall, enzymatic separation combined with microbial conversion represents a promising strategy for transforming complex polymer waste into valuable bio-based products while reducing environmental impact, energy demand, and reliance on fossil-based resources.

References

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CO01 - BUCHI: integrated solutions for efficient and reproducible lab processes

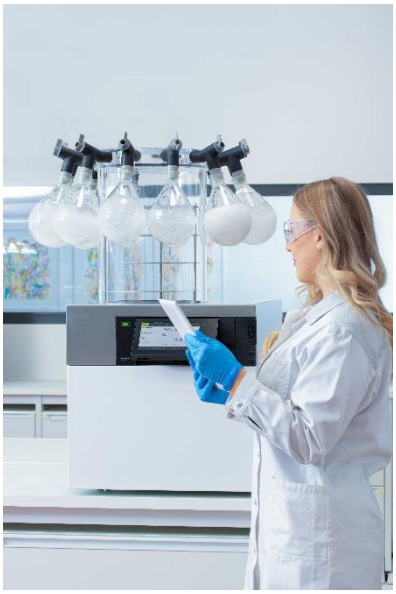
Erika Tarro Genta[a]

[a] BUCHI ITALIA S.R.L. Via Galileo Galilei,34 - 20007 Cornaredo (MI), Italy

E-mail: tarrogenta.e@buchi.com

This presentation introduces BUCHI's integrated solutions designed to improve efficiency, reproducibility, and sustainability in Pharma-Chem laboratory workflows. By combining advanced instrumentation with intuitive and user-friendly software, BUCHI enables laboratories to achieve consistent and reliable results across sample preparation and process optimization. The session will highlight how integrated lab solutions can streamline daily operations, reduce manual errors, and enhance data traceability. Ultimately, these capabilities support higher productivity, better decision-making, and elevated quality standards in both research and industrial Pharma-Chem environments.





IL01 - The circular bioeconomy for a competitive, innovative and resilient European Union

Mario Bonaccorso[a]

[a] Director Cluster SPRING, Italian Circular Bioeconomy Cluster, via Bergognone 34, 20144, Milano, Italy

E-mail: mario@clusterspring.it

It is now widely recognized that the circular bioeconomy represents a real global opportunity to regenerate regions and foster innovation by connecting multiple value chains. It is no coincidence that it was included in the Clean Industrial Deal (CID), officially presented by the European Commission in February 2025. In the same year, in November, the European Commission also published its new Bioeconomy Strategy: "A strategic framework for a competitive and sustainable EU bioeconomy" [1]. The circular bioeconomy is a key tool in European strategies and policies to fight climate change and increase the competitiveness of Italy and Europe.
To achieve the transition to a circular and regenerative bioeconomy, bio-based products must be used as key tools for "doing more with less," overcoming the overexploitation of resources, pollution problems, and closing the carbon cycle. To this end, there are three priorities:

I. Promoting reuse, recycling, and recovery

Generating new raw materials (secondary raw materials) for production chains, reducing the extraction of primary raw materials.

II. Using bio-based products to trigger a cultural shift

Redesigning the way materials are produced, consumed, and disposed of, encouraging the growth of high-value-added multi-product supply chains.

III. Reduce water and soil degradation and pollution

Use biodegradable products for applications where there is a high risk of environmental accumulation and to avoid wasting valuable organic matter.

The global race for leadership in biotechnology and the bioeconomy has begun, and Europe's competitors are moving quickly. We risk losing a huge strategic resource for Europe, in terms of competitiveness, skilled employment, economic growth, income opportunities for farmers, fishermen, and foresters, local communities and regions, and local supply chains, not to mention the sustainability of these technologies.

Today, Europe has (at least) two "valleys of death": 1. Investments for industrial-scale growth, with a very low number of VCs focused on this sector; 2. Regulations that slow down approval processes and limit the development of startups or force them to relocate outside Europe. The second is deeper and more time-consuming than the

first—and negatively impacts it. Unclear rules and long waiting times discourage investors.
We must start by recognizing the circular bioeconomy and look at the decisions the EU must now take through ongoing policies and initiatives. There is a significant opportunity for social and industrial transformation, in line with the sustainability and security objectives that make Europe a global benchmark.
Europe, now more than ever, is called upon to provide a systemic and coherent legislative framework through which innovation can thrive and mature, and industry can invest to build long-term capacity, adaptability, and resilience, responding to European needs.
In a highly uncertain and unpredictable global geopolitical context, it is urgent to stimulate demand for European industrial leadership in sustainable biotechnologies and bio-based technologies.
Full recognition of the circular bioeconomy must be based on the following key points:

i. Introduction of NACE codes for biorefineries, as already happens in the United States. This will help highlight and enhance the sector's unique characteristics, eliminating some barriers that impede the valorization of secondary raw materials.

ii. Recognizing the contribution of bio-based products to the transition through legislation, including incentives for such products and/or bio-based content requirements, promoting existing integrated European supply chains that are driving significant transformations in the production, use, and life cycle of products.

iii. Promotion of bio-based, biodegradable, and compostable products that do not accumulate in soil and water, as well as those that facilitate the collection and treatment of organic waste. This includes the development of adequate infrastructure for the treatment of organic waste and the production of quality compost.

iv. Promotion of the sustainable use of biomass, establishing criteria in line with those contained in the Renewable Energy Directive.

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OC03 - Biocatalytic synthesis of functional polyesters from dimethyl L-malate and aliphatic diols

Ioana-Cristina Benea[a], Ioan Bîtcan[a], Robert-Andrei Drugă[a], Anamaria Todea[a]

[a] Politehnica University Timișoara, Faculty of Chemical Engineering, Biotechnologies and Environmental Protection, 6 Vasile Pârvan Boulevard, 300223, Romania

E-mail: ioana.benea@upt.ro

Within the framework of the transition of the chemical sector towards bioeconomy, malic acid is regarded as one of the top bio-based platform chemicals that can be obtained from biological feedstocks. Hence, malic acid is an important eco-friendly substitute for various fossil-derived materials and is increasingly produced by microbial fermentation from renewable substrates such as biomass sugars or crude glycerol from biodiesel [1]. Therefore, malic acid can be regarded as a suitable monomer in the synthesis of various valuable materials, such as bio-based polymers. The importance of malic acid in polyester chemistry is related to the dicarboxylic C4 backbone with a pendant hydroxyl group, conferring trifunctional reactivity that enables the formation of various chemical architectures with either a free carboxyl or hydroxyl group [2]. Functional polyesters derived from malic acid, featuring pendant hydroxyl groups, exhibit a strong potential for medical applications because of their biodegradability and biocompatibility [3].

Enzymatic biocatalysis represents a suitable pathway for the production of malic acid polymeric derivatives, specifically as lipases can serve as highly effective biocatalysts for the direct polycondensation of malic acid with other comonomers. In this study, the enzymatic polymerization of dimethyl L-malate was explored with various diols (1,4-butanediol, 1,6-hexanediol, and 1,8-octanediol). The synthesis was carried out at 85 °C under solvent-free conditions, while the *Candida antarctica* lipase B immobilized on commercial methacrylic supports was used as the biocatalyst. Prior to this, dimethyl L-malate was synthesized from L-malic acid and methanol *via* Fischer esterification. The resulting polyesters were characterized through several analytical techniques, such as GPC analysis, to confirm their chemical structure and properties.

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OC04 - Sustainable enzymatic polycondensation of vanillin-based semi-aromatic polyesters in green solvents

Cicely M. Warne[a,b,c], Georg Gübitz[b,c], Alessandro Pellis[d]

[a] University of Pisa, Department of Chemistry and Industrial Chemistry, Via Giuseppe Moruzzi 13, 56124, Pisa, Italy.
[b] BOKU University, Department of Agricultural Sciences, Institute of Environmental Biotechnology, Konrad-Lorenz-Strasse 20, 3430 Tulln an der Donau, Austria.
[c] acib GmbH, Konrad-Lorenz-Strasse 20, 3430, Tulln an der Donau, Austria.
[d] Universitá di Genova, Dipartimento di Chimica e Chimica Industriale, Via Dodecaneso 31, 16146, Genova, Italy.

E-mail: cicely.warne@unipi.it

Plastics with aromatic moieties are useful as they tend to have good thermal and mechanical properties. However, the majority of these plastics are unsustainable; they are produced from petroleum feedstocks, synthesized under harsh conditions, and accumulate in the environment when discarded. Current research is instead focusing on green and sustainable practices. Bio-based feedstocks can be used to replace petroleum ones, sustainable synthesis practices can be used, and polymers with labile bonds such as polyesters can be focused on for easier recycling. Lignin, as the second most abundant biopolymer in nature, is an excellent source of aromatic compounds that can be used to synthesize polymers. Here, the biocatalyst *Candida antarctica* lipase B (CaLB) was used to sustainably synthesize several semi-aromatic bio-based polyesters in green solvents. Enzymatic catalysts are inherently biobased and furthermore, this work uses green bio-based solvents as reaction media.
Several polyesters based on vanillin were synthesized [1]. A vanillin-based diol compound with the potential to be polymerised via enzymatic means was selected from the literature [2], and the polycondensation of this monomer was investigated with various diesters and green solvents. Use of anisole as a reaction solvent resulted in polymers with up to 21.0 M_n, outperforming traditional petroleum derived solvents [1]. Interestingly, CaLB also outperformed chemical catalysts when diethyl terephthalate was used as the diester [2]. This work shows the versatility of CaLB in its ability to polymerise bulky semi-aromatic monomers to produce polyesters with a high degree of aromaticity.

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OC05 - Investigation of sterically-demanding neopentyl glycol in enzyme-catalyzed polyester synthesis

Lena Graf[a], Diana I. Dăescu[b], Klara M. Saller[a], Clemens Schwarzinger[a] and Alessandro Pellis[c]

[a] Institute for Chemical Technology of Organic Materials, Johannes Kepler University Linz, Altenbergerstrasse 69, 4040 Linz, Austria
[b] Faculty of Industrial Chemistry and Environmental Engineering, University Politehnica Timișoara, 300001, Vasile Pârvan 6, 300001 Timișoara, Romania
[c] Department of Chemistry and Industrial Chemistry, Università degli Studi di Genova, Via Dodecaneso 31, 16146 Genova, Italy

E-mail: lena.graf@jku.at

Neopentyl glycol has been recognized as a promising and technologically-relevant monomer in conventional polyester synthesis due to its structure with two pendant methyl groups and the resulting beneficial polyester properties. By contrast, neopentyl glycol has been poorly explored in enzyme-catalyzed reactions. To assess the feasibility of using neopentyl glycol in CaLB-catalyzed polyester synthesis, a comparative screening was performed. Two different reaction scales were tested to examine scalability and only 1% *w*/*w* biocatalyst (Sustine 110 IM, formerly known as Novozyme 435) was used. We investigated the monomer-dependent catalyst performance such as influence of acidity (free acid versus dimethyl ester), temperature-dependence and effect of alcohol properties (steric demands versus polarity) in polyester and copolyester synthesis. The reactivity profile of the CaLB-based catalyst was established by combining results from ^{1}H-nuclear magnetic resonance spectroscopy (^{1}H-NMR), size exclusion chromatography and matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS) (Figure 1).

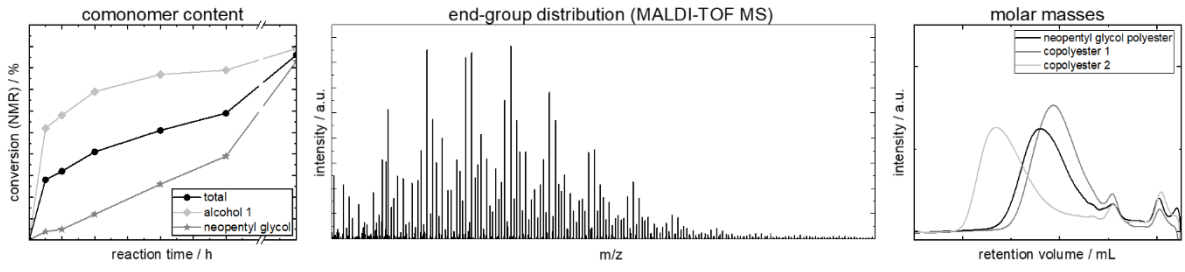


Figure 1: Combination of different types of analysis within the investigation of neopentyl glycol in polyester synthesis with biocatalyst Sustine 110 IM.

OC06 - Thermostable polyester hydrolases as emerging CaLB alternatives for enzymatic synthesis

Francesco Papatola[a], Filippo Fabbri[b], Virender Kumar[c], Chiara Siracusa[b,d], Felice Quartinello[b,d], Doris Ribitsch[b], Cristiano Varrone[c], Georg M. Guebitz[b,d], Alessandro Pellis[a]

[a]Università di Genova, Dipartimento di Chimica e Chimica Industriale, Via Dodecaneso 31, 16146, Genova, Italy.
[b]Institute of Environmental Biotechnology, Department of Agricultural Sciences, IFA-Tulln, BOKU University, Konrad Lorenz Strasse 20, 3430 Tulln an der Donau, Austria
[c]Department of Chemistry and Bioscience, Aalborg University, 9220 Aalborg, Denmark
[d]Austrian Centre of Industrial Biotechnology, Konrad Lorenz Strasse 20, 3430 Tulln an der Donau, Austria

E-mail: francesco.papatola@edu.unige.it

The synthetic capabilities of three thermophilic enzymes belonging to the α,β-hydrolase superfamily, recently identified as efficient polyester degrading biocatalysts, were evaluated for esterification, transesterification and polyester synthesis reactions. The enzymes investigated (leaf-branch compost cutinase, LCC; its engineered variant LCC^{ICCG}; and Thb from *Thermoanaerobacterales bacterium*) were recombinantly expressed, purified and immobilized onto polypropylene beads. A Design of Experiments-based approach was employed to assess their performance in the synthesis of short-chain flavor esters. Enzyme thermostability and substrate selectivity toward alcohols and acids of varying chain lengths were examined; key reaction factors, including temperature, alcohol chain length, acid chain length and reaction time, were optimized using MODDE® software to establish predictive models describing the optimal operating conditions for each biocatalyst. The acid conversion, quantified by GC-FID analysis, was used as the response variable. The models identified optimal reaction temperatures of 60 °C for LCC, 55 °C for LCC^{ICCG}, and 80 °C for Thb, with the highest substrate conversions achieved using long-chain alcohols and acids. To validate the predictive models and explore the applicability of these enzymes in polymer synthesis, polycondensation reactions were performed using dimethyl adipate and 1,8-octanediol as building blocks. The results demonstrated that these thermophilic hydrolases, traditionally associated with polyester degradation, can also work effectively as biocatalysts for synthetic applications. This alternative enzymatic route enables the sustainable production of aliphatic polyesters with high monomer conversion efficiency [1]. Nuclear magnetic resonance analysis revealed monomer conversions of ~ 90% for all three enzymes, while gel permeation chromatography measurements showed number average molecular weights ranging from approximately 3.6 kDa for LCC and LCC^{ICCG} to 3.8 kDa for Thb.

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PL02 - Enzymatic refining of textile cotton waste

Sonja Salmon[a], Jeongmin Oh[a], Isabel Albelo[a], Eunkyoung Shim[a]

[a] North Carolina State University, Textile Engineering, Chemistry and Science, 1020 Main Campus Dr., Raleigh, NC 27603, USA

E-mail: sisalmon@ncsu.edu

Textiles are refined – in their comfort, beauty and structure. They are carefully formed and processed at many levels to become the clothing, household furnishings and technical fabrics that enrich our lives and protect us. However, the same intricate hierarchical compositions that provide excellent functionality are obstacles for recycling. Therefore, additional refining strategies are needed to separate useful fractions from waste textiles and make recovered components more valuable. Since polyester and cotton, both used primarily for apparel and home textiles, together make up >80% of global fiber production [1] and significant amounts are used in blends [2], recovery and refining strategies that focus on these fibers will have a major impact on solid waste reduction and material circularity. Targeted enzymatic degradation of the cellulose in cotton and in other cellulosic fibers efficiently converts long fibers to small fragments or soluble sugars that can, due to their small size, be washed away from non-degraded fibers, like polyester, to generate separated product streams [3]. Such fractionation by size achieves physical and molecular refining which is assisted by chemical pre-treatments to overcome the presence of dyes or finishing chemicals that inhibit direct enzymatic degradation processes. Using these methods, cotton or lyocell fibers were converted to slurries with varying levels of micro-sized fiber fragments and weight loss (glucose) depending on reaction conditions. Chemical pretreatments induced fiber swelling or cracking that improved enzyme accessibility leading to more complete degradation – up to >95% solubilization for lyocell fibers. Alternatively, conversion of cotton to slurries dominated by cotton fiber fragments (CFFs) resulted in unique feedstocks that were formulated and fabricated by additive manufacturing to create “all-cellulose” 3D printed objects with desirable, tunable properties controlled by composition and processing conditions. Thus, revisiting refining transforms cotton or other cellulosic waste and adjacent fibers recovered from blends to new uses.

