europeanbioplastics

Side Event to the EBC 24

Recycling strategies for bioplastics: What's next?

Novel approaches in recycling and upcycling bioplastics

About us

The projects BioSupPack, BIOMAC, MoeBIOS, ReBioCycle and PROSPER are funded by the European Commission under the European Union Research and Innovation Programme Horizon 2020, Horizon Europe and their European Partnerships, the Bio-based Industries Joint Undertaking (BBI JU) and the Circular Bio-based Europe Joint Undertaking (CBE JU). These innovative projects are working on novel or improved recycling technologies to apply them to bioplastics, pursuing the goal of keeping bioplastics in the circular loop for the longer time possible.

Authors

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TORWASH: Jan Pels **(ReBioCycle)**
Wageningen Food & Biobased Research: Wouter Post **(PROSPER)**

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December 2024

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The Challenge

As the bioplastics market grows ([1]), it is essential to address the issue of recycling biodegradable bioplastics and to study their most effective recycling pathways, to be able to manage bioplastic products at their end of life. Bioplastic waste does not yet constitute a relevant amount of the total plastic waste (being only 1% in weight)[2].

An efficient waste management for bioplastics is key to the European Commission's flagship policy goal of a resource-efficient Europe and a circular economy vision. According to the European Commission Waste Framework Directive[3], waste should be managed according to a precise hierarchy indicating a priority order in the legislation and policy for waste prevention and management: prevention; preparing for re-use; recycling; other recovery, e.g. energy recovery; and disposal.

In the past years, several projects, BioSupPack is one of them, have been funded by the Horizon Programme for Research and Innovation and the Circular Bio-based Europe Joint Undertaking to improve and upscale bioplastics' recycling technologies.
Recently, three new projects, MoeBIOS, ReBioCycle and PROSPER, have kicked off, to bring upscaling of recycling technologies for bioplastics even further.

This event connects experts working on novel or improved recycling technologies for bioplastics from academia and the private sector, offering expertise along the whole process of bioplastics waste management from the foundation (e.g., waste sorting and pretreatment, creation of value chains) to recycling technologies - mechanical, chemical and enzymatic/microbial recycling- to upscaling and the development of new applications, in particular packaging, textiles and agriculture.

The presentations at this event revolve around the following recycling technologies:

- Mechanical Recycling

Projects using this technology: ReBioCycle, MoeBIOS, PROSPER, BIOMAC.

- Chemical Recycling

Projects using this technology: BioSupPack, ReBioCycle, MoeBIOS, PROSPER.

- Enzymatic and Microbial Recycling

Projects using this technology: ReBioCycle, MoeBIOS, BioSupPack.

A short outline of the plans and activities of these projects is presented in the current document.

[1] https://www.european-bioplastics.org/bioplastics-market-development-update-2023-2/
[2] ReBioCycle factsheet https://zenodo.org/records/14038703
[3] https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en#ref-2023-amendment-to-the-waste-framework-directive

MoeBIOS: Improving waste management of biobased plastics and the upcycling in packaging, textile and agriculture sectors

Representative and coordinator: Miriam Lorenzo Navarro (ITENE), MoeBIOS project.
Presentation: Recycling for PLA and PLA blends, PHA and its blends, PBS and PEF in MoeBIOS, Miriam Lorenzo Navarro (ITENE), MoeBIOS project.

The MoeBIOS project was launched in June 2024 to address cover sorting waste streams for optimal treatment and scaling up several recycling technologies. The goal is to demonstrate that novel bioplastics can be sorted in existing sorting and recycling schemes without line disruption.

