Newsletter 05_2022

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Welcome to the fifth issue of the BIO-PLASTICS EUROPE Newsletter!

The BIO-PLASTICS EUROPE project aims to replace commonly used plastics with bio-based and biodegradable alternatives. Within the project, bio-based polymers are produced and then tested in terms of their degradability and properties for their intended use. 30 months into the project, the first round of bio-based compounds' testing is done. Our industry partners (NaturePlast and Arctic Biomaterials) have used these test results to modify the compounds to improve their physical and chemical properties. Please enjoy reading about the recent Executive Board meeting, the test results as well as how they are applied to develop sustainable products.

THIS ISSUE

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Completed: 3rd Executive Board Meeting

By Jasmin Röseler (HAW Hamburg, Germany)

The third BIO-PLASTICS EUROPE Executive Board Meeting took place from 16th to 17th of March. The meeting, organized by the HAW Hamburg, was attended by the project's Work Package Leaders, project companies Arctic Biomaterials and NaturePlast, as well as Impact and Technical Coordinators. During those two days, the group discussed the project's progress during the last six months, agreed on future steps and discussed new ideas.

During Day 1, the overall situation of the project during the first 30 months was outlined. The biodegradable bio-based compounds developed during the project have been modified using the results of testing round I and samples of the new compounds are now being produced to enter into round II of testing. The schedule of the production and testing processes was shared and discussed among all attendees. Furthermore, the key findings for recommendations regarding the testing standards of biodegradable bio-based plastics were shared. Lastly, the partners discussed an evaluation of the biodegradable bio-based plastics market to analyze competition and demand for the developed compounds.

Day 2 revolved around how project results are used to inform policy and decision makers. Existing safety policies as well as results of safety analyses carried out during the project are being used to develop a safety protocol for bio-based plastics. As part of this safety protocol, a sustainability framework outlines how sustainability can be implemented for biodegradable bio-based plastic products. BIO-PLASTICS EUROPE is also working on a policy framework, that uses inputs from the project to produce recommendations for EU policy development. Furthermore, a newly published handbook on the impacts of biodegradable bio-based plastics on

Image 1: The 3rd Executive Board Meeting kicked off in high spirits (Source: HAW Hamburg).

waste management systems was presented to the partners during the meeting.

This third Executive Meeting highlighted the harmonious workflow between all Work Packages without any major problems. The BIO-PLASTICS EUROPE project is well on its way towards achieving its aim: shifting towards a more circular economy by promoting sustainable bio-based and biodegradable plastic alternatives.

Biodegradable & bio-based toys – it's all about the compounds

By Katrin Weinhandl, Franz Stelzer (ACIB, Austria) and Simon Gölden (Fraunhofer LBF, Germany)

Plastics play a big role in our everyday lives. Their diverse properties paired with relatively low costs and longevity make them one of the most used man-made materials. However, they come at a high environmental cost. From the fossil-based raw materials used in their production to their persistence in the environment as a polluter, a large part of their lifecycle is linked to negative environmental impacts. In the BIO-PLASTICS EUROPE project, our overall goal is to identify and test new possibilities to replace commodity plastics that frequently end up in the environment, with bio-based, biodegradable polymers to avoid negative effects. Well-known examples are single use cutlery and tableware, sand and swim toys, packaging materials and fishing baits. All of which get lost in the environment quite regularly and often unintentionally. Therefore, the compounds they are made of should be biodegradable without harming the environment.

Our task within the BIO-PLASTICS EUROPE consortium is to explore different material options and test them for their suitability in terms of the desired properties such as color, design, and mechanical properties. Also, the intended usage time for the applications must be kept in mind and the materials designed accordingly. For instance, cutlery is designed to be sturdy and dish-washer safe for multiple uses but should still biodegrade if lost. When focusing on toys, it is important to consider that for example sand toys and swim toys do not require the same material properties (sand toys should be rigid but not brittle, while swim toys require a soft and "rubbery" appearance). The materials that we test in the frame of the project include PHAs (polyhydroxyalkanoate) and PHA blends. The PHBV (poly(3-hydroxybutyrate-co-3-hydroxyvalerate)) material from our partner NaturePlast, a French manufacturer of bio-based polymers, was found to be well-suited for sand toys but must be modified towards a softer behaviour for swim toys.

ACIB, the Austrian Centre of Industrial Biotechnology, has started to develop new compounds based on natural polymers. For this purpose, we are

using processing roller mixers, mini extruders and mini injection molding machines to produce these blends and samples thereof. Various ratios of the components have been investigated so far and the second round of analyses and experiments will focus on the properties and processability of these compounds.

Image 2: Device for the production of sample specimens: mini extruder & injection molding machine for production of test specimen for toys and baits (Source: ACIB).