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OC07 - Enzymatic biotechnology for recovery and reuse of wool blended textile waste

Jinsong Shen[a,c], Mahmudul Akonda[a], Worku Molla[a], Edward Smith[a], Chetna Prajapati[b]

[a] Textile Engineering and Materials Research Group, School of Design Innovation, De Montfort University, Leicester, LE1 9BH, UK
[b] School of Design and Creative Arts, Loughborough University, Loughborough, LE11 3TU, UK

E-mail: jshen@dmu.ac.uk.

The new challenge facing the global textiles industry is to develop technologies for upcycling, recycling, and reuse of textile waste to achieve textile circularity. Blended fabrics have proved difficult to recycle due to fibres being intimately blended and the lack of innovation to enable effective separation of different fibre components, so blended textiles waste often end up in either landfill or incineration.

Enzyme-based biotechnology has demonstrated its potential to provide innovative solutions to improve textile performance properties and reduce the negative impact of textile production on the environment. In this current research, enzyme-based biotechnology processes were explored for recycling and reuse of wool blended fabrics from post-consumer and/or manufacturing waste streams. Enzymatic extraction of wool fibre components from wool/flax, and wool/hemp blended fabrics have enabled the recovery of flax and hemp fibres for closed-loop fibre to fibre recycling. Recycling and reuse of bast fibres from waste textile materials can contribute towards diverting land use for other types of farming, saving energy and water during processing, and also meet the increasing demand for the supply of bast fibres for different sectors.

The research also demonstrates the potential to recover dyes from waste dyed wool or wool blended fabrics. Coloured wool fibres were broken down by enzymatic hydrolysis, the undamaged dyes were recovered and produced in powder form with the potential for re-application for textile coloration by either dyeing or printing. These research outcomes demonstrate opportunities to reduce the environmental impact of textile production and support the global textile industry transition to a circular system.

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OC08 - Exploring the effects of agitation on cellulase performance for cotton fiber hydrolysis in textile substrates

Jeannie Egan[a,b], Martina Demuth[a], Lina Zirbs[a], Felice Quartinello[a,c], Birgit Herbinger[a], Judith Rudolf-Scholik[a], Agnes Gruenfelder[a], Georg M Guebitz[c], Christian B Schimper[a]

[a] JRC ReSTex, University of Applied Sciences Wiener Neustadt Biotech Campus Tulln, Konrad-Lorenz-Strasse 10, 3430 Tulln an der Donau, Austria
[b] BOKU University, Department of Natural Sciences and Sustainable Resources, Institute of Chemistry of Renewable Resources, Konrad-Lorenz-Strasse 24, 3430 Tulln an der Donau, Austria
[c] BOKU University, Department of Agricultural Sciences, Institute of Environmental Biotechnology, Konrad-Lorenz-Strasse 20, 3430 Tulln an der Donau, Austria

E-mail: jean.egan@fhwn.ac.at

The hydrolysis of cotton fibers with cellulase enzymes has been a relevant area of study in different fields like biorefining, bioethanol production, and textile waste remediation. Within this project, enzymatic hydrolysis is performed on polyester/cotton blended textiles to separate the fiber types to prepare isolated material fractions for recycling. With a focus on industrial viability, one of the most important parameters that needs to be reduced for enzymatic hydrolysis to be cost-effective is the reaction time, as most studies report extended length of at least 24 hours to achieve full separation. For cellulase enzymes, it is well known that increased agitation can increase fiber hydrolysis because of the mechanical action leading to faster breakage of fiber fragments or fibrils from the main fiber after enzymatic damage [1]. However, it has also been seen that some cellulase enzymes can be susceptible to over-agitation, leading to deactivation and consequently less hydrolysis [2]. In this work, 6 different commercial enzymes with different protein compositions were investigated in two different experimental setups: a benchtop setup in gram-scale with mild agitation and a reactor setup with high agitation. This setup included testing each enzyme at different pH and temperature conditions in both setups to account for any variance based on optimal conditions for a single formulation. The findings relevant to industrial application and the use case of textile blend separation will be discussed.

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OC09 - Selective enzymatic extraction of wool fibres' regions and fabrication of regenerated wool composites

Clemence Belbeoch[a], Jinsong Shen[a], Edward Smith[a]

[a] De Montfort University, Textile Engineering and Materials (TEAM) Research Group, Leicester, LE1 9BH, UK

E-mail: clemence.belbeoch@dmu.ac.uk

Wool from European sheep breeds faces commercial competition, from fine Southern Hemisphere Merino and synthetic fibre alternatives. The end-uses of European wool in the fashion industry are limited, due to the coarse fibre's thickness and prickle, and propensity to itch upon wear. Nonetheless, wool is a material with many useful qualities, such as insulation – from cold, heat and noise, fire-retardancy, anti-microbial properties and biodegradability. L-cysteine, has been used as a sustainable reducing agent to erode wool fibres' cuticle's scales and improve the softness and machine-washability wool [1]. Recently, an equally sustainable proteolytic enzyme, a subtilisin, was combined to L-cysteine's action to extract wool polypeptides, and reuse the extract for various purposes [2].

In this study, an L-cysteine-assisted enzymatic extraction process was adapted to selectively extract the different regions of the wool fibres – microfibrils and matrix proteins. These regions have different amino acid compositions, as well as different native mechanical and physical properties: their respective role in wool fibres is different and complementary. The strong microfibrils, organised as α-helix coiled coils, provide the fibres with strength; the amorphous matrix regions offer cushioning and flexibility [3]. These regions were extracted, recovered, and reused in the fabrication of regenerated bi-layer wool structures, according to their properties. Microfibrils were used as a primary scaffolding layer, and matrix proteins were mixed with biodegradable co-polymers, transglutaminase or sodium alginate. Transglutaminase is mostly involved in the biological pathway resulting in the keratinisation of skin and other keratin-rich organs [4], and is used commercially primarily in the food industry as a "meat glue". Sodium alginate is an algae-derived polysaccharide used in the fabrication of hydrogels [5]. The co-polymers' additional properties improved the composite structures' tensile behaviour and resistance to fire. Transglutaminase added to the flexibility of the regenerated wool structure, sodium alginate created lightweight foams; both preserved or improved the fire-retardancy of native wool. Applications for these composites in packaging or insulation should be explored.

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PL03 - Nature's PHA tailor-made for medical applications

Manfred Zinn[a], François Bianchi[a], Véronique Amstutz[a]

[a] University of Applied Sciences and Arts Western Switzerland (HES-SO Valais-Wallis), School of Engineering, Institute of Life Sciences, Rue de l'Industrie 23, CH-1950 Sion, Switzerland

E-mail: manfred.zinn@hevs.ch

To date, more than 300 bacterial species are capable of intracellularly accumulating the carbon and energy storage compound polyhydroxyalkanoate (PHA) and more than 150 different monomers have been described in literature. Depending on the bacterial species and its growth conditions, the monomeric unit composition of PHA can be tailored, allowing for tailoring the material's properties [1]. Specialized purification methods for PHA have been developed to reduce endotoxin content to below 1 EU/g, thereby enabling its use in medical applications.

To date, poly(3-hydroxybutyrate) (P3HB) is the most common PHA found in nature and has been successfully implemented in drug delivery systems and tissue engineering due to its strength and slow degradation profile. Poly(3-hydroxybutyrate-*co*-3-hydroxyvalerate) (P3HBHV) has been preferred for its higher toughness compared to pure P3HB, making it suitable for implants and scaffolds in regenerative medicine. Poly(4-hydroxybutyrate) (P4HB) is a thermoplastic with a higher elongation at break of approx. 1000%. P4HB is currently the only FDA-approved PHA.

The PHA subgroup containing medium-chain-length PHAs (mcl-PHAs) remains relatively unexplored for medical applications. However, these materials show significant potential due to the functionalization of their side chains during biosynthesis. Olefinic PHAs offer promising opportunities for further chemical modifications, such as formation of comb polymers, covalent linkage of amino acids in their side chains, and crosslinking to create rubber-like thermoset materials.

Functionalized PHAs can be further customized using mild chemistry to design blocky PHAs [2]. Recent advancements have demonstrated that recombinant polymerase systems enable in vivo biosynthesis of blocky PHAs, opening new possibilities for tailor-made biopolymers [3].

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OC10 - Enzymatic polymerization for hair styling

Madalena Martins [a,b] and Artur Cavaco-Paulo [b,c]

[a] Centre of Chemistry, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal
[b] SOLFARCOS – Soluções Farmacêuticas e Cosméticas, Lda., 4700-034, Braga, Portugal
[c] Centre of Biological Engineering (CEB), University of Minho, Campus of Gualtar, 4710-057 Braga, Portugal

E-mail: mms@solfarcos.com

Enzymatic esterification catalysed by lipases has been widely reported as an effective method for the synthesis of various chemical compounds, including polyesters [1]. In this study, two natural deep eutectic solvents (NADES) composed of glycerol and an organic acid (citric acid and oxalic acid) were employed to synthesize polyesters via lipase-catalyzed polymerization using *Aspergillus oryzae lipase*, while laccase was employed to catalyze oxidative polymerization reactions. To promote esterification and prevent reverse hydrolytic reactions, the NADES were lyophilized prior to polymerization. The resulting esters can interact with functional groups of the hair keratin fiber, contributing to the modification of the native hair shape. The induced curly configuration remained stable after three consecutive washes with a commercial shampoo. Samples treated with NADES exhibited enhanced hair curling compared with the control sample (Asian virgin hair subjected to the same thermal curling treatment but without NADES or enzyme) [2]. Otherwise, to facilitate oxidative polymerization on the hair fiber, keratin hair was first treated with L-cysteine amino acid to induce disulfide bond cleavage, resulting in chemical reduction and fiber swelling. Subsequently, oxidant-mediated catechol grafting occurs, enabling covalent attachment of oxidized catechol species to amine or thiol groups of the hair keratin, allowing the colour and curl of bleached hair to remain stable for up to three washing cycles.

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OC11 - Observation of hair structure using a simple digital microscope and its application to hair care

Kenzo Koike[a]

[a] Kobe Shoin Wemen University, Kobe City, Hyogo, Japan

E-mail address: kenzokoike@aol.com

Human hair exhibits a complex structure that reflects both genetic factors and daily environmental influences. Understanding its morphology is essential not only in dermatology and cosmetic science but also in practical hair-care education. Recent advances in low-cost optical devices have made it possible for students and consumers to observe hair structure directly. This study demonstrates how a simple digital microscope can be used to visualize the major components of hair and discusses how such observations can support hair-care assessment.

A commercially available USB digital microscope (approximately 50-250x magnification) was used to observe individual hair samples. Hair strands were placed on a flat black surface, and images were captured under LED illumination. Both untreated hair and hair subjected to common stressors, such as brushing, bleaching, or heat exposure, were examined to compare structural differences.

Microscopic observation revealed clear morphological features: Healthy hair showed tightly aligned cuticle scales with smooth edges. Friction-damaged hair exhibited lifted or partially broken cuticles. Heat-damaged hair showed melting, cracking, or fusion of cuticle layers. Chemically treated hair displayed significant cuticle erosion and exposure of the cortex. These findings demonstrate that even a low-cost microscope can provide sufficient resolution to evaluate hair condition and identify early signs of damage.

The ability to visualize hair structure directly has several practical benefits: Improved understanding; learners can connect theoretical knowledge with real morphological evidence. Damage assessment; consumers and students can evaluate the effects of daily habits or treatments. Behavioral change; seeing actual cuticle damage encourages more careful hair-care practices. Cosmetic product evaluation; before-and-after comparisons help assess the effectiveness of conditioners, oils, or heat-protective agents. Such visual feedback is particularly effective in educational settings, beauty training programs, and consumer outreach. In Conclusion, a simple digital microscope provides an accessible and powerful tool for observing the structural features of human hair.

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OC12 - Advanced enzymatic and ionic crosslinked hydrogel as a tailored natural bioink for chronic wound management

Camilla Mazzanti[a], Rossella Laurano[a,b], Monica Boffito[a,b], Claudio Cassino[c], Simona Bronco[a], Gianluca Ciardelli[a,b]

[a] National Research Council, Institute for Chemical-Physical Processes, via G. Moruzzi 1, 56124, Italia
[b] Politecnico di Torino, Department of Mechanical and Aerospace Engineering, Corso Duca degli Abruzzi 24, 10129, Italia
[c] Università del Piemonte Orientale, Department of Science and Technological Innovation and Magnetic Resonance Platform (PRISMA-UPO),Viale Teresa Michel 11,18902, Alessandria, Italy

E-mail: camillamazzanti@cnr.it

Chronic wound management is one of the major healthcare challenges to address. In this regard, a patient-specific wound dressing was engineered by 3D printing a properly formulated biocompatible hydrogel. The hydrogel matrix consisted of hyaluronic acid (HA) and alginate (Alg), both sourced from natural waste and double crosslinked for enhanced structural integrity. HA was functionalized with tyramine (Tyr) using a green, water-based carbodiimide-mediated grafting reaction, enabling horseradish peroxidase (HRP)-catalyzed enzymatic crosslinking. Functionalization was confirmed by infrared spectroscopy (amide bands at 1540, 1640, 1725 cm-1) and proton nuclear magnetic resonance (^{1}H-NMR) spectroscopy, showing phenolic peaks (6,6 - 7,3 ppm), with about 20% Tyr substitution on HA, respectively. Protocol's reproducibility was validated by ultraviolet-visible and ^{1}H-NMR spectroscopies with Tyr units/$g_{HA\text{-}Tyr}$ quantified to be ca. 10^{20}. Optimal enzymatic crosslinking parameters, including HRP and H_2O_2 concentrations, were identified by tube inverting tests, balancing gelation kinetics and mechanical properties. Printability of Alg/HA-Tyr (3% w/v) ink was proved by extruding stable and uniform filaments (0.7 mm) under mild printing conditions, paving the way for the extrusion of complex wound geometries. Rheological tests revealed excellent self-healing recovery after 1000% strain. Furthermore, post-printing ionic crosslinking with calcium and magnesium chloride improved shape fidelity and mechanical performance (Young's modulus: 0.5-3 kPa), influenced by immersion time (15-60 min) and ion type, as confirmed by frequency sweep tests. Swelling studies evidenced rapid exudate absorption (20% within 6 hours) with preserved stability for 5 days. In conclusion, this customized hydrogel exhibited significant potential as an advanced bioink for fabricating mechanically robust, biocompatible, patient-specific wound dressings.
This work was supported by the ATTITUDE project titled "vAlorization of wasTe products for the fabrication of sustainable paTient-personalIzed paTches targeting different phases of the woUnD hEaling cascade", which was financed by Fondazione Pisa (Italy) Call 2022 "Scientific and Technological Research" in macroarea of Biomedicine.

KN03 - Tailoring lignin properties via biocatalytic approaches for advanced materials applications

Matteo Gigli[a], Massimo Sgarzi[a], Claudia Crestini[a]

[a] Ca' Foscari University of Venice, Department of Molecular Sciences and Nanosystems, Via Torino 155, 30172 Venezia Mestre

E-mail: matteo.gigli@unive.it

The efficient upcycling of technical lignins, produced annually at the 100 Mt scale as byproducts of pulp and paper and biorefinery processes,[1] requires strategies capable of generating lignin-based materials with controlled properties. Biocatalytic approaches are particularly relevant in this context, as laccase-mediated oxidation provides a versatile route to modulating lignin structure, reactivity, and material performances.

In this contribution, a biocatalytic platform that combines solvent-based fractionation with treatment using an alkaline-stable, genetically engineered bacterial laccase is presented.[2] The developed approach was applied to different technical lignins, including kraft and organosolv lignins, with the dual aim of selectively releasing valuable lignin-derived monomeric phenolics and generating polymerized lignin fractions with markedly increased molecular weight and tailored hydrophobicity.

The structural modifications introduced by the laccase treatment were further exploited for the preparation of lignin nanoparticles (LNPs), for which pre-oxidation and fractionation strongly influenced particle yield, size, and surface chemistry.[3] The final properties of the LNPs were governed by molecular weight distribution, hydroxyl group content, chain-folding ability, supramolecular interactions, and solvation effects.

Overall, biocatalytic oxidation coupled with rational fractionation emerges as an environmentally benign and tunable strategy for transforming technical lignins into functional nanoparticles for sustainable applications.