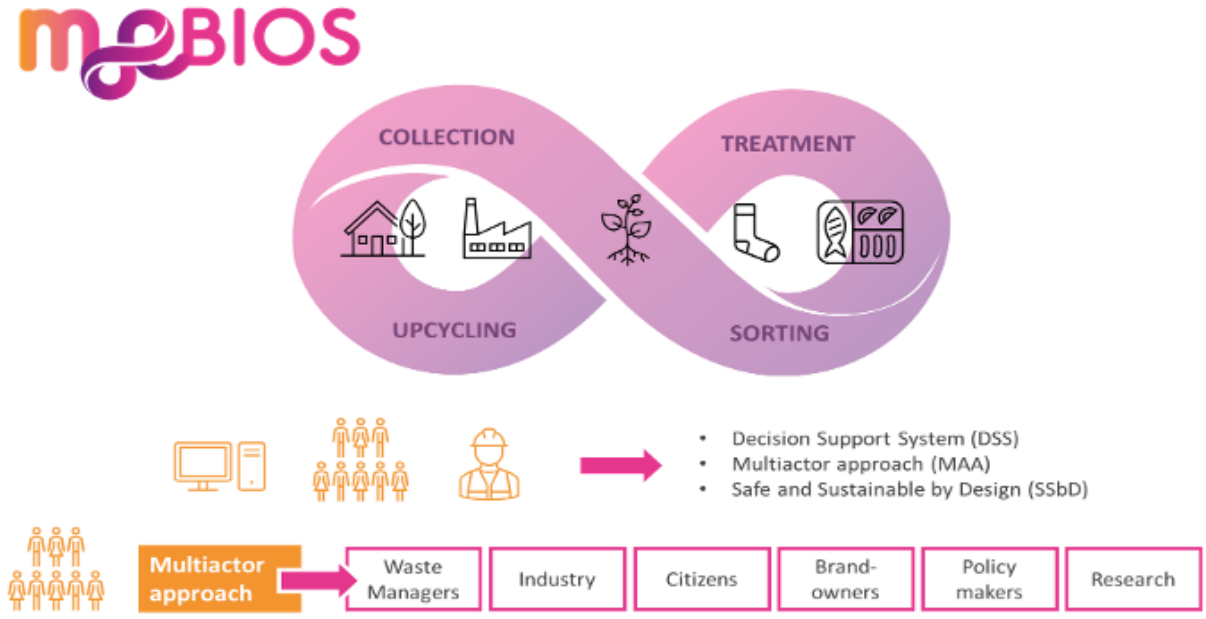

Fig.1: Closing the loop of bioplastics end of life. Source: ITENE.

MoeBIOS works on mechanical, enzymatic, chemical, and thermo-chemical recycling for biobased and biodegradable plastics (in short, BIOS) in three value chains: textiles, packaging, and agricultural waste. The goal is to find integral treatments to keep the materials in the loop as long as possible versus landfilling and incineration. Digital libraries will be built for bioplastics to increase the efficiency of compositional sorting.

- For the packaging, the waste managers will bring in municipal solid waste with a separate collection.
- For the agricultural waste streams, the waste managers will focus on the post-use and post-industrial waste.
- For the textile waste streams, the waste managers will use post-use and post-industrial waste.

The sorting will be based on innovative infrared and ultraviolet technologies, using hyperspectral and chemometrics. The treatment will then be based on mechanical recycling, enzymatic recycling, chemical recycling, and thermo-chemical recycling in a hierarchical approach aimed at giving each waste stream its optimal treatment from a technical, economic and environmental

point of view. The upcycling will be based on the validation of recycled products from packaging, agriculture, and textile products, counting on the expertise of brand owners in the sectors mentioned above.