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IL02 - Chemoenzymatic synthesis of polysaccharide-grafted functional polymeric materials

Jun-ichi Kadokawa[a]

[a]Graduate school of science and engineering, Kagoshima university, 1-21-40 Korimoto, Kagoshima 890-0065, Japan

E-mail: kadokawa@eng.kagoshima-u.ac.jp

Branched or grafted polysaccharides are often present in nature and such structures contribute to exhibiting important in vivo functions. Accordingly, synthetic methods for polysaccharides with branching and grafting structures are expected to produce new functional polymeric materials. Enzymatic polymerization has been identified as a powerful approach to obtain well-defined polysaccharides because it proceeds with highly controlled regio- and stereo-selectivities. Glucan phosphorylase (GP) is one of the enzymes, which have been employed as catalysts for practical synthesis of well-defined polysaccharides [1]. GP catalyzes enzymatic polymerization of α-D-glucose 1-phosphate (Glc-1-P) as a monomer, initiated from the maltooligosaccharide primer, to produce a pure amylose. Because the initiation takes place only at the non-reducing end of the primer, the GP-catalyzed polymerization can be performed using the primers modified on the other polymeric substrates at the other end site. Accordingly, after such polymeric primers are prepared by appropriate chemical reactions, the GP-catalyzed polymerization are progressed from the obtained polymeric primers to obtain amylose-grafted polymeric materials, as examples of carboxylmethyl cellulose (CMC) and poly(γ-glutamic acid) (PGA) (chemoenzymatic method) [2]. The amylose-graft chains formed double-helixes among the CMC or PGA main-chains to produce nanofiber film and hydrogel, respectively, composed of supramolecular network structures.

Because GP shows weak specificity for the recognition of substrates, it recognizes several analogue substrates of Glc-1-P as monomers in the polymerization to give unnatural polysaccharides. For example, GP catalyzes enzymatic polymerization of D-glucal, via the in-situ formation of 2-deoxy-α-D-glucose 1-phosphate (2dGlc-1-P) from D-glucal, to produce 2-deoxyamylose. The copolymerization of D-glucal with Glc-1-P was also progressed by GP catalysis to obtain partially 2-deoxygenated amyloses. Owing to their large number of hydrophobic regions than the natural amylose, their cast films found to be hydrophobic. Accordingly, the thermostable-GP catalyzed enzymatic grafting of the partially 2-deoxygenated amylose chains achieved hydrophobization of hydrophilic natural polymers, such as CMC and PGA [2].

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OC13 - Hydrophobization of cellulose materials by means of thermal infrared activation

R. D'Orsi[a, b], C. Danielli[c, d], M. Spennato[c], E. Guazzelli[a], E. Martinelli[a], F. Asaro[c], L. Gardossi[c, d], A. Operamolla[a, b]

[a] Università di Pisa, Dipartimento di Chimica e Chimica Industriale, Pisa, Italy
[b] Consorzio Interuniversitario Nazionale di ricerca in Metodologie e Processi Innovativi di Sintesi C.I.N.M.P.I.S., Pisa, Italy
[c] Università di Trieste, Dipartimento di Scienze Chimiche e Farmaceutiche, Trieste, Italy
[d] Consorzio Interuniversitario di Reattività Chimica e Catalisi (CIRCC), Bari, Italy

E-mail: chiara.danielli@units.it

The use of fossil-derived polymers in packaging and coating materials is associated with significant issues, including marine and land pollution, toxicity to wildlife, and greenhouse gases emission. Replacement of these materials with analogues derived from waste agricultural biomass is currently studied as a safer and cost-effective alternative. For example, hydrophobized rice husk (RH) could be used in composite materials or as filler in biodegradable plastic.

In the present study, infrared thermal activation (IRTA) was used as an innovative approach for the solvent-less functionalization of cellulose nanocrystals (CNCs) and milled RH, using epoxidized linoleic acid (ELA) obtained through a chemoenzymatic route. The epoxidation of linoleic acid was conducted in solvent-less conditions, at 50°C and ambient pressure, in the presence of H_2O_2 and lipase B from *Candida antarctica* as catalyst. The employed reaction conditions allowed for complete epoxidation of the double bonds in the fatty acid chain in under 4 hours. The obtained ELA was used for hydrophobization of CNCs and RH, using IR thermal activation at a temperature of 120°C and in the presence of *p*-toluenesulfonic acid as a catalyst. The products were fully characterized using ATR-FTIR, ^{1}HNMR and ssNMR, as well as SEM microscopy. The analyses pointed to a functionalization via esterification of hydroxyl groups on cellulose with the carboxyl moiety of the acid, as well as crosslinking of ELA molecules *via* epoxide ring opening. In the case of CNCs, used as a cellulose-rich material benchmark, hydrophobization was successfully achieved, yielding a material with a water contact angle of 40° after 120 s. In the case of RH, the hydrophobized material had a water contact angle of 65°.

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OC14 - Biomodified technical lignin for high-value applications

Sebastian A. Mayr[a], Sebastian Gritsch[a], Sabrina Bischof[a], Georg M. Guebitz[a, b]

[a] BOKU University, Department of Agricultural Sciences, Institute of Environmental Biotechnology, Konrad Lorenz-Strasse 20, 3430 Tulln an der Donau, Austria
[b] Austrian Centre for Industrial Biotechnology (ACIB), Konrad Lorenz Strasse 20, 3430 Tulln, Austria

E-mail: sebastian.mayr@boku.ac.at

The reduction in waste accumulation and the search for biobased and sustainable products to replace common fossil-based ones have become more important again. One resource accruing in huge amounts annually in the paper and biorefinery industries is lignin. It is part of lignocellulose as found in trees and plants. Laccase catalyzed oxidation and subsequent polymerization of lignins, specifically lignosulfonates (LS), turns the lignin into a solid, gel-like material which becomes insoluble in water and other organic solvents. It was shown that only minor structural changes induce the huge impact on the resulting biomodified LS (FTIR, NMR) [1]. The biomodified lignosulfonate can be directly applied as hydrogel in agriculture, due to its water retaining abilities. However, by targeted functionalization the same process can be used for various other products. The biomodified LS was successfully applied as coating for fertilizers. Thereby it was shown that it leads to slower and steadier release of the fertilizer and, by additional incorporation of microbes, the fertilizing effect could be improved simultaneously [2].

Aside from this, it was also shown to be an alternative to phenol-formaldehyde in convenient adhesive formulations. It was found to be suitable as binder for wooden floor panels and in particle boards for wall boards, leading to biobased materials competitive to actual commercial ones [3]. Further possibilities for the application as binder were shown in paper bags and textiles, such as leather and wool tissues. Another approach is to form films out of the biomodified LS spiked with plasticizers and other functional molecules. This allows for the application of tailor-made modified biopolymers with potential uses in agriculture, packaging or construction. While the initial work focused on LS, due to its availability and water solubility, it since was demonstrated that also other technical lignins, such as kraft lignin or ionic liquid lignin, are suitable for this biomodification process [4]. Although further investigation and optimization are required, these findings present possible ways to produce new sustainable and functional bio-based materials, which will be able to compete with the fossil-based ones used today.

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KN04 - Computational guided biocatalysis for sustainable polyester synthesis

Anamaria Todea[a,b], Monia Renzi[c], Emanuele Carosati[a], Lucia Gardossi[b]

[a] Department of Chemical and Pharmaceutical Sciences, University of Trieste, Via L. Giorgieri 1, 34127 Trieste, Italy
[b]Politehnica University Timisoara, Faculty of Industrial Chemistry and Environmental Engineering, Biocatalysis and Green Chemistry Group, Vasile Pârvan 6, 300223 Timisoara, Romania
[c]Department of Life Sciences, University of Trieste, via Licio Giorgeri 10, 34127 Trieste, Italy

E-mail: anamaria.todea@upt.ro

The widespread use of esters and polyesters in cosmetics, food packaging, lubricants, adhesives and fishing nets emphasizes the urgent need for eco-design criteria that focus on biodegradability and ecotoxicity. Biocatalysis offers a sustainable approach to synthesizing and degrading bio-based polyesters under mild, environmentally friendly conditions [1]. This study developed automated computational workflows combining molecular docking, molecular dynamics simulations and cheminformatics tools to identify the most suitable enzyme-substrate combinations for polyester synthesis and hydrolysis. Six hydrolases and twenty bio-based oligomeric substrates were screened using an automated pipeline implemented in modeFRONTIER that integrated AutoDock and Gromacs simulations [4]. The computational predictions correlated well with experimental polycondensation data and literature reports on polyester degradation. Lipase CAL B exhibited the greatest efficiency in polyester synthesis, while cutinases, particularly Thermobifida cellulosilytica cutinase, demonstrated the highest hydrolytic potential. Correlations were also observed between substrate structure, hydrophobicity, biodegradability and ecotoxicity [2, 3]. Overall, these results demonstrate that bio-based polyester systems are a promising sustainable alternative for future polymeric materials, and highlight the potential of computational workflows for the rational eco-design of greener polymers.

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OC15 - Molecular Dynamics and Beyond: Computational Insights In Cosmetics Research

Tiago Ferreira[a], Artur Cavaco-Paulo[a,b], Tarsila Castro[a]

[a] CEB - Center of Biological Engineering, University of Minho, 4710–057 Braga, Portugal
[b] SOLFARCOS - 4700–034 Braga, Portugal

E-mail: artur@deb.uminho.pt

The vast field of cosmetics is mainly explored through experimental methods, while computational tools find broader application in structural biology. The world of formulations remains relatively untouched or nondisclosed due to commercial interests. This work aims to better understand the applications of in silico methods in cosmetics research, at the molecular level, and how the recent work is advancing the state of the art. The integration of AI, molecular docking, and molecular dynamics simulations in cosmetics research enables the efficient discovery and optimization of ingredients, leading to innovative and effective cosmetic products. Importantly, the establishment of predictive computational protocols suitable for different cosmetic applications optimizes experimental processes and simplify testing, being economically important for the industry.

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CO03 - Molecular Determinants of Nylonase Efficiency

Miguel Ángel Bayo Valero[a], Valerio Ferrario[a]

[a] BASF SE, RGQ/SB-A30, Carl-Bosch-Straße 38, 67056, Ludwigshafen am Rhein, Germany

E-mail: miguel-angel.bayo-valero@basf.com

Nylon6 and nylon66 are widely used polymers with applications spanning textiles, automotive components and electronic materials.[1] Given their intrinsic stability, these materials can require hundreds of years to degrade under natural conditions,[2] thus growing scientific interest in technologies for their recycling, including enzyme catalysis. While catalytic mechanisms are indeed relevant to this effort, additional factors, such as enzyme–polymer interactions, play a major role in determining degradation efficiency. In this study, these interactions are investigated by modeling a simplified system comprising tetrameric nylonase enzymes and surrogate oligomers of nylon6 and nylon66, neglecting polymer crystallinity as an initial approximation. To characterize the binding process in detail, a combination of molecular docking, molecular dynamics (MD) simulations and classical energy decomposition analysis is employed. The analysis identifies catalytically relevant poses as well as the most probable interactive patches on the enzyme surface paving the way for engineering strategies capable of improving the polymer hydrolytic process.

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Circular bio-based materials by enzyme catalysis

Per-Olof Syrén[a,b]

[a] KTH Royal Institute of Technology, Science for Life Laboratory, School of Engineering Sciences in Chemistry, Biotechnology and Health, Department of Fibre and Polymer Technology, Teknikringen 56-58, 100 44 Stockholm, Sweden.
[b] Swedish University of Agricultural Sciences, Department of Molecular Sciences, 750 07 Uppsala, Sweden

E-mail: perolof.syren@slu.se

Biocatalysis offers a potential route to make polymer chemistry more selective and circular, yet the use of enzymes in polymer science remains limited by the narrow repertoire of transformations and substrates that have been explored in nature. In this oral presentation I will discuss how enzyme discovery and engineering can be combined with bio-based monomer design to enable more sustainable polymer biotechnology. First, I will highlight our recent work on terpene-derived materials, where α-pinene, an abundant monoterpene from renewable feedstocks, was converted into chiral diols for the preparation of bio-based polyesters and unsaturated pre-polymers thereof. These materials benefit from structural rigidity and stereochemical complexity inherent to the bicyclic terpene scaffold while providing chemical recyclability and susceptibility to enzymatic degradation; providing a platform for circular polyesters with tunable properties [1,2]. Second, to enable managing polymers at their end-of-life, I will present recent progress on chemoenzymatic cascade depolymerization. Bulky polymer chains often adopt conformations that are poorly matched to engage with enzyme active sites, which limits depolymerization rates. We address this challenge by combining protein engineering with polymer pre-treatment to generate matching enzyme-substrate conformations. This concept of an unselective chemical step followed by selective enzyme depolymerization has enabled improved depolymerization of synthetic polymers into their constituent monomers beyond polyesters. We recently extended this concept to polyurethanes, a challenging class of difficult-to-recycle synthetic polymers. [3,4]. Together, these studies demonstrate that enzymatic catalysis can contribute not only to the synthesis of renewable polymer architectures, but also to their selective deconstruction into added value chemicals.

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KN05 - Biosynthesis and molecular design of spider silk.

Keiji Numata[a,b]

[a] Kyoto University, Department of Material Chemistry, KyotodaigakuKatsura, Nishikyo, Kyoto 615-8510, Japan
[b] RIKEN Center for Sustainable Resource Science, 2-1, Hirosawa, Wako-shi, Saitama 351-0198, Japan

E-mail: numata.keiji.3n@kyoto-u.ac.jp / keiji.numata@riken.jp.

Structural protein such as silk, collagen, and keratin, is one of the key molecules to realize the unique properties and functions of natural tissues and organisms. Spider silks are among the toughest known materials and thus provide models for renewable, biodegradable, and sustainable biopolymers. However, the entirety of their diversity still remains elusive, and silks that exceed the performance limits of industrial fibers are constantly being found. My research group is interested in spider silk as assembly of nanofibers as well as molecular network materials. Some of our findings help to understand the link between the structural changes and mechanical behaviors of spider dragline silk fibers and contribute to the design and development of silk-inspired structural materials. In this talk, the liquid-liquid phase separation and self assembly behaviors of silk proteins and the nano fiber formations with high aspect ratio will be introduced. Further, my research group is interested in photosynthetic production of biopolymers to reduce production costs and to contribute sustainable society. My research group studies on the photosynthetic bacteria and plant cells to produce spider silk-like polymers. To establish the fundamental platforms for photosynthetic technology, we are currently developing peptide-mediated transformation and protein introduction methods for alga, photosynthetic bacteria, and plants. These new methodologies will be able to support the high-throughput characterizations for biopolymer productions.

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OC16 - Laccase-Bamboo Biochar-Based Column Systems Remove Efficiently Hazardous Dyes from Water by Electrostatic Absorption and O_2-Supported Bimodal Oxidative Degradation

Emma Garofani[a], Omar Ginoble Pandoli[b,c], Alessandro Pellis[a], Silvana Alfei[b]

[a] DCCI, University of Genoa, Via Dodecaneso 31, Genova, Italy
[b] DIFAR, University of Genoa, Viale Cembrano, 4, Genova, Italy
[c] IIT, Via Morego 30, Genova, Italy

E-mail: silvana.alfei@unige.it

Laccase (L)-free and L-immobilized bamboo biochar pyrolysed at 400°C under CO_2 (BB400, L-BB400), packed in columns, already demonstrated high long-term efficiency (LTRE%) in removing cationic dye methylene blue (MB^+) from water, in continuous flux, and best RE% in tests "stop-flow", where 10 mL of fresh MB^+ solutions were recirculated 1 h × 10 cycles, through the same column, purging O_2 [1]. Electrostatic absorption, O_2-supported degradative oxidation by persistent free radicals (PFR) and catalytic oxidation by L, were recognized as main mechanisms of removal. Here, the performance of BB400 and L-BB400 was evaluated in the removal of anionic methyl orange (MO^-), basic rhodamine (RHNH), and cationic crystal violet (CV^+), to establish the actual influence of electrostatic interactions on their removal performance, which revealed to be crucial. Anionic MO^- was not removed (0% RE%), since repelled by phenate and carboxylate anions formed on BB in basic conditions. RHNH, at natural pH of water, was poorly removed for similar reasons (10%). Acidification to pH 3-4 further worsened LTRE%. Conversely, CV^+, having highly delocalized, large cationic radii, was removed less efficiently than MB^+ only up to 40 mL fractions, 84 minutes refluxing (44% CV^+ vs. 98% MB^+), but more efficiently from 126 minutes refluxing (60 mL), up to 3.5 hours refluxing (100 mL, 36% CV^+ vs. 12% MB^+), as in Figure 1. Purging O_2 as air in the systems overnight, temporally reported LTRE% from 2-35% to 69-86% (Figure 1), thus confirming the essential role of oxidative degradation by PFRs (10^{19} spins g^{-1}) and of the catalytic oxidation of laccase, both refreshed by O_2 purging overnight. Analogously, RE% from 10 mL solutions cyclically recirculated was higher than that from 10 mL fractions, withdrawn during continuous flux (Figure 2). The potential of engineered L-BBs as oxygen supported catalytic materials for sustainable water treatment, based on an optimal combination of electrostatic, PFRs concentrations and oxidative action of L, was demonstrated.