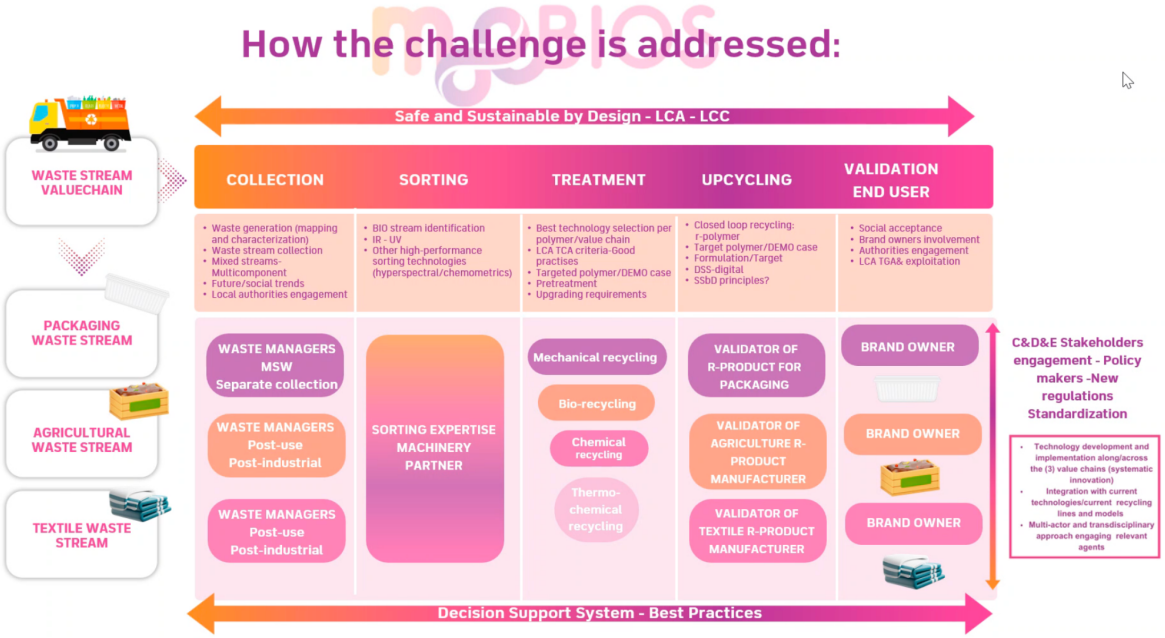

Fig. 2: How MoeBIOS addresses the challenge of recycling biobased plastics. Source: ITENE.

MoeBIOS has been funded under the call HORIZON-JU-CBE-2023-IA-04: Recycling biobased plastics increasing sorting and recycled content (upcycling), together with two additional projects, ReBioCycle and PROSPER, which have similar, but complementary approaches to the MoeBIOS'.

KEY FACTS

- Type of project: Innovation Action- Demonstration
- Project coordinator: Miriam Lorenzo Navarro, ITENE
- Project duration: 1 June 2024- 31 May 2028
- CBE-JU funding: € 7 013 928
- Focus: Packaging, textiles, agriculture
- Feedstock: Industrial waste streams, bioplastics

BioSupPack: Demonstrative process for the production and enzymatic recycling of environmentally safe, superior and versatile PHA-based rigid packaging solutions by plasma integration in the value chain

Representatives: Chrysa Argeiti and Eva Georgiadou (Agricultural University of Athens), BioSupPack project.
Presentation: Integrated plasma-based biorefineries for circular biopolymer production and recycling of post-consumer bioplastics Eva Georgiadou and Chrysa Argeiti (AUA) BioSupPack project.

A potential source for the bioplastics' production is the brewers' spent grains, a by-product of the brewing industry. Its use as a feedstock is currently limited; most of it goes to animal feed, some for bioethanol, and parts of it go into landfill. It is a challenging raw material: it has a high moisture content, low levels of fermentable sugar content and can spoil quickly. At the same time, however, it offers several potential advantages as a feedstock for PHA production: It is produced in substantial quantities, it is widely available all year round, it is relatively stable, and the prior malting and mashing make it relatively easy to isolate the 2G sugars.
The goal of the BioSupPack project is to deliver novel, cost-competitive and versatile biobased packaging solutions based on PHA. These will be derived from highly (>85%) renewable, second- and third-generation raw materials and will provide high-performance packaging for food and drink, cosmetics and home care products.

BioSupPack integrates plasma technology in three different points of the value chain, e.g., biomass pre-treatment, packaging production and packaging waste pre-treatment, by increasing PHB production yield, PHB purity, packaging performance (high oxygen and water barrier) and effectiveness and yield of enzymatic recycling.