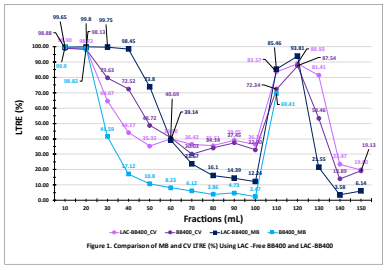


Figure 1. Comparison of MB and CV LTRE (%) Using LAC -Free BB400 and LAC -BB400

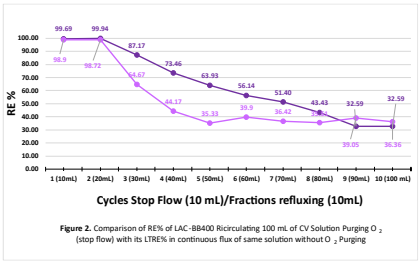


Figure 2. Comparison of RE% of LAC -BB400 Ricirculating 100 mL of CV Solution Purging O_2 (stop flow) with its LTRE% in continuous flux of same solution without O_2 Purging

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OC17 - Crosslinking of chitosan: bio-based alternatives to glutaraldehyde

Asja Feruglio[a,b], Alice Montanari[b], Maria Antonietta Sbordone[a], Lucia Gardossi[b]

[1] Vanvitelli University, Department of Architecture and Industrial Design, Via San Lorenzo - Abazia di San Lorenzo 81031 - Aversa (CE), Italy
[2] University of Trieste, Department of Chemical and Pharmaceutical Sciences, Via Licio Giorgieri 1, 34127 Trieste, Italy

E-mail: asja.feruglio@unicampania.it

Chitosan is an abundant, renewable biopolymer whose primary amino groups make it an attractive platform for covalent crosslinking and for the design of functional hydrogels [1]. Glutaraldehyde is the conventional crosslinker, yet it is cytotoxic, environmentally hazardous [3] and forms chemically complex oligomeric adducts [2]. Here we report chitosan hydrogels crosslinked with a bio-based dialdehyde derived from renewable feedstocks, which reacts with the polymer amines through Schiff-base (imine) formation to give a more sustainable and chemically defined network.
The crosslinked network was characterized by complementary analytical methods. ATR-IR confirmed imine bond formation. Combining a TNBS assay for residual free amines with UV–Vis quantification of crosslinker conversion allowed the monofunctional (pendant, non-bridging) fraction to be distinguished from the bifunctional (interchain-bridging) one, yielding the effective rather than the nominal crosslinking density. Oscillatory rheology revealed a predominantly elastic gel ($G' >> G''$, $G' \approx 300–490$ Pa) that remained stable between 25 and 45 °C.
These results show that bio-based dialdehyde crosslinking produces chitosan hydrogels with a tunable, chemically well-defined and mechanically stable network, representing a sustainable alternative to glutaraldehyde for the development of chitosan-based functional materials.

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OC18 - From post-consumer textiles to biobased polymers: step-wise conversion and life cycle impact

Francesca Stella [a], Felice Quartinello [b], Cristina Campano [c], Natalia Hernández-Herreros [c], Francesca Demichelis [a], Georg Guebitz [b], Fabio Deorsola [a].

[a] Department of Applied Science and Technology (DISAT), Politecnico di Torino, Corso Duca Degli Abruzzi 24, 10129, Turin, Italy
[b] BOKU-University, Department of Agricultural Sciences, Institute of Environmental Biotechnology, Department of Agricultural Sciences, Konrad-Lorenz-Strasse 20, Tulln an der Donau, 3430, Austria
[c] Biological Research Centre CIB-CSIC, Calle de Ramiro de Maeztu, 9, Moncloa, 28040 Madrid, Spain

E-mail: francesca.demichelis@polito.it

The textile sector is an underestimated source of environmental pollution, land contamination, wastewater generation, and microplastic emissions. This study investigates the conversion of post-consumer mixed-fibre textiles into industrially relevant building blocks and bioplastics, integrating experimental data into a block-based life cycle assessment (LCA) and comparing the proposed pathway with conventional waste management options, including landfilling and incineration.

Laboratory-scale experiments were performed to optimise alkaline pretreatment and enhance enzymatic hydrolysis of the natural fibre fraction. Hydrolysis was carried out using Cellic CTec3® and Celluclast® to produce fermentable sugars for subsequent conversion into polyhydroxybutyrate (PHB). LCA analyses were conducted to quantify the environmental impacts of the valorisation pathway and compare them with conventional disposal practices.

The results showed that alkaline pretreatment increased enzymatic hydrolysis yields of cellulose-containing textiles by up to 48%, as confirmed by SEM and HPLC analyses. Rayon and viscose exhibited higher conversion efficiencies than cotton–PET blends, consistent with literature reports of near-complete glucose conversion for regenerated cellulose fibres. Different textile compositions proved suitable substrates for glucose production, demonstrating the applicability of the process to heterogeneous waste streams. The generated glucose was successfully converted into PHB, achieving a maximum concentration of 1.93 g/L from a 10 g/L glucose solution. Mixed waste-derived feedstocks yielded higher PHB production than commercial glucose controls, confirming the biological compatibility of waste-derived substrates. The LCA revealed that textile-derived glucose fermentation scenarios showed environmental impacts comparable to commercial glucose-based fermentation, while remaining higher than landfill and incineration under current process conditions. Energy-intensive pretreatment was identified as the primary environmental hotspot. These findings demonstrate the technical feasibility of textile waste valorisation while highlighting pretreatment optimisation and mixed-waste processing as key priorities for improving industrial-scale sustainability and supporting circular textile value chains under emerging European EPR frameworks.

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OC19 - Waste-to-Biomaterial: Circular Bioeconomy-Driven Bacterial Cellulose Production via SCOBY Kombucha Fermentation

Loris Savino[a], Laura Spagnuolo[b], Rosarita D'Orsi[b], Alessandra Operamolla[b], Chiara Pelosi[b], Elena Pulidori[b], Celia Duce[b], Giorgio Grillo[c], Nicola Di Fidio[a], Isabella Pisano[a]

[a] University of Bari Aldo Moro, Department of Bioscience, Biotechnology and Environment, Via E. Orabona 4, 70125 Bari, Italy
[b] University of Pisa, Department of Chemistry and Industrial Chemistry, Via. G. Moruzzi 13, 56124, Pisa, Italy
[c] University of Turin, Department of Drug Science and Technology, Via P. Giuria 9, 10124, Turin, Italy

E-mail: l.savino14@phd.uniba.it

Bacterial cellulose (BC) is one of the most promising biopolymers for replacing fossil-based materials in non-food applications, owing to its exceptional porosity, high chemical purity, and remarkable mechanical strength[1]. While industrial production traditionally relies on pure single-strain cultures in costly synthetic media, the use of the symbiotic consortium of bacteria and yeasts (SCOBY Kombucha) offers an ecologically sustainable approach aligned with the principles of the circular bioeconomy[2]. The metabolic robustness of this biosystem enables the efficient conversion of agro-industrial by-products into low-cost culture media, thereby drastically reducing the overall economic footprint compared to conventional media[3]. In the present study, a fermentation bioprocess was developed using a commercial SCOBY starter culture for BC production via static fermentation at 30 °C, initially assessed in Hestrin-Schramm medium. Scale-up trials at 100, 400, and 800 mL confirmed that the solid inoculum can be effectively reused across successive cycles, achieving BC yields of 22.98 ± 0.33, 19.04 ± 1.71, and 20.71 ± 3.20 g/g glucose consumed, respectively. Morphological characterisation was performed by SEM, revealing an intricate and porous nanofibrillar network with an average fibre diameter of 49.36 nm, also indicative of high crystallinity. Physicochemical characterisation was performed by ATR-FTIR, elemental analysis, TGA and DSC, confirming the thermal stability of the produced BC. To reduce raw material costs, fermentations were successfully conducted on agro-food waste streams, specifically ultrafiltered apple permeate and nanofiltered prickly pears permeate. This approach would establish an integrated bioprocess delivering significant advantages in terms of economic and environmental sustainability, fully aligned with circular bioeconomy principles.

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OC20 - Self-assembling fungal protein as functional building blocks for reinforced biopolymer fibres

Giulia Fichera[a], Paola Cicatiello[a], Irene Bonadies[b], Fabiana Gallo[c], Giovanna Tomaiuolo[c], Stefano Guido[c], Paola Laurienzo[b], Paola Giardina[a], Alessandra Piscitelli[a]

[a] University of Naples Federico II, Department of Chemical Sciences, Via Cintia 21, 80126 Naples, Italy
[b] CNR, Institute for Polymers, Composites and Biomaterials (IPCB), Via Campi Flegrei 34, 80078 Pozzuoli, Italy
[c] University of Naples Federico II, Department of Chemical, Materials and Industrial Production Engineering (DICMAPI), Piazzale Vincenzo Tecchio 80, 80125 Naples, Italy

E-mail: giulia.fichera@unina.it

The development of sustainable, bio-based materials requires building blocks that combine structural performance, biocompatibility and intrinsic functionality. In nature, proteins are widely exploited to build high-performance materials with remarkable mechanical properties and complex biological functions, including adhesion, self-assembly and signalling. [1,2] In this framework, fungal hydrophobins offer a unique opportunity. These small amphiphilic proteins self-assemble into highly stable interfacial films and amyloid-like fibrillar architectures, enabling them to modify surface properties and form ordered supramolecular structures. [3] Here, we investigated Vmh2, a class I hydrophobin extracted from *Pleurotus ostreatus* mycelium, as a structural and functional component for polymeric fibre-based systems. Pre-formed Vmh2 nanofibrils were incorporated into alginate fibres using a PDMS microfluidic cross-junction device. The alginate/protein core stream was combined with a calcium chloride/PEG sheath flow, enabling rapid ionic cross-linking and continuous fibre formation. Confocal microscopy with Thioflavin T confirmed the presence of β-rich Vmh2 fibrils within the alginate matrix and SEM analysis suggested that increasing Vmh2 concentration promoted more compact and homogeneous fibre morphologies. Tensile testing further revealed a protein-dependent reinforcement effect, with increased Young's modulus. Overall, these findings highlight fungal self-assembling proteins as promising natural reinforcing elements for sustainable biopolymer fibres, combining the processability of alginate with the hierarchical self-assembly of Vmh2.

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CO03 - From pyrolysis to infrared spectroscopy: a multi-instrumental workflow for integrated analytical solutions in the characterization of biopolymers, fibers and biobased and/or biodegradable polymeric materials

Camilla Fantasia[a]

[a] SRA Instruments, Cernusco sul Naviglio (MI), Italy

E-mail: fantasia@srainstruments.com

The characterization of biopolymers, fibers and bio-based and/or biodegradable polymeric materials requires multi-technique approaches providing structural, compositional and thermal information. An integrated workflow is proposed, based on Pyro-GC/MS, bench FTIR (coupled with DSC and TGA) and portable FTIR, for the identification, characterization and quality control of complex materials and biomaterials.
The workflow begins with Pyro-GC/MS, based on the Frontier Laboratories EGA/PY-3030D multi-mode micro-furnace pyrolyzer interfaced to an Agilent GC/MS system. An initial Evolved Gas Analysis (EGA) step generates the thermal profile of the sample, identifying optimal temperatures for selective thermal desorption (TD) and controlled pyrolysis. Dedicated software enables qualitative and quantitative analysis of polymers, additives and contaminants, and detection of microplastics at trace levels, even in unknown samples [1,2].

The Agilent Cary 630 FTIR [3] enables rapid non-destructive screening of fibers and biobased materials thanks to interchangeable sampling modules and dedicated spectral libraries. Its modularity allows further coupling with DSC-FTIR for thermal transitions (crystallization, melting, glass transition) [4], and with FTIR-TGA for real-time correlation between mass loss and gases evolved during thermal degradation [5]. The Agilent 4300 Handheld FTIR [6] completes the workflow with portable non-destructive verification on fibers, textiles and biobased materials, directly on the production line.
This integrated approach provides a complete analytical profile for bio-based and/or biodegradable materials, from sample identification and microplastics detection to thermal stability evaluation and monitoring of functionalization processes.

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OC21 - From lignocellulose to polylactic acid: an integrated second-generation biorefinery approach

Colacicco M.[a], Montrone M. [b], Matera, M. [a], Liuzzi F. [c], Amazio P. [d], Di Fidio N. [a], Cappella C. [a], Agrimi G.[a], De Bari I.[c], Capozzi M.A.M.[b], Pisano I.[a]

[a] University of Bari Aldo Moro, Department of Bioscience, Biotechnology and Environment, Via E. Orabona 4, 70125 Bari, Italy
[b] University of Bari Aldo Moro, Department of Chemistry, Via E. Orabona 4, 70125 Bari, Italy
[c] Italian National Agency for New Technologies, Energy and Sustainable Economic Development, ENEA, C.R. Trisaia, S.S. 106 Jonica, Rotondella, MT 75026, Italy
[d] Next Technology Tecnotessile Società Nazionale di Ricerca, via del Gelso, 13, Prato, 59100, Italy.

E-mail: mattia.colacicco@uniba.it

The transition toward a circular bioeconomy requires integrated strategies able to valorize locally available agro-industrial residues while minimising environmental impact [1]. Within the PERCIVAL project, this study developed a multi-step biorefinery chain that converts wheat straw lignocellulosic biomass, into high-value bioproducts through a cascade approach. In the upstream stage, lignocellulosic residues are subjected to steam explosion pretreatment followed by high-solid enzymatic hydrolysis (30% w/w), yielding second-generation (2G) sugar hydrolysates with high glucose levels (c.ca 90 g/L) and low inhibitor content. These hydrolysates are used as renewable feedstock for microbial fermentation using selected *Lactobacillus* strains, producing lactic acid at concentrations up to 60 g/L with productivity of 0.82 g/L/h and yield of 0.49 g/g, followed by downstream purification achieving 84% recovery [2].

To obtain the optical purity required for polylactic acid (PLA), *L. brevis* was metabolically engineered to produce a single enantiomer. Purified lactic acid was then converted into PLA through a novel solvent-free, atmospheric-pressure polymerisation process assisted by infrared (IR) light. Compared with conventional methods, this approach reduces energy demand and avoids solvent use while improving heat distribution. Previous studies demonstrated the process feasibility, achieving a maximum number-average molecular weight (Mn) of 33,740 Da after 24 h of reaction with only 6 kW of energy consumption [3].

The resulting PLA can be further processed by electrospinning into nanofibrous mats and functionalized with organic or inorganic additives to obtain biodegradable materials with tailored mechanical and biological properties [4].

These results demonstrate a coherent, scalable, and low-waste pathway from agricultural by-products to a biodegradable biopolymer, offering a replicable model for sustainable biomanufacturing.

Acknowledgements
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OC22 - Lignin as Sustainable Colorant for Textile Dyeing

Priscila Aparecida Horn, Vitória Batista de Oliveira, Maria Eduarda Emrich Marques, Monicke Weber, Beatriz Toniolo, Adrian Kreuz, Jürgen Andreaus

Universidade Regional de Blumenau - FURB, Chemistry Department, Rua Antônio da Veiga, 140, 89030-030, Blumenau –mudei SC, Brazil.

E-mail: jandr@furb.br

Lignin is the most abundant renewable aromatic biopolymer and represents a promising alternative to synthetic dyes due to its natural color, antioxidant and UV absorbing properties and wide availability as a by-product of pulp and paper industry [1, 2]. In this study, Kraft lignins from two different sources (acid and alkaline lignin) were evaluated as sustainable colorants for textile dyeing. Three lignin formulations were investigated: dissolved lignin, lignin nanoparticles (LNPs), and lignin powder. LNPs were produced by nanoprecipitation and characterized by dynamic light scattering and Zeta potential measurements. Dyeing experiments were performed on AATCC multifiber fabrics under different processing conditions, including lignin concentration, pH, temperature, and dyeing time. Color development was evaluated by reflectance spectroscopy and dye fixation efficiency was assessed by washing. Nanoparticle size strongly depended on lignin source and concentration. LNPs prepared from acid lignin exhibited significantly smaller particle sizes than those produced from alkaline lignin, while both systems showed good colloidal stability. Dyeing performance was mainly influenced by fiber type and processing temperature. Wool and cotton exhibited the highest affinity towards lignin. Higher dyeing temperatures promoted color intensity for all lignin formulations. Compared to dissolved and powdered lignin, LNPs led to more homogeneous coloration, particularly on cellulose acetate fibers. These findings demonstrate that lignin nanoparticles are promising bio-based colorants for sustainable textile dyeing [3], offering improved dyeing performance while contributing to the valorization of lignin as a renewable resource for environmentally friendly textile applications.