BioSupPack uses enzymatic recycling to transform PHA/PHB into a carbon source. When using lignocellulosic feedstock such as brewers' spent grains to produce bioplastics, enzymatic steps are generally necessary when second-generation sugars are liberated from the cellulose and hemicellulose fraction. The use of commercial hydrolytic enzymes in this stage is usually another step that makes the process more expensive, as they represent between 10 and 30% of the total cost. One solution to reduce the use of commercial enzymes would be to produce the enzymes in the same biorefineries and use the same wastes used for bioplastic production. By fermentation, we can produce cellulases that we will use for enzymatic hydrolysis to recover the sugars present in the waste after a second stage. Therefore, by incorporating the two production systems (both hydrolytic enzymes and bioplastics) in the same biorefinery, since the same equipment is needed, lignocellulosic biomass recovery costs can be reduced.

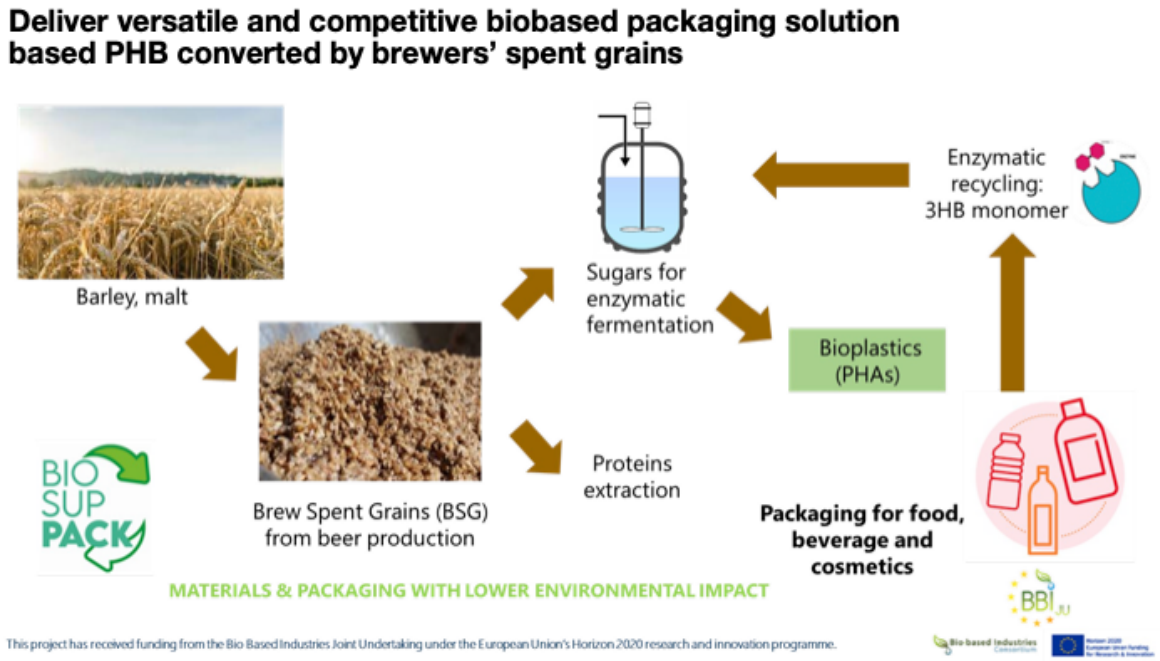

Fig. 3: Versatile and competitive biobased packaging solution-based PHB converted by brewers' spent grains. Source: R. Jiménez Lorenzo, AIMPLAS.

KEY FACTS

- Type of project: Innovation Action- Demonstration
- Project coordinator: Rosa Gonzalez, AIMPLAS
- Project duration: 1 June 2021 - 31 March 2026
- CBE-JU funding: € 6 403 796
- Focus: Packaging
- Feedstock origin: Agrofood waste

BIOMAC: European Sustainable Biobased Nanomaterials Community

Representative: Ronny Salcedo Santana (EVERSIA), BIOMAC project
Presentation: The industrial perspective of recycling, Ronny Salcedo Santana (EVERSIA), BIOMAC project.

The biobased sector is one of Europe's most resource-intensive sectors. Recent developments in biobased nanomaterials can be combined with biotechnologies to convert renewable resources into high-value-added biopolymers used in applications such as food packaging, construction, automotive and printed electronics. BIOMAC has set up an Open Innovation Test Bed (OITB) ecosystem, which is openly accessible to industrial players of any side (from micro to large companies) interested in or already operating with biobased nanomaterials, enabling innovation and minimising investment risks. The OITB is an open collaboration community that supports innovation by providing services such as assessing regulatory requirements, safety requirements, sustainability, circularity and market potential with modelling, process control, standardisation and characterisation. The services of the OITB are accessible at fair conditions and costs. In the OITB, technologies related to the use and implementation of biobased nanomaterials have been developed around TRL 4-5 and upscaled and validated up to TRL 7.

KEY FACTS

- Type of project: Innovation Action- Demonstration
- Project coordinator: Dimitris Bikiaris, Aristotle University of Thessaloniki
- Project duration: 1 January 2021- 30 June 2025
- Total costs: € 10 416 832
- Horizon 2020 funding: € 16 721 764
- Focus: Food Packaging, Construction, Automotive and Printed Electronics

ReBioCycle: A new European blueprint for circular bioplastics upcycling solutions

Representative: Jan Pels (TORWASH), ReBioCycle project.
Presentation: Recovery of PLA, PHA, Composites in the project's novel, innovative hubs, Jan Pels (Torwash), ReBioCycle project.

ReBioCycle aims to demonstrate that biobased biodegradable plastics can be kept in the cycle for as long as possible through innovative recycling technologies and that end-of-life biobased biodegradable plastics can be used in the circular bioeconomy. ReBioCycle proves a portfolio of bioplastic sorting and recycling technologies within three complementary waste-processor-centric hubs at a demonstration scale and in the real operational environment the effective and efficient recycling of three types of bioplastics (PLA, PHA, composites) to demonstrate higher impact of obtaining the same or superior grade recycled polymers and other higher-value applications.

The Dutch Hub – Leader: TORWASH. Focus on: Chemical technology to be upscaled to TRL6, using TORWASH technology to recycle PLA and PHA polymers and transform them into rPLA, and PBM to make PHBV from hydrolysed PHA and PLA. **Partners:** Dutch waste sorting, NTCP, the site owner and sorter, TotalEnergies Corbion, Paques Biomaterials, and Corbion. Kaneka Belgium is also supporting this hub.

The Italian Hub- Leader: NOVAMONT. Focus on: Chemical technology to be upscaled to TRL7. NOVAMONT technology will be used to recycle mixed composites to achieve rComposites for flexible and rigid packaging with a 15% recycled content. rPHA from the Dutch and Spanish Hub will be tested in the Italian hub to blend into bioplastic formulations. **Partners:** The IREN Group waste sorting site of Borgaro Torinese (Piedmont, Italy), NOVAMONT bioplastics recycling plant in Terni (IT) plant, AMIAT and I.BLU.

The Spanish Hub – Leader: AIMPLAS. Focus on: 1) Enzymatic recycling technology to be upscaled to TRL6. 2) Microbial recycling technology to be upscaled to TRL7 to produce rPHA. 3) Mechanical recycling technology will be upscaled to TRL7 to achieve rPLA and rPHA. **Partners:** Trinity College Dublin, GlasPort Bio, University of Galway O' Flaherty Lab, CSIC CIB Biological Research Center, TotalEnergies Corbion. The hub activities will be implemented in the waste sorting site of Manises (Valencia, Spain) run by the S.A. Agricultores de la Vega de Valencia. Kaneka Belgium is also supporting this hub.