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List of the abstracts presented as posters

P01 - Synthesis of Levoglucosenone-Derived Primary Diols and Their Use in Biocatalyzed Polymerization

Francesco Raboni[a], Atsushi Tahara[b], Takayuki Doi[b], Lisa Moni[a], Alessandro Pellis[a]

[a] Dipartimento di Chimica e Chimica Industriale, Università degli Studi di Genova, Dodecaneso 31, Genova 16146, Italy
[b] Graduate School of Pharmaceutical Sciences, Tohoku University, 6-3 Aoba, Aramaki, Aoba-ku, Sendai 980-8578, Japan

E-mail: francesco.raboni@edu.unige.it; tahara.a.aa@tohoku.ac.jp

Levoglucosenone (LGO; 1,6-anhydro-3,4-dideoxy-β-D-*glycero*-hex-3-enopyranos-2-ulose) is a versatile platform molecule obtained from cellulose waste, such as sawdust, through a straightforward acidification and pyrolysis process[1]. Its attractiveness derives from the presence of two stereocenters, an enone functional group, and a cyclic acetal bridge, all of which can be readily exploited in a wide range of chemical transformations[2]. Recently, polyhydrazones incorporating two LGO units linked via a double thia-Michael reaction were reported[3]. Although aromatic dithiols efficiently yield the desired products, they are petroleum-derived, malodorous, and impart excessive rigidity to the resulting materials. In the present work, two LGO units were instead connected using flexible, biobased aliphatic diols, namely 1,4-butanediol, 1,6-hexanediol, and 1,8-octanediol. The diketone intermediate was first synthesized through an oxa-Michael reaction. Subsequently, a Baeyer–Villiger oxidation was carried out under neat conditions using hydrogen peroxide, affording a molecule bearing two primary alcohol groups and two lactone functionalities (*Fig.1*). The newly synthesized diol monomers were then employed in enzymatic polymerization with various dimethyl esters, using Candida antarctica Lipase B (CaLB) as a selective biocatalyst to preserve the integrity of the lactone moieties.

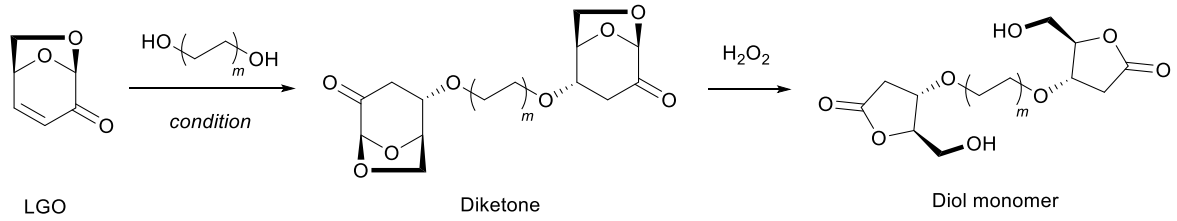


Figure 1: Procedure for the synthesis of the LGO-derived monomers.

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P02 - Ketone-functionalized oligomers by enzymatic polycondensation: Toward sustainable crosslinked architectures

Diana-Ionela Dăescu[a,b], Nathan Jourdainne[c,d], Christian Vigo[b], Giacomo Damonte[b], Anamaria Todea[a], Orietta Monticelli[b], Nathanael Guigo[c,d,*], Alessandro Pellis[b,*]

[a] Politehnica University Timişoara, Faculty of Chemical Engineering, Biotechnologies and Environmental Protection, Timişoara 300223, Romania
[b] University of Genoa, Department of Chemistry and Industrial Chemistry, Genova 16146, Italy
[c] Nice Institute of Chemistry (CNRS UMR 7272), University Côte d'Azur, Valrose Avenue, 28, Nice 06100, France
[d]Mines Paris, PSL University, CEMEF (CNRS UMR 7635), Sophia Antipolis 06904, France

E-mail: diana.daescu@student.upt.ro

Enzymes have emerged as a sustainable alternative to toxic metal catalysts for polyester synthesis. Operating at moderate temperatures (40-90℃) rather than the conventional (>150℃), enzymatic processes enable the incorporation of thermally sensitive monomers. Immobilized *Candida antarctica* lipase B (CaLB) has proven particularly effective, combining stability in organic solvents, thermal resistance up to 100℃, and facile product separation [1, 2, 3].

In this work, two potentially bio-based dimethyl esters (dimethyl 2-oxoglutarate and dimethyl 3-oxoglutarate) derived from 2 structural isomers of ketoglutaric acid were used in a solventless polymerization reaction with 1,8-octanediol in presence of CaLB as the biocatalyst. Priamine™ 1071, a bio-based diamine, was then used to crosslink the polymers using a solvent-free and catalyst-free reaction showing that a higher π-electron density of the ketone leads to a better formation of imine linkages. DSC analyses showed that the obtained polyesters are semicrystalline materials while the crosslinked materials behaved like fully amorphous systems.

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P03 - Enzymatic Homopolymerization of Difunctionalized Aromatic Monomers Catalyzed by CaLB

Maria Jose Calandri[a], Giacomo Damonte[a], Martina Letizia Contente[b], Orietta Monticelli[a], Alessandro Pellis[a]

[a] Department of Chemistry and Industrial Chemistry, University of Genoa, via Dodecaneso 31, 16146, Genova, Italy.
[b] Department of Food Environmental and Nutritional Sciences (DeFENS), University of Milan, via Celoria 2, 20133 Milano, Italy

E-mail: mariajose.calandri@edu.unige.it

This work investigates the enzymatic polymerization of a series of disubstituted aromatic monomers catalysed by *Candida antarctica* lipase B (CaLB). The simultaneous presence of an alcoholic group and an ester moiety on the aromatic ring enables the synthesis of homopolymers, materials that are highly interesting yet scarcely explored in enzymatic catalysis. All monomers share the same *para*-regiochemistry but differ in their functional groups, including aromatic alcohols (phenols), aliphatic linear alcohols, and phenolic carboxylic esters. This structural variation represents the key factor governing their reactivity. In addition to substrate structure, the reaction environment was systematically evaluated. Under identical operational conditions such as enzyme loading, applied vacuum, and reaction time, different solvents were compared: the conventional DPE, the bio-based alternatives Cyrene and Cygnet 2, and, when feasible, bulk conditions. The influence of monomer concentration was also assessed by performing reactions by varying this parameter to determine its effect on the degree of polymerization. The results demonstrate that the most critical parameter is the nature of the alcoholic group. Phenolic substrates do not show any reactivity, whereas protecting the aromatic hydroxyl group with an alkyl substituent significantly enhances conversion. Overall, the polymers obtained display moderate chain lengths, consistent with enzymatic polymerizations involving aromatic substrates. For most monomers bearing non-aromatic alcohol residues, the purified polymers reach degrees of polymerization around DP ≈ 15. Bulk reactions yield slightly lower values (around DP ≈ 8), indicating that the presence of a solvent, although not strictly necessary, exerts a modest positive effect. A particularly relevant outcome is the demonstration that diphenyl ether—an effective but environmentally problematic solvent due to its aquatic toxicity—can be replaced by renewable, bio-based alternatives such as Cyrene and its derivative Cygnet 2, for some monomer polymerization. This substitution represents a meaningful step toward more sustainable polymerization processes.

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P04 - Enzymatic Synthesis of Interpenetrating Polymer Networks with Tannin and Chitosan for Surface Membrane Modification

Lisette Lagos[a], Luis Pino[b], Myleidi Vera[a].

[a] Universidad de Concepción, Departamento de polímeros, Facultad de Ciencias químicas, Edmundo Larenas 129, Concepción 4030000, Chile
[b] Universidad de Concepción, Departamento de Ingeniería Química, Facultad de Ingeniería, Edmundo Larenas 219, Concepción 4030000, Chile.

E-mail: lislagos@udec.cl

Enzymatic polymerization is emerging as a sustainable and versatile platform for designing advanced functional materials. Operating under mild, aqueous conditions without toxic reagents, these systems offer high selectivity and enable the formation of structured architectures such as interpenetrating polymer networks (IPNs), which provide enhanced stability and synergistic properties [1].

Membrane-based separation processes are critically limited by surface fouling, leading to flux decline, reduced selectivity, and increased energy consumption. Surface modification via IPN formation has therefore gained attention as an effective strategy to improve membrane performance [2,3].

In this work, tannins valorized from *Pinus radiata* bark and chitosan were used as bio-based precursors to form an IPN in situ on a commercial membrane, enzymatically polymerized by laccase from *Myceliophthora thermophila*. The objective is to extend membrane lifetime and enable selective removal of target species.

Characterization by FTIR-ATR, SEM-EDS, TGA, permeability, and contact angle confirms IPN incorporation within membrane pores, demonstrating a sustainable route for advanced separation technologies.

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P05 - LPMO-enabled surface carboxylation of lyocell for improved cationic dye uptake

Maximilian Huemer[a,b], Olanrewaju Raji[c], Sebastian España Orozco[a], Robert H. Bischof[d], Doris Ribitsch[b], Georg M. Guebitz[b], Emma R. Master[c]

[a] Department of Biorefinery Processes & Composite Materials, WOOD K Plus – Kompetenzzentrum Holz GmbH, Altenbergerstraße 69, 4840 Linz, Austria
[b] Department of Agricultural Sciences, Institute of Environmental Biotechnology, BOKU University, Konrad-Lorenz-Straße 20, A-3430 Tulln an der Donau, Austria
[c] Department of Chemical Engineering and Applied Chemistry, University of Toronto, 200 College Street, Toronto, Canada
[d] Lenzing AG, Werkstraße 2, Lenzing, Austria

E-mail: maximilian.huemer@wood-kplus.at

Regenerated cellulosic fibers such as lyocell are fully bio-based, biodegradable, and valued for their desirable properties. Targeted surface functionalization can further improve processing, especially dyeing. Reactive dyes dominate cellulosic dyeing because of their high affinity and covalent bonding to cellulose; however, these bonds hinder efficient color removal during textile recycling [1]. By contrast, cationic dyes show low affinity to unmodified cellulose unless additional anionic binding sites are introduced [2]. Here, we demonstrate an enzymatic approach that installs carboxyl groups on lyocell surfaces using a C1-oxidizing lytic polysaccharide monooxygenase (LPMO), *Dc*LPMO9A from *Delitschia confertaspora*, to enhance cationic dye uptake without substantial loss in fabric yield [3]. The degree of C1 oxidation was quantified via carboxyl-selective labelling and fluorescence analysis and correlated directly with dyeing performance. Using rhodamine 6G (R6G) as a model cationic dye, R6G uptake increased by up to 75% at enzyme loadings below 1% w/w, while fabric yield and fiber quality were maintained. This mild, selective, and potentially scalable biocatalytic route introduces anionic sites on lyocell, enabling efficient cationic dyeing and offering a pathway to reduce reliance on reactive dyes, with potential benefits for circular textile processing.

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P06 - Bamboo Derived Biochar as a Functional Enzyme Support: Effect of Pyrolysis Conditions on biocatalytic polymerization

Lizeth Marlen Moreno Pascual[a], Natalia Nicotra[a], Francesco Papatola[a], Omar Ginoble Pandoli [b,c], Alessandro Pellis[a]

[a] University of Genova, Department of chemistry and Industrial Chemistry, Via Dodecaneso 31, 16146, Genova, Italy
[b] University of Genova, Department of Pharmacy, Viale Cembrano 4, 16148, Genova, Italy
[c] Istituto Italiano di Tecnologia (IIT), Via Morego 30, 16163, Genova, Italy

E-mail: natalia.nicotra03@gmail.com

Bamboo is a renewable lignocellulosic biomass with significant potential as a sustainable precursor for functional carbon materials. In this work, untreated *Dendrocalamus giganteus* was converted into bamboo-derived carbon (biochar) through fast pyrolysis (300–600°C) under N_2 followed by in situ CO_2 activation and further pulverized by ball-milling. This approach enabled precise tuning of the structural porosity, surface area and chemistry, also adding paramagnetic properties resulting in carbonaceous material including permanent free radical formation. The biochar materials were characterized by DRIFT, and BET surface area analysis, Pyrolysis temperature strongly influenced chemical functional groups, aromaticity of graphene-like structures and pore dimensions with B600 being predominantly microporous, B500 exhibiting a mesoporous structure, and B400 displaying a macroporous network, making these materials attractive candidates for enzyme immobilization [1].

The biochars were evaluated as support for *Candida antarctica lipase* B (*CaL*B). The catalytic performance of immobilized *CaL*B was assessed using a model polycondensation reaction of 1,8-octanediol and dimethyl adipate, producing an aliphatic polyester. The monomer conversion and polyester properties were analyzed by ^{1}H-NMR and GPC. High monomer conversions were achieved across all materials (97% B300 and B400, 94% for B500, and 75% for B600), with substantial differences in the polymer molecular weight. B300 enabled the formation of polyesters with a Mn of approximately 4 kDa while B400 yielded the highest molecular weight of 11 kDa, compared to 7.5 kDa for B500 and only 1.5 kDa for B600. These results indicate that a balance of chemical surface (hydrophobic sites) and morphology (macropores) contribute to a successful immobilization and favor the enzyme orientation and accessibility to enhance the polymer chain growth.

Acknowlegdments

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P07 - A Recombinant PHA Depolymerase with Activity toward Bioplastics

Garegin Hakhoyan, Mariam Karapetyan, Lev Khoyetsyan, Ani Paloyan

Scientific and Production Center “Armbiotechnology” National Academy of Science of Armenia, Gyurjyan str., 0014 Yerevan

E-mail: gar.haxoyan@gmail.com

Poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) (PHBH) is a biodegradable polymer belonging to the polyhydroxyalkanoate (PHA) family and represents a promising alternative to petroleum-based plastics. As the use of PHBH continues to increase, efficient biodegradation strategies are becoming increasingly important. PHA depolymerases play a key role in this process by catalyzing the hydrolysis of PHA polymers [1].

The aim of this study was to obtain a recombinant PHA depolymerase, optimize its expression conditions, and evaluate its activity toward PHBH and related bioplastics. *Priestia megaterium* L8, isolated from a plastic-polluted environment, was identified as a PHA-degrading bacterium. The gene encoding a PHA depolymerase was cloned and heterologously expressed in *Escherichia coli* BL21(DE3). Optimal soluble expression was achieved using 0.1 mM IPTG at 18°C for 16 h and 120 rpm.

SDS–PAGE analysis confirmed the production of a recombinant protein with an approximate molecular weight of 60 kDa. The hydrolytic activity of the recombinant enzyme was subsequently evaluated against PHBH. Enzymatic treatment resulted in visible surface and structural alterations of the polymer, indicating cleavage of polymer chains and progressive biodegradation of the material. The enzyme exhibited degradative activity toward PHBH, causing visible surface and structural changes in the polymer. It was also active against PHB and PHBV, while no activity was detected against PLA, PBS, PCL, or PBAT.

These results demonstrate the potential of the recombinant PHA depolymerase for the biodegradation and recycling of PHA-based bioplastics.

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P08 - From Soybean Hulls to Value-Added Materials: Cellulose, Derivatives, and Applications in the Circular Economy Framework

E. Laurenti[a], M. L. Tummino[b], M. Rigoletto[a], C. Angileri[a], A. Arencibia[c], M. J. López Muñoz[d], G. Grillo[e], S. Tabasso[e], V. Bortolotto[f], C. L. Bianchi[f]

[a] University of Turin, Department of Chemistry, Via P. Giuria 7, 10125, Turin, Italy
[b] National Research Council (CNR), Institute of Intelligent Industrial Systems and Technologies for Advanced Manufacturing (STIIMA), Corso G. Pella 16, 13900 Biella, Italy
[c] Rey Juan Carlos University, Department of Chemical, Energy and Mechanical Technology, ESCET, C. Tulipán, s/n, 28933 Móstoles, Madrid, Spain
[d] Rey Juan Carlos University, Department of Chemical and Environmental Technology, ESCET, C. Tulipán, s/n, 28933 Móstoles, Madrid, Spain
[e] University of Turin, Department of Drug Science and Technology, Via P. Giuria 9, Turin, 10125, Italy
[f] University of Milan, Department of Chemistry, Via Golgi 19, 20133 Milan, Italy

E-mail: enzo.laurenti@unito.it

Soybean hulls (SBHs), one of the major by-products of soybean processing, are commonly used as animal feed or discarded as low-value biomass. Nevertheless, they represent a promising renewable resource for the development of high-value-added products within a circular economy framework. Over the past years, our research has focused on the sustainable valorization of SBHs through the optimization of extraction processes for soybean peroxidase and cellulose [1,2], as well as the development of cellulose-based derivatives [1,3,4] and functional materials [1,2]. These materials have been designed for applications in environmental remediation, antimicrobial treatments, and active packaging systems. Particular attention has been devoted to sustainability throughout the entire material life cycle, including green extraction and functionalization strategies, material reusability, biodegradability, and Life Cycle Assessment (LCA) studies. This contribution provides an overview of the approaches developed to transform soybean hulls from an agricultural residue into a versatile platform for sustainable and functional bio-based materials.

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P09 - *Streptomyces* as a potential platform for the biodegradation of synthetic and natural textiles

Vukašin Janković[a], Brana Pantelić[a], Marijana Ponjavić[a], Jasmina Nikodinovic-Runic[a], Tatjana Ilic-Tomic[a]

[a]*University of Belgrade, Institute of Molecular Genetics and Genetic Engineering, Vojvode Stepe 444a, 11042 Belgrade, Serbia*

E-mail: vukasin.jankovic@imgge.bg.ac.rs

The genomes of three *Streptomyces* strains (*Streptomyces* sp. R1, *Streptomyces spectabilis* BPS43, and *S. rubiginosohelvolus* NP10), previously shown to interact with textiles [1] were analyzed to determine their polyamide (PA) and polyurethane (PU) degrading potential. Polymer-degrading homologous enzymes were identified through searches against PAZy (The Plastics-Active Enzyme Database) [2] and PlasticsDB (Plastic Biodegradation Database) [3]. Whole-genome analysis of three strains identified 22 homologs in total, including multiple putative PA/PU-degrading enzymes, with *S. spectabilis* BPS43 contributing the highest number: 14 (6 for PA and 8 for PU). Evolutionary analysis of these homologs demonstrated four distinct clades corresponding to amidases, peptidases, hydrolases, and esterases. Selection of these enzymes served as a starting point for reconstructing the ancestral sequences from *Streptomyces* PA/PU degrading enzymes and computational enzyme engineering to obtain robust biocatalysts for streamlined textile waste upcycling. Collectively, these findings highlight Streptomycetes as promising candidates for accelerated degradation of synthetic polymers, and support their application in sustainable textile waste valorization.

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Keywords
Streptomyces; polyamide; polyurethane; biodegradation; textile

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P10 - Crystal Violet Removal by Water Over Time Using Bamboo Biochar (BB) and Laccase (L)-BB: Kinetic and Chemometric Studies

Emma Garofani,[a] Omar Ginoble Pandoli, [b,c] Alessandro Pellis,[a] Silvana Alfei[b]

a DCCI, University of Genoa, Via Dodecaneso 31, Genova, Italy
b DIFAR, University of Genoa, Viale Cembrano, 4, Genova, Italy
c IIT, Via Morego 30, Genova, Italy

E-mail: silvana.alfei@unige.it

Pyrolyzed biochar can both provide solutions to reduce the surplus processing waste, and possess exceptional capabilities to reduce water pollutants, including dyes, thus fully fitting into the goal of a circular economy [1]. CO_2-activate laccase (L)-free and L-containing bamboo biochar BB400 and L-BB400, packed in column systems [1] demonstrated to efficiently remove cationic dye crystal violet (CV^+) [2], both in continuous flux (3.5 hours) and in an 1-hour recirculating mode through the same column "stop-flow" of 10 mL fresh CV^+ solutions × 10 cycles, purging O_2 [2].
Kinetic and chemometric studies on all available data of CV^+ removal, have been carried out first modelling them using Freundlich and Langmuir isotherms, to get their parameters (Table 1), which both best fitted our data (R^2 = 1).
Secondly, by fitting pseudo first (PFO) and second order (PSO) kinetic models to same data to find the best fitting one and related parameters. PSO was found to be the best model for all removal data having the highest R_2 values (Table 1), thus establishing that chemisorption and chemical interactions formation between CV^+ and BB are the main mechanisms governing CV^+ removal.

Table 1. Parameters of Isotherms and Kinetic models (PFO and PSO) for both BB400 and LAC-BB400 in different operational conditions.

L-BB400	**Isotherm**	**Slope**	**Intercept**	**R^2**	**K_F**	**K_L**	**n_F**	**Q_m**	
	Freundlich	1	2.3026	1	≈ 10	N.A.	1	N.A.	
	Langmuir	10	2^{-14}	1	N. A.	1^{-15}	N. A.	1^{14}	
	Kinetic Model	**Slope**	**Intercept**	**R^2**	**K_{PFO}**	**K_{PSO}**	**$Q_{min\ (100mL)}$ $^{\$}$ PFO**	**$Q_{min\ (100mL)}$ $^{\$}$ PSO**	**$Q_{min\ EXP}$**
	PFO	0.0061	3.6605	0.4581	0.0061	N. A.	≈ 38.9	N. A.	37.52
	PSO	0.0301	-0.3081	0.9861	N. A.	-0.0029	N.A.	33.2	37.52
BB400	**Isotherm**	**Slope**	**Intercept**	**R^2**	**K_F**	**K_L**	**n_F**	**Q_m**	
	Freundlich	1	2.3026	1	≈ 10	N.A.	1	N.A.	
	Langmuir	10	2^{15}	1	N. A.	1^{16}	N. A.	1^{15}	
	Kinetic Model	**Slope**	**Intercept**	**R^2**	**K_{PFO}**	**K_{PSO}**	**$Q_{min\ (100mL)}$ $^{\$}$ PFO**	**$Q_{min\ (100mL)}$ $^{\$}$ PSO**	**$Q_{min\ EXP}$**
	PFO	0.0164	2.8176	0.7009	0.016	N. A.	≈16.75	N. A.	33.55
	PSO	0.0341	0.5199	0.9548	N. A.	-0.0022	N. A.	29.33	33.55
L-BB400 *	**Isotherm**	**Slope**	**Intercept**	**R^2**	**K_F**	**K_L**	**n_F**	**Q_m**	
	Freundlich	1	2.3026	1	≈ 10	N.A.	1	N.A.	
	Langmuir	10	9^{-14}	1	N. A.	4.371^{-15}	N. A.	2.288^{13}	
	Kinetic Model	**Slope**	**Intercept**	**R^2**	**K_{PFO}**	**K_{PSO}**	**$Q_{min\ (10\ cycle)}$ $^{\#}$ PFO**	**$Q_{min\ (10\ cycle)}$ $^{\#}$ PSO**	**$Q_{min\ EXP}$**
	PFO	0.2114	2.3359	0.8564	0.211	N. A.	≈10.335	N. A.	33.24
	PSO	0.0033	0.0061	0.9187	N. A.	-0.01786	N. A.	30.3	33.24

* Recirculation mode under O_2 purging; $ amount Q (mg/mL) of CV^+ removed after 3.5 hours refluxing; # amount Q (mg/mL) of CV^+ removed after 10 cycles of 10 mL CV^+ solution recirculated 1 hour each one by the same column under O_2 purging.

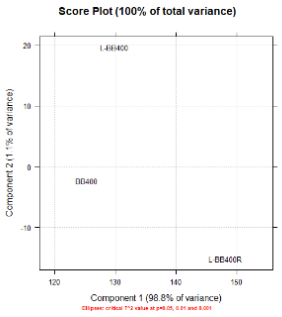


Figure 1.

A multivariate analysis on kinetics data in Table 1 was then carried out by processing them using Principal Component Analyses (PCA), whose results have been reported as score plot in Figure 1. Explanations and details on data in Table 1 and PCA results are available in the communication.

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P11 - Oxidizing Recalcitrant Hydrocarbons with Bacterial Laccase *PIL*

Maren Rickert, Doris Ribitsch, Georg Gübitz

BOKU University, Department of Agricultural Science – IFA-Tulln Institute of Environmental Biotechnology, Konrad Lorenz Straße 20, A-3430 Tulln, Austria

E-mail: maren.rickert@boku.ac.at

Environmental samples harbor diverse microbial enzymes that can power a circular economy by selectively transforming and depolymerizing materials, reducing our reliance on fossil-based resources. However, enzymatic depolymerization of recalcitrant, hydrocarbon-rich materials remains a major bottleneck for circular polymer systems. We addressed this gap by studying a novel bacterial laccase *PIL* from *Parvibaculum lavamentivorans*, discovered in contaminated field soil, that exhibits oxidative activity toward long-chain hydrocarbons relevant to polyolefin-derived materials [1]. Treatment of saturated hydrocarbons like eicosane C20 mediated by 1-hydroxybenzotriazol (HBT) resulted in up to 50% weight loss after 4 days of incubation at ambient temperature (Fig. 1). Product formation was tracked by GC-MS (including headspace) and HPLC, however, at this stage no discrete intermediates were detected that might elucidate the enzyme's reaction pathway. Furthermore, *PIL* exhibited pronounced instability, losing activity within few hours at room temperature and no stabilizing buffer/additive conditions could be identified up to date. Previous work has shown that fusing substrate-binding modules to target enzymes can enhance stability as well as activity, particularly when processing highly hydrophobic substrates [2] [3]. Therefore, future work will assess the effect of binding modules and immobilization on the enzymatic degradation.

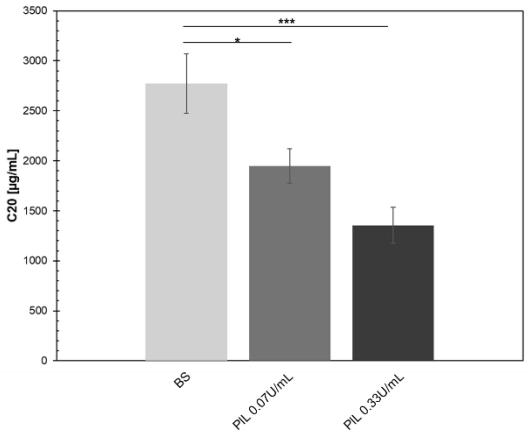


Fig 1. Weight loss of eicosane after 4 days of treatment with different concentrations of PIL. Reaction was performed in 0.1M Sodium Phosphate Buffer (pH 6) and 2mM HBT at ambient temperature. BS: Buffer and Substrate. Asterisks indicate statistically significant difference of enzyme test on day 4 to BS (Test: ordinary one-way ANOVA).

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P12 - Fosfomycin Nanoparticles Disrupt MRSA Quorum Sensing and Virulence

Fadilah Sfouq Aleanizy[a]

[a] King Saud University/research, Department of Pharmaceutics/College of Pharmacy1, 22452, Riyadh/Saudi Arabia1

E-mail: faleanizy@ksu.edu.sa.

Background: Methicillin-resistant Staphylococcus aureus (MRSA) infections are driven by quorum-sensing (QS)-regulated virulence and biofilm formation [1,2]. Encapsulating antibiotics in biocompatible nanoparticles may improve delivery and attenuate virulence [3]. Methods: Fosfomycin-loaded chitosan/alginate nanoparticles (FOS-CS/ALG NPs) were prepared by ionic gelation and characterized for size, zeta potential, morphology, encapsulation efficiency, and release. Antibacterial activity against clinical MRSA strains was evaluated by MIC and time–kill assays. Anti-biofilm effects used crystal violet staining and confocal microscopy. Hemolytic and protease activities assessed functional virulence; cytotoxicity was tested on mammalian cells. Results: NPs were spherical (≈180–220 nm), positively charged, with 75–85% encapsulation and sustained release over 48 h. Compared with free fosfomycin, NPs reduced MICs 2–4-fold and accelerated bacterial killing. Biofilm biomass and viability decreased by 60–80% with disrupted architecture on microscopy. Treatment reduced hemolysis and protease activity by (≈2–6-fold). Cytotoxicity remained low (>90% cell viability) at therapeutic concentrations. Conclusions: FOS-CS/ALG NPs enhanced antibacterial and anti-biofilm activity against MRSA and attenuated QS-dependent virulence with minimal cytotoxicity, supporting further development as a combined antimicrobial and anti-virulence strategy.

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P13 - Bio-based and biodegradable polyesters to mitigate microplastic impact

Lucia Gardossi[1], Chiara Danielli[1], Fioretta Asaro[1], Alessia De Piero[1], Emanuele Carosati[1], Raffaele Bruschi[1], Monia Renzi [2]

[1] University of Trieste, Department of Chemical and Pharmaceutical Sciences, Via Licio Giorgieri 1, 34127 Trieste, Italy

E-mail: gardossi@units.it

Bio-based and biodegradable polyesters were designed and synthesised using enzymes to produce a new generation of polymers that are safe and sustainable by design. These polymers can be used for products and applications that pose a high risk of dispersing into the open environment and that are not suitable for recovery or recycling. These include mulching film for agriculture, cosmetics components, bio-lubricants and adhesives. The design was planned in accordance with the Safe and Sustainable by Design principles of the European Commission's Joint Research Centre (JRC). Marine biodegradability was studied using Oxitop systems, and ecotoxicity was assessed in marine and freshwater organisms. The results indicate that a number of bio-based monomers and polyesters are not toxic and are readily biodegradable. The data were used to create models able to correlate polymer structures with biodegradability. This study was conducted in parallel with an experimental investigation into the quality of microplastics present in the water grids of north-eastern Italy.

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P14 - Isolation and Bioinformatic Analysis of Bioplastic-Degrading Bacteria

Ani Paloyan[1], Mariam Karapetyan[1], Lev Khoyetsyan[1], Garabed Antranikian[2]

[1]Scientific and Production Center "Armbiotechnology" National Academy of Science of Armenia, Gyurjyan str., 0014 Yerevan
[2]Center for Biobased Solutions, Institute of Technical Biocataysis, TUHH, 21073 Hamburg, Germany

E-mail: anipaloyanm@gmail.com

The growing accumulation of bioplastics in the environment has increased the demand for efficient microbial systems capable of their biodegradation [1]. The aim of this study was to identify and characterize bioplastic-degrading bacteria from both environmental samples and the microbial collection of SPC "Armbiotechnology" NAS RA.

As an initial step, strains from the Microbial Depository Center of SPC "Armbiotechnology" were screened for bioplastic-degrading activity. Among the *Pseudomonas* collection, 25 strains were selected for primary screening, of which five exhibited relatively rapid degradation, producing visible degradation zones within 68h. Taxonomic characterization revealed that the most active isolates belonged to *Pseudomonas syringae*, *Pseudomonas fluorescens*, *Pseudomonas chlororaphis* subsp. *chlororaphis*, and *Stenotrophomonas maltophilia* subsp. *melanogenes*. These strains demonstrated biodegradation activity toward poly(butylene succinate) (PBS) and polycaprolactone (PCL). Similarly, screening of *Bacillus* strains resulted in the selection of five highly active isolates, showing activity toward PBS PCL, poly(3-hydroxybutyrate) (PHB) with the most efficient strain producing a degradation zone within 48 h.

In parallel, environmental samples were collected from plastic-polluted sites, the vicinity of Yerevan Salt Lake, and saline soils from different regions of Armenia. Screening of the obtained isolates revealed seven strains capable of degrading PHB, poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV), and poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) (PHBH), two strains exhibiting degradation activity toward PBS, and one strain capable of degrading PCL.

The results demonstrate that the strains represent valuable sources of bioplastic-degrading enzymes. These strains provide promising candidates for future studies on biodegradation mechanisms, enzyme discovery and application.

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P15 - Chemo-enzymatic methods for the valorisation of biomass from Côte d'Ivoire for the synthesis of bio-based chemicals

Davide Seibig[a*], Asengo Gerardin Mabia[a,b], Chiara Danielli[a], Fioretta Asaro[a], Kouassi Benjamin Yao[b], Lucia Gardossi[a].

[a] University of Trieste, Department of Chemical and Pharmaceutical Sciences, Via Licio Giorgieri 1, 34127 Trieste Italia
[b] Institut National Polytechnique Félix Houphouët Joint Research and Innovation Unit in Agronomic Sciences and Transformation Processes (UMRI SAPT), INP-HB Site Nord BP, 1093 Yamoussoukro Côte d'Ivoire

E-mail: davide.seibig@studenti.units.it

Biomass valorization through the local transformation of agricultural residues into added-value materials and chemicals represents an important opportunity for implementing sustainable bioeconomy in rural regions. Côte d'Ivoire is the world's leading cocoa producer, with cocoa representing a major contributor to the national economy, while sugarcane is another important agricultural commodity. Our research focuses on the valorization of two agricultural by-products: cocoa pod husks (CPH) and sugar molasses. An alkaline oxidative delignification protocol was developed to obtain a cellulose-rich CPH fraction, which was characterized by FTIR spectroscopy. Enzymes were immobilized on the cellulosic fraction and the activity was evaluated.

Another research area concerns sugar molasses, which were successfully fermented for lactic acid production [1], followed by the development of a lactic acid extraction protocol [2]. Current research focuses on the biocatalytic conversion of lactic acid into lactate esters using immobilized lipases under solvent-free conditions. These compounds have potential applications as biodegradable bio-based plasticizers and biolubricants, fostering a sustainable circular bioeconomy.

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P16 - Reshaping Recycled Cotton Through Enzymatic and Mechanoenzymatic Treatment.

Pedro J. Martínez[a], Meri Lundahl[a], Bruno D. Mattos[a].