KEY FACTS

- Type of project: Innovation Action- Demonstration
- Project coordinator: Kevin O'Connor, University College Dublin, BiOrbic Bioeconomy SFI Research Centre
- Project duration: 1 October 2024- 30 September 2028
- CBE-JU funding: € 7 497 001
- Focus: Biobased polymers & plastics
- Feedstock: Bioplastics

PROSPER: Promoting innovation for sustainable sorting and recycling of dedicated biobased plastics

Representative: Wouter Post (Wageningen Food & Biobased Research) PROSPER project.
Presentation: The recycling approach of the PROSPER project, Wouter Post (Wageningen Food & Biobased Research).

The PROSPER project demonstrates technically and financially viable sorting and recycling of biobased plastics in packaging. PROSPER integrates AI-sorting innovations and tests them in real waste management settings. It also evaluates market dynamics and consumer perceptions to boost the viability of the recycled biobased plastic sector. The project integrates these plastics into current waste management practices and implements policy tools like Extended Producer Responsibility (EPR) systems. PROSPER seeks to boost demand for biobased plastics by highlighting their recyclability and sustainable origins.

PROSPER brings together three biobased plastic producers (including PLA and AAPE-blend producers), a major brand owner, an EPR scheme/PRO participant, a supplier of AI-sorting technology, a sorting testing center, four waste management companies, a municipality and a specialised consultant. It is supported by the scientific expertise of three research institutions and universities and a policy-oriented non-profit organisation. The project offers a comprehensive approach by developing policy interventions and EPR fee scenarios and quantifying recycling rates and cost benefits associated with these scenarios. It also focuses on demonstrating technical advancements in sorting and recycling at an industrial scale inside four real waste management companies. PROSPER will also evaluate the market potential for recycled bio-based plastic products through consumer studies, and engagement with companies and PROs, while also assessing the Life Cycle, Social Life Cycle, material circularity indicators and economic business models.

Institutionalising a system change by the stakeholders in the biobased plastics value chain will be crucial in achieving circularity, improving environmental performance and fostering positive impacts in the biobased economy.

KEY FACTS

- Type of project: Innovation Action- Demonstration
  Project coordinator: Steven De Meester, Ghent University
- Project duration: 1 September 2024- 31 August 2028
- CBE-JU funding: € 7 498 855
- Focus: Packaging
- Feedstock: Plastics and composites

Contributing Projects

MoeBIOS: Improving waste management of biobased plastics and the upcycling in packaging, textile and agriculture sectors.

Website: https://www.cbe.europa.eu/projects/moebios

LinkedIn: https://www.linkedin.com/company/moebios-eu-com

MoeBIOS has received funding from the Circular Bio-based Joint Undertaking (JU) and its members under the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101157652. The JU receives support from the European Union's Horizon Europe Research and Innovation Programme and the Bio-based Industries Consortium.

BioSupPack: Demonstrative process for the production and enzymatic recycling of environmentally safe, superior and versatile PHA-based rigid packaging solutions by plasma integration in the value chain.

Website: https://biosuppack.eu/

LinkedIn: https://www.linkedin.com/company/biosuppack-project/

BioSupPack has received funding from the Bio-based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 101023685. The JU receives support from the European Union's Horizon 2020 Research and Innovation Programme and the Bio-based Industries Consortium.

European Sustainable Biobased Nanomaterials Community.

Website: https://www.biomac-oitb.eu/en/normal/home

LinkedIn: https://www.linkedin.com/company/biomacoitb

BIOMAC has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 952941

A new European Blueprint for Circular Bioplastics Upcycling Solutions.

Website: https://rebiocycle.eu/

LinkedIn: https://www.linkedin.com/company/rebiocycle/

ReBioCycle has received funding from the Circular Bio-based Joint Undertaking (JU) and its members under the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101156032. The JU receives support from the European Union's Horizon Europe research and innovation programme and the Bio-based Industries Consortium.

Promoting innovation for sustainable sorting and recycling of dedicated bio-based plastics

LinkedIn: https://www.linkedin.com/company/prosperbioplastics

PROSPER has received funding from the Circular Biobased Joint Undertaking (JU) and its members under the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101157907. The JU receives support from the European Union's Horizon Europe Research and Innovation Programme and the Bio-based Industries Consortium.