[a] Aalto University, School of Chemical Engineering, Department of Bioproducts and Biosystems, Vuorimiehentie 1, FI-00076, Finland

E-mail: meri.lundahl@aalto.fi and bruno.dufaumattos@aalto.fi

This work explores the use of enzymatic treatments to modify the fiber morphology of textile waste, aiming to enhance its potential for material recovery and reuse. The effects of two endoglucanases, derived from *Aspergillus niger* (EA) and *Trichoderma reesei* (ET), were first evaluated on recycled cotton fibers. Morphology (fibre quality analysis and scanning electron microscopy), coupled with chemical and molecular analysis (X-ray diffraction, intrinsic viscosity, and ion chromatography), revealed differences in the mechanisms of how these enzymes act on cellulosic fibers. The treated fibers were processed into sheets to evaluate their mechanical properties and to establish correlations between enzymatic modification, fiber morphology, and material performance. EA released more soluble glucose 254.56 mg/L versus 32.91 mg/L for ET) and promoted external surface fibrillation, whereas ET reduced the degree of polymerization and produced a less surface-erosive modification. Based on these results, ET was selected to compare an aqueous reaction against a mechanoenzymatic reaction at high consistency (20 wt%). The mechanoenzymatic route approximately tripled the tensile index relative to the aqueous ET treatment (3.89 versus 1.27 kN*m/kg) and roughly doubled handsheet strength overall.

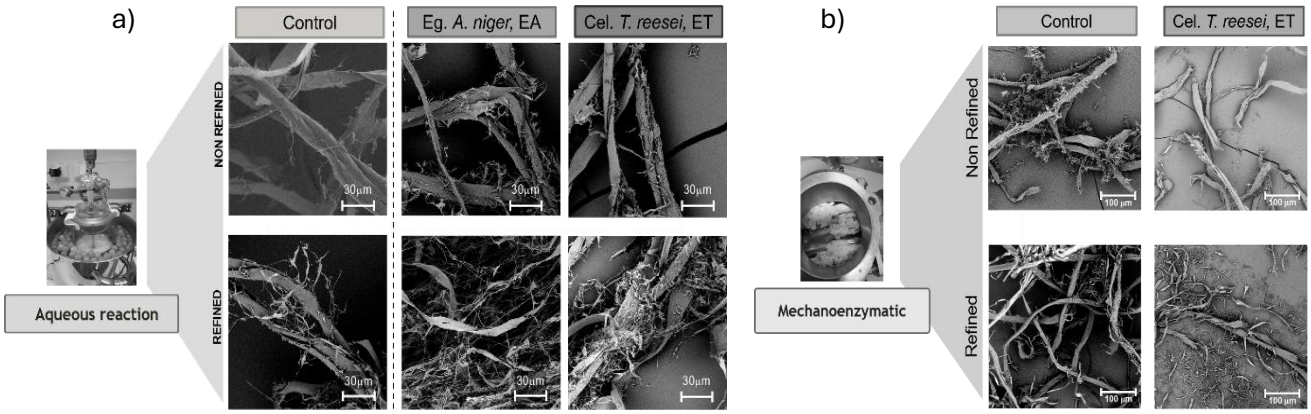


Figure 1. Cotton fiber morphology after enzymatic treatment with an endoglucanase from A. niger, and a cellulase from T. reesei under a) an aqueous reaction, and b) a mechanoenzymatic reaction. Only the cellulase from T. reesei was used for the Mechanoenzymatic, based on its performance in the aqueous reaction.

P17 - The Chemo-Enzymatic Processes Laboratory (CEPLab) of the Department of Chemistry and Industrial Chemistry, University of Genova

Francesco Raboni[a], Maria Jose Calandri[a], Andrea Pasquale[a], Lizeth Marlen Moreno Pascual[a], Leonardo Giribaldi[a], Diana-Ionela Daescu[a], Natalia Nicotra[a], Irene De Kermarek[a], Francesco Papatola[a], Alessandro Pellis[a]

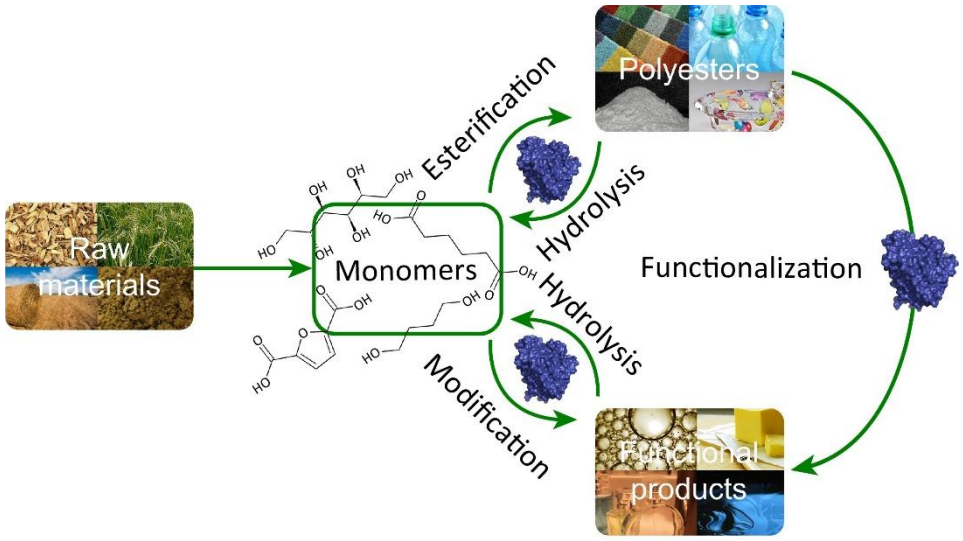
[a] Università di Genova, Dipartimento di Chimica e Chimica Industriale, Via Dodecaneso 31, 16146, Genova, Italy.

E-mail: francesco.raboni@edu.unige.it

The Chemo-Enzymatic Processes Laboratory (CEPL) is a young and dynamic research team. The CEPL was founded in October 2021 when Dr. Alessandro Pellis joined the University of Genova as Assistant Professor in Organic Chemistry.

The group's main research interests are:

- Enzymatic synthesis of polymers carrying lateral functionalities;
- Degradation and surface functionalization of polymeric materials;
- Biocatalysts immobilization, optimization and its biochemical characterizations;
- Chemo-enzymatic post-polymerization functionalization techniques;
- Valorization of the lignocellulosic feedstock.
-



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P18 - Designing new bio-based compounds for liquid repelling textile coatings using safe and sustainable by design principles: the BIO-TEXTILE-SSbD project.

Cicely M. Warne[a], Lucia Gardossi[b], Anamaria Todea[c], Alessandra Operamolla[a]

[a] University of Pisa, Department of Chemistry and Industrial Chemistry, Via Giuseppe Moruzzi 13, 56124, Pisa, Italy.
[b] Universita' degli Studi di Trieste, Dipartimento di Scienze Chimiche e Farmaceutiche, Via Licio Giorgieri,1 34127, Trieste, Italy.
[c] University Politehnica Timisoara, Biocatalysis and Green Chemistry Group, Faculty Chemical Engineering, Biotechnologies and Environmental Protection, Bulevardul Vasile Pârvan 6, 300322, Timisoara, Romania.

E-mail: cicely.warne@unipi.it

Omniphobic materials (those that have both hydrophobic and oleophobic qualities), have many different applications, including in the textile industry. Traditionally, omniphobic coatings have been fabricated with per- and poly-fluoroalkyl substances (PFAS), however these substances are highly persistent, bioaccumulate, and documented negative effects on human health [1]. As a result, although regulatory frameworks addressing PFAS already exist, they are becoming even more restrictive [2]. Common alternatives include polysiloxanes, but synthesis of these compounds is energy intensive, and recycling of such materials is not yet commercially mature [3].

With this context, the BIO-TEXTILE-SSbD project aims to design and synthesize a fully bio-based omniphobic coating for textile applications. Utilizing Safe and Sustainable by Design (SSbD) principles, the project applies sustainable methodologies at all stages of materials synthesis, generating non-toxic outputs (for both humans and the environment). To achieve this, BIO-TEXTILE-SSbD will first utilize computational techniques to design bio-based molecules suitable for omniphobic coatings, reducing waste and energy usage. Sustainable synthesis routes will be investigated, prioritizing biocatalytic pathways when possible. After synthesis, the ecotoxicity and biodegradability of the new coatings will be assessed before application to textiles. Finally, infrared thermal activation (IRTA), as an efficient surface functionalization technique with great potential for scale up [4], will be applied in the textile coating step.

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P19 - Mannosylated chitosan nanoparticles for targeted antimicrobial drug delivery

Fulwah Yahya Alqahtani[a]

[a] King Saud University/research, Department of Pharmaceutics/College of Pharmacy1, 22452, Riyadh/Saudi Arabia1

E-mail: fyalqahtani@ksu.edu.sa

Background: The emergence of bacterial resistance to current drugs has raised great concern globally [1]. Solithromycin showed superior activity against multiple-resistant strains [2], and chitosan nanoparticles (CNPs) [3], which are known to have antimicrobial activity, in conjunction with a mannose moiety to increase cellular uptake by tissue macrophages, thereby limiting bacteria from surviving and replicating inside macrophages. This study aims to prepare solithromycin-mannose-conjugated chitosan-loaded NPs, investigate their physicochemical characteristics, and characterize their antimicrobial activity. Methods: The ionic gelation method was used to prepare CNPs, and then 5 formulations (CS-NPs, MCS-NPs, S-MCS-NPs, S-CS-dex-NPs, S-MCS-dex-NPs) were characterized in terms of their particle size (PZ), polydispersity index (PDI), and zeta potential. Encapsulation efficiency (EE %) is used to determine the percentage of drug entrapped into CNPs by a UV-visible spectrophotometer. Fourier transform infrared spectroscopy (FTIR) spectrometers to assess the conjunction of mannosylated chitosan. The antimicrobial activity of these formulations was investigated against resistant bacterial strains using the broth dilution method. Results: The mean average PZ, ZP, and PDI of empty CS-NPs and the full formulation S-MCS-dex-NPs were 292.8nm, 36.4mV, 0.267, and 494.4nm, 16.8mV, 0.533, respectively. Moreover, FTIR revealed successful conjugation of Mannose to chitosan. Conclusions: The findings of this study revealed successful preparation of mannose-conjugated nanoparticles, and their antimicrobial activity will be characterized in future studies.

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P20 - Synthesis and characterization of biofilms based on chitosan and *Pinus radiata* tannins for use in active packaging

Edison Monroy[a], Alessandro Pellis[b], Myleidi Vera[a]

[a] Universidad de Concepción, Facultad de Ciencias Químicas, Departamento de Polímeros, Edmundo Larenas 129, Concepción, Chile
[b] University of Genova, Department of Chemistry and Industrial Chemistry, Via Dodecaneso 31, 16146, Genova, Italy

E-mail: emonroy2025@udec.cl

Plastic pollution has become a major global challenge, driving the development of biodegradable materials, particularly for single-use packaging applications, which represent a significant source of waste. In this context, materials derived from renewable resources have emerged as promising alternatives for sustainable food packaging. [1]
This work proposes the use of biomass-derived compounds, specifically tannins extracted from *Pinus radiata* bark, together with chitosan, a biopolymer obtained from renewable sources, for the synthesis of biopolymer films with potential application in active food packaging. Film formation was carried out via an enzymatic approach using laccases, enabling polymerization under mild and environmentally friendly conditions. [2]
The biofilms obtained were characterized by Fourier-transform infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), tensile testing, and evaluation of their antioxidant and antimicrobial activities. The resulting films exhibited homogeneous structures, along with suitable mechanical, thermal, and functional properties.
These results demonstrate the effectiveness of laccase-mediated polymerization for the synthesis of chitosan–tannin copolymer films, highlighting their potential as sustainable materials for active food packaging applications.

Acknowledgments
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P21 - Engineering pyrolysed bamboo fibers into single-fiber electrochemical platforms for bioanalytical applications

Thiago Pereira Galvão[a,b], Maria Claudia Guimarães Valvassori[c], Leonardo Hideki Hasimoto[a,d], Marcos Vinicius Lorevice[a,e], Murilo Santhiago[a,d], Omar Ginoble Pandoli[f]

[a]Brazilian Center for Research in Energy and Materials (Brazilian Nanotechnology National Laboratory), Brazil
[b]University of Campinas, Institute of Chemistry, Brazil
[c]Federal University of Santa Catarina, Chemistry department, Brazil
[d]Federal University of ABC, Center for Natural and Human Sciences, Brazil
[e]University of Campinas, School of Technology, Brazil [f]University of Genoa, Pharmacy department, Italy.

E-mail: omar.ginoblepandoli@unige.it

Lignocellulosic electrochemical devices (LCEDs) are promising materials due to their renewability, abundance, and versatility [1]. LCEDs are widely reported in the field of electronics and electrochemical sensors [2]. However, due to the random lignocellulosic fiber arrangement of the bulk material, variations in conductivity, porosity, wettability, and electrochemical surface area can occur, making it difficult to establish a proper correlation between electrochemical properties and surface functionalization. To overcome these issues, the objective of this work is to fabricate the first single-fiber electrochemical sensor using a single pyrolyzed fiber as microelectrode. In this study, the bamboo species *Dendrocalamus giganteus* was used as the raw material for microelectrode fabrication due to its low cost, high availability, and ordered fiber arrangement [3]. Delignified bamboo fibers (BFs) were pyrolyzed at 1000°C to ensure high electrical conductivity. The BFs were characterized by Raman spectroscopy, confirming graphitization after pyrolysis. Morphological analysis was carried out using SEM and AFM. EDS and XPS showed that pyrolysis increased the C/O ratio and sp^2-hybridized carbon, respectively, indicating the loss of oxygen containing groups and improved electrical conductivity. Electrochemical measurements were obtained in the presence of $[Fe(CN)_6]^{4-}$ redox probe, and the voltammograms exhibited a sigmoidal shape characteristic of microelectrodes. By using a UV-laser, we tuned the area of the electrodes and fabricated fully integrated electrochemical cells using a single fiber. The electrochemical detection of NADH was performed using the carbon-based single-fiber electrodes, and the analytical curve presented a linear range from 0,1 to 1 mmol L^{-1}.

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P22 - N-terminal dynamics govern stability, oligomerization, and crystallization of Class I polyhydroxyalkanoate synthases

Javier A. Linares-Pastén[a], Nan Wu[a], Derek T. Logan[b]

[a] Lund University, Department of Process and Life Sciences Engineering, LTH, Biotechnology and Applied Microbiology, Naturvetarvägen 22, Postal address: Box 124, 221 00 Lund, Sweden.
[b] Lund University, Department of Chemistry, Biochemistry and Structural Biology, Center for Molecular Protein Science, Naturvetarvägen 16, Postal address: Box 124, 221 00 Lund, Sweden.

E-mail: javier.linares-pasten@ple.lth.se

Polyhydroxyalkanoate synthases (PhaCs) catalyze the polymerization of hydroxyacyl-CoA substrates into biodegradable polyesters and are central determinants of PHA biosynthesis. Although recent structural and computational studies have clarified important aspects of PhaC catalysis, substrate entry, product egress, and dimer architecture, the relationship between PhaC conformational dynamics, protein stability, oligomeric state, and crystallization behavior remains incompletely understood [1,2]. Here, we perform a comparative structure–function and physicochemical analysis of three Class I PhaC enzymes: PhaCCs from *Chromobacterium* sp., PhaCAc from *Aeromonas caviae*, and PhaCCn from *Cupriavidus necator*. Sequence analysis, AlphaFold 3 modeling, and molecular dynamics simulations show that the catalytic domains are structurally conserved, whereas the N-terminal regions differ strongly in flexibility. Recombinant expression, OMNISEC, mass spectrometry, and nanoDSF reveal distinct experimental behavior among the enzymes: PhaCAc forms a stable dimer, PhaCCn is conformationally fragile and poorly suited for crystallization, and PhaCCs is susceptible to construct-dependent degradation. N-terminal His-tagging stabilizes PhaCCs, suppresses degradation, improves monodispersity, and enables crystallization of its catalytic domain. The refined PhaCCs catalytic-domain structure at 1.8 Å provides a high-resolution structural framework for comparison with previously reported PhaCCs and PhaCCn catalytic-domain structures. These results show that divergent N-terminal dynamics, rather than conservation of the catalytic core, largely determine the experimental behavior of Class I PhaC synthases. The study provides a practical strategy for PhaC structural biology based on N-terminal stabilization and comparative biophysical screening.

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P23 - From PLA upcycling to recyclable biocatalysts: stereocomplex PLA microparticles as supports for enzymatic polyester synthesis

Alessandro Fortunato[a], Francesco Papatola[a], Martina Cozzani[a], Giacomo Damonte[a], Alessandro Pellis[a], Orietta Monticelli[a]

[a] Università di Genova, Dipartimento di Chimica e Chimica Industriale, Via Dodecaneso 31, 16146, Genova, Italy

E-mail: alessfortu@gmail.com

The development of bio-based and recyclable catalytic systems is a key objective for implementing polymer synthesis processes that meet key environmental requirements. In relation to this object, this work presents a novel strategy for poly(lactic acid) (PLA) recycling through aminolysis with cysteamine and valorisation of the resulting products to develop efficient enzyme supports. Specifically, the approach was extended to the stereoregular polymers poly(L-lactic acid) (PLLA) and poly(D-lactic acid). The resulting functional oligomers were combined to prepare highly crystalline stereocomplex PLA microparticles, which were subsequently employed as supports for the immobilization of Candida antarctica lipase B (CaLB).[1] The catalytic performance of the immobilized enzyme was evaluated in the polycondensation of dimethyl adipate and 1,8-octanediol, with particular attention given to the biocatalyst reusability over five consecutive reaction cycles.[2] The immobilized CaLB maintained high catalytic activity, achieving monomer conversions > 96% throughout all reaction cycles. Similarly, the synthesized polyesters exhibited number-average molecular weights ranging from 8.5 kDa to 13.5 kDa, showing an initial increase followed by a tendency toward a plateau. The combination of high conversion and sustained polyester formation across five consecutive cycles suggests excellent enzyme retention on the support and preservation of catalytic activity. Beyond catalytic efficiency, the proposed support offers a significant sustainability advantage. Unlike conventional immobilization matrices, stereocomplex PLA derived from upcycled polymeric materials can be hydrolyzed under mild conditions after use, contributing to a more circular catalyst lifecycle. Therefore, the results demonstrate that stereocomplex PLA obtained from chemically upcycled PLA can serve as an effective support for CaLB immobilization, providing sustained activity over multiple reaction cycles, and the potential for more sustainable biocatalytic polyester production.

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P24 - Oral delivery of entecavir with hydroxypropyl methylcellulose as solid dispersion

Bushra T. AlQuadeib[a]

[a] Department of Pharmaceutics, College of Pharmacy, King Saud University, Saudi Arabia, P.O. Box 84428, Riyadh 11671, Saudi Arabia

E-mail: bquadeib@ksu.edu.sa

Internationally, more than 70 million people's diagnosed with chronic hepatitis C virus [1-2]. Treatment of Hepatitis C is done by administration of direct-acting antiviral, Entecavir. Entecavir exhibits poor aqueous solubility, which significantly limits its clinical applications. The aims of this study to develop oral Entecavir-loaded nanoparticles employed hydroxypropyl methylcellulose (HPMC) as a carrier and utilized supercritical anti-solvent (SAS) technology to prepare amorphous Entecavir/HPMC solid dispersions (SDs).

The tested formulation of Entecavir nanopertilces will be subjected to in vitro characterization [3] such as; particle size, polydispersity index, encapsulation efficiency, and in vitro drug release. The proposed nanoparticles will be visualized using scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FTIR). Suitable high performance liquid chromatography technique will be modified, to measure the drug content, drug loaded as well as in vitro release, in vivo, ex vivo measurement. Furthermore, in vivo studies will then be performed on the promising formulation using Westar rats as an animal model.

Acknowledgements

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P25 - Investigating roadside soil microbiomes: metagenomic analyses to identify taxa driving rubber degradation

Daniela Bucchieri[a,b], Marcella De Divitiis[a,b], Alessia Dicesare[a,b], Luca Giannini[c], Silvia Guerra[c], Paola Branduardi[a], Immacolata Serra[a]

[a] University of Milano-Bicocca, Department of Biotechnology and Biosciences, Piazza della Scienza 2, 20126 Milano, Italy
[b] University of Milano-Bicocca, Department of Materials Science, Via Roberto Cozzi 55, 20125 Milano, Italy
[c] Pirelli Tyre S.p.A., Viale Piero e Alberto Pirelli 25, 20126, Milano, Italy

E-mail: immacolata.serra@unimib.it

The substantial environmental accumulation of waste tyres and the release of significant amounts of particulate debris, predominantly tyre and road wear particles (TRWP) generated by the friction between tyres and road surfaces, pose a critical challenge. While biodegradation has been extensively studied for other recalcitrant polymers such as plastics, rubber has received little attention. Moreover, current research often focuses on individual rubber-degrading microbial strains, whereas the complexity of rubber-based compounds suggests that efficient degradation requires synergistic interactions within microbial consortia. A broader overview of rubber degradation processes is therefore essential.
In this work, we investigated this potential by enriching microbial communities derived from roadside soil collected from heavily trafficked road using rubber compounds as the sole carbon source. This selective pressure promoted the growth of rubber-degrading taxa. Subsequently, we utilized high-throughput sequencing approaches - DNA metabarcoding and shotgun metagenomics- to characterize the taxonomic composition of the whole microbial communities from both the original soil and the enriched samples.
Comparative analyses (amplicon and shotgun sequencing), demonstrating concordance between taxonomic and functional profiles, facilitated the identification of key taxa and revealed significant shifts in microbial community structure. This allowed us to assess the overall metagenomic divergence driven by the selective pressure of the enrichment conditions. By comparing microbial communities from heavily trafficked road soils with those enriched under controlled, rubber-only incubations, this work provides novel insights into environmental responses to rubber pollutants and the microbial potential for their breakdown.

P26 - PLA surface functionalization by enzymatic processes: the first effective step in the development of gas-barrier films

Leonardo Giribaldi[a], Giacomo Damonte[a], Alessandro Pellis[a], Orietta Monticelli[a]

[a] Università di Genova, Dipartimento di Chimica e Chimica Industriale, Via Dodecaneso 31, 16146 Genova, Italy

E-mail: leonardo.giribaldi@edu.unige.it

Poly(lactic acid) (PLA) is one of the most promising bio-based polymers; however, its poor mechanical properties, slow crystallization rate, and limited barrier ability hinder its broader application. Considering that the latter property can affect its specific use in the packaging sector, which represents one of the main application areas for PLA, overcoming this drawback is crucial. One method to improve the gas barrier is the application of proper coating. However, due to the lack of polymer functional groups, which are necessary to ensure adhesion of the surface coating, this can be challenging. Surface functionalization is therefore the first essential step for the film coating, and is generally carried out by chemical functionalization, which can cause significant surface material erosion with a detrimental of mechanical properties. This work focused on the PLA films functionalized using an enzymatic process as an alternative to impactful chemical methods, with the aim of making the film suitable for interactions with pullulan and chitosan, two bio-based compounds known for their oxygen barrier performance. The functionalization of the PLA surface was carried out via enzymatic hydrolysis, using a 5 μM *Humicola insolens Cutinase* (HiC) solution buffered at pH 7. The reaction, carried out at 37°C for 24 hours, generated superficial hydroxyl and carboxyl groups that increased the film's wettability towards water, as demonstrated by a drastic reduction in the contact angle from 75° to 35°. To produce the pullulan and chitosan layers, 0.5% w/v aqueous solutions were cast onto the modified PLA. The coatings were evaluated by contact angle measurements, and tested individually, in combination, and as pullulan-montmorillonite mixtures. The combined materials exhibited synergistic behavior, specifically an enhanced resistance of the coating to water solubilization. The same effect was observed in thermally annealed samples treated at 60°C for 30 minutes. Overall, it was demonstrated that the enzymatic surface functionalization of PLA is a reliable method for applying polar coatings that could improve the barrier properties of the material, enabling the development of novel green and biodegradable packaging materials.

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P27 - Integrated Enzymatic and Microbial Upcycling of Polyester Packaging Waste into Sustainable Plasticizers

Florent Pruvost[a], Felice Quartinello[a], Georg Guebitz[a]

[a] Institute of Environmental Biotechnology, Department of Agricultural Sciences, BOKU University, Vienna, Konrad Lorenz-Strasse 20, 3430 Tulln an Der Donau, Austria

E-mail: florent.pruvost@boku.ac.at

Plastic waste accumulation has become a critical environmental issue, largely driven by short-lived applications such as food packaging. The efficient processing of these waste streams remains challenging, particularly for complex polyester-based materials. Among them, poly(butylene adipate-co-terephthalate) (PBAT)/starch blends have attracted significant attention due to their widespread use as biodegradable packaging materials.

In this context, enzymatic depolymerization represents a promising strategy, enabling the recovery of monomers that can be further valorized into sustainable plasticizers for biopolymer formulations (Kremser et al., 2021; Pellis et al., 2023). The enzymatic systems employed primarily involve cutinases and amylases, applied either sequentially or in one-pot processes. Process conditions are optimized using a Design of Experiments (DoE) approach, while hydrolysis efficiency is evaluated through monomer quantification by High-Performance Liquid Chromatography (HPLC).

The recovered monomers are subsequently upgraded into value-added intermediates via chemical and/or microbial pathways, and further converted into plasticizers through enzymatic polycondensation. These plasticizers are characterized using Nuclear Magnetic Resonance (NMR) spectroscopy and Gel Permeation Chromatography (GPC).

Their performance is then assessed in biopolymer matrices such as poly(lactic acid) (PLA) and polyhydroxyalkanoates (PHA), through chemical, thermal, and mechanical analyses. Finally, enzymatic hydrolysis assays and biodegradability tests are conducted to evaluate the degradation behavior and overall sustainability of the developed materials.

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P28 - Novel galactarate-based plasticizers

Andrea Pasquale[a], Martina Galatini[a], Giacomo Damonte[a], Anamaria Todea[b], Laura Cipolla[c], Dario Cavallo[a], Alessandro Pellis[a]

[a] Department of Chemistry and Industrial Chemistry, University of Genova, via Dodecaneso 31, 16146, Genova (GE), Italy
[b] Faculty of Industrial Chemistry and Environmental Engineering, Polytechnic University of Timisoara, Carol Telbisz 6, 300001 Timisoara, Romania
[c] Department of Biotechnology and Biosciences, University of Milano-Bicocca, Piazza della Scienza 2, Milano I-20126, Italy

E-mail: giacomo.damonte@edu.unige.it

Carbohydrates represent some of the most abundant biopolymers on Earth and provide a valuable feedstock for the production of high-value chemicals. Galactaric acid is a particularly appealing bio-based platform molecule whose potential remains underexplored [1,2]. At present, increasingly demanding regulations, sustainability goals, safety-by-design principles, and performance criteria are reshaping the development of polymer additives. Consequently, innovation must advance rapidly to create novel materials with improved functionality. To address this need, new galactaric acid-derived sugar-based plasticizers were synthesized (*Figure 1*). Poly(lactic acid) (PLA), a brittle bio-based polymer, was chosen to assess their effectiveness in enhancing mechanical performance [3]. The most effective additive increased the elongation at break by up to 260% relative to neat PLA. Experimental findings, supported by computational analyses, demonstrate that subtle changes in molecular structure can significantly affect both the synthesis and performance of these additives.

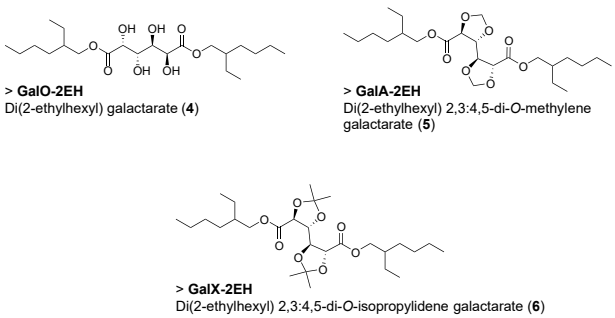


Figure 2. Novel galactarate-based plasticizers GalO-2EH, GalA-2EH and GalX-2EH synthesised.

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P29 - Chemical pretreatment-assisted refining of recycled textile fibres for sustainable fibre-based construction materials

Muhammad Faisal Afridi[a], Meri Lundahl[a] , Bruno Dufau Mattos[a]

[a] Department of Bioproducts and Biosystems, School of Chemical Engineering, Aalto University, P.O. Box 16300, FI-00076 AALTO, Finland

E-mail: bruno.dufaumattos@aalto.fi, meri.lundahl@aalto.fi

Recycling mixed cotton/polyester (PET) textile waste is challenging because the two fibre types respond differently to chemical and mechanical treatments. Previous studies have shown that pretreatment strategy strongly influences downstream processing of cotton/PET blends, whether the subsequent step is enzymatic hydrolysis [1] or, as investigated here, mechanical refining for fibre-based materials. In this work, recycled cotton, polyester (PET), and 50/50 polycotton fibres were chemically pretreated using either an alkaline NaOH/urea solution (5/12 wt%) or concentrated acetic acid (50 wt%) prior to mechanical refining. The effects of the pretreatments on fibre structure, surface properties, fibrillation behaviour, and suspension processability were evaluated for the development of lightweight fibre-based foams for construction applications. Fibre properties were characterised by water retention value (WRV), ATR-FTIR spectroscopy, scanning electron microscopy (SEM), X-ray diffraction (XRD), and X-ray photoelectron spectroscopy (XPS). Polycotton suspensions were further evaluated by oscillatory rheometry, Turbiscan stability analysis, and the apparent density of the resulting foams.

NaOH/urea pretreatment increased the WRV of cotton fibres by 12.1% and, following refining, promoted extensive longitudinal fibril delamination, consistent with the swelling behaviour of cellulose in NaOH/urea systems [2]. XPS analysis showed an increase in the surface O/C ratio from 0.57 to 0.62 together with a substantial reduction in nitrogen-containing sizing residues, indicating greater cellulose exposure at the fibre surface. In comparison, acetic acid pretreatment reduced the WRV of cotton by 9.4% and resulted in a slightly higher crystallinity index (70.26%) than the untreated cotton (68.65%). PET fibres exhibited only minor chemical and structural changes under either pretreatment, consistent with their resistance to these relatively mild treatment conditions.

Compared with pure cotton, the effects of both pretreatments were less pronounced in polycotton, suggesting that the PET component restricts fibre swelling and reagent penetration. Nevertheless, NaOH/urea-pretreated polycotton formed a substantially stronger viscoelastic gel (G'_0 = 2,970 Pa) than acetic acid-pretreated polycotton (454 Pa), exhibited improved suspension stability, and produced the lightest foams, with a density of 7.13 kg m^{-3}.

These findings demonstrate that chemical pretreatment plays an important role in controlling fibre fibrillation, network formation, and suspension processability in recycled cotton/PET textile waste. Among the investigated pretreatments, NaOH/urea produced the most favourable fibre modifications for preparing lightweight fibre-based construction materials. The improved understanding of fibre structural and surface modifications also provides a useful basis for future studies evaluating enzymatic or combined chemo-enzymatic processing of recycled textile fibres.

Keywords: Textile waste recycling; chemical pretreatment; mechanical refining; polycotton; sustainable construction materials, circular economy

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P30 - Functionalized biodegradable PLA porous films for controlled retention and release under enzymatic conditions

Martina Cozzani[a], Alessandro Fortunato[a], Giacomo Damonte[a], Alessandro Pellis[a], Orietta Monticelli[a]

[a] Università di Genova, Dipartimento di Chimica e Chimica Industriale, Via Dodecaneso 31, 16146 Genoa, Italy

E-mail: martina.cozzani@edu.unige.it

The development of polymeric systems combining controlled retention capacity with enzymatic degradability is of great interest for biomedical and biotechnological applications. Investigating how degradation processes affect adsorption and release behaviour is crucial for the design of effective delivery platforms. In this work, porous films based on polylactic acid (PLA) and a star-shaped polycaprolactone bearing carboxylic end groups (PCL-COOH) were prepared through Non-solvent Induced Phase Separation (NIPS). [1] The incorporation of PCL-COOH provided a high concentration of acidic functionalities within the porous structure, promoting specific interactions with positively charged molecules. Morphological characterization revealed homogeneous porous architecture and a uniform dispersion of the functionalized PCL throughout the PLA matrix. Particular attention was given to enzymatic hydrolysis using *Humicola insolens* Cutinase (HiC), an enzyme known for its activity toward aliphatic polyesters, especially PCL. [2] Degradation tests confirmed the biodegradable nature of the films and showed that the presence of PCL-COOH promoted the hydrolysis of the PLA-based matrix. Moreover, the retention and release capacity of the films were evaluated using pararosaniline hydrochloride as a model cationic compound and doxorubicin as a model therapeutic agent under enzymatic conditions. The films exhibited high loading efficiency, and the adsorption capacity strongly depended on the concentration of carboxylic groups. Release tests demonstrated controlled and sustained delivery of both compounds, even as the polymer matrix underwent enzymatic degradation. Overall, these findings demonstrate that the developed PLA/PCL-COOH porous films can maintain their functional performance while undergoing enzymatic hydrolysis, making them promising candidates for the design of drug-delivery systems and applications requiring biodegradable and functional polymer substrates.

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