Based on PLA (polylactic acid), PBS (polybutylene succinate) and PHBV, NaturePlast, Arctic Biomaterials, our Finish manufacturer, and Fraunhofer LBF, the Fraunhofer Institute for Structural Durability and System Reliability LBF, are developing compounds suitable to innovate different fields of plastic applications. Potential uses include packaging, toys, fishing bait, mulch film and multiple-use cutlery, which have much improved properties for plastic conversion by manufacturers, application by end-users and for end-of-life. Depending on the disposition of the finished product, short or long usage phases can lead to recycling, composting or degradation in the field. Based on the same polymer types, a concept for a multi-layered film for large-scale production of innovative bio-based packaging is also under development.

Together with other project partners, we are testing typical mechanical and toxicological properties of these compounds (with and without aging) and evaluating degradability in a range of natural environments, such as coastal water and the natural agricultural environment, and across different climate zones (e.g., the Mediterranean and the North Sea). The time-consuming experiments are accompanied by in-vitro investigations of the degradability by applying enzymatic degradation methods. At the end of life, the decay of plastic is also related to its ecotoxicity, because the release of substances can be faster or slower dependent on the circumstances. The effect of a substance on humans, animals, plants, and microorganisms can differ significantly. A short period of high concentration (fast degradation) or chronic low concentration (slow degradation) can also influence the ecotoxicity. The combination of in-vitro and field testing in BIO-PLASTICS EUROPE enables us to provide some insight into this very complex issue.

The integration of a feedback loop is important to improve the materials under development directly. In this context, the BIO-PLASTICS EUROPE consortium applied the concept of “Design Thinking” to improve all materials for their application, because the introduction of bio-based materials will only be successful if they meet market demands.

The trans-European perspective is very helpful in this sense. The markets for bio-based plastics can be geographically different, and so are the expectations of these materials. This has led to the identification of a range of different testing approaches which partners who share similar scientific backgrounds are interested in.

But all together we will come closer to our vision of commercial production in a bio-based economy!

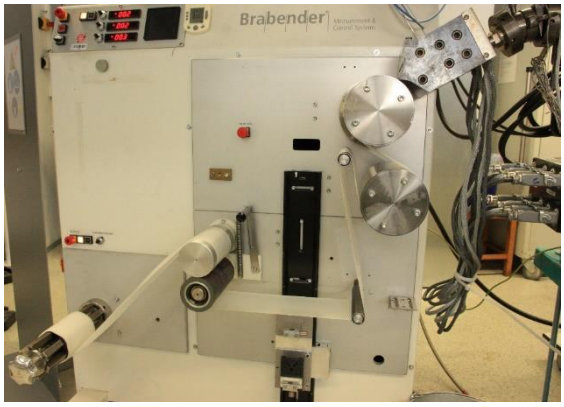

Image 3: Production of samples: bio-based plastic film being calendered, a process in which the polymer melt is stretched, cooled and collected to a film of desired thickness using a series of rollers (Source: Fraunhofer LBF).

Insights from the first round of testing on bio-based biodegradable prototypes

By Elisabetta Arato, Samantha Caputo, and Stefano Gianazzi (Tecnologie Innovative per il Controllo Ambientale e lo Sviluppo Sostenibile (TICASS) Scrl, Italy)

As a co-leader of a 10-partner strong working group, TICASS coordinates the implementation of the experimental activities in the project, towards the next generation of bio-based biodegradable plastics.

The next generation of bio-based biodegradable plastics will have the strength and durability of conventional plastics, but with a more environmentally friendly footprint. To ensure this, the bio-based polymers developed within the BIO-PLASTICS EUROPE project undergo extensive testing, to find and eliminate weaknesses. Five different plastic alternatives were tested over a 15-month period, from September 2020 to December 2021. The selected materials were biodegradable polymers, based on PLA, PBS, and PHBV, that had been matched to different intended applications, such as cutlery, rigid and soft packaging, agricultural mulch films, toys, and fishing materials.

The workflow, defined jointly with the project partners involved, included proper evaluations of the structure, stability, and degradation properties of bio-based biodegradable plastics in both natural environments (i.e., Mediterranean Sea, Northern Sea, limnic water, natural soil) and under specific controlled conditions based on the selected applications. The latter involved, e.g., the study of the effects of aging on bio-based plastics through the weathering of sample materials via a climate chamber, and in light of the diversity of intended applications,

the storage of materials inside or in direct contact with the bio-based prototypes (i.e., food, alcoholic beverages and soft-drinks, detergents, etc.) were also mimicked. In addition, biodegradability tests have also been performed, in order to evaluate the possibility of sustainable disposal.

The results showed general low degradability over different environmental conditions and for composting. Only slight decrease of material properties was reported, more evident with temperature increase. Prototypes deployed appeared to be more sensitive to UV-induced aging compared to on-field treatment (soil, seawater and limnic water). Photo-oxidation phenomena could be overcome by adding a light stabilizer additive, allowing UV-resistance, and increasing the shelf-life while ensuring biodegradability. Furthermore, testing in controlled composting conditions and hydrolytic enzyme assay confirmed limited amounts of degradation and low degradation rates.

Environmental impact of bio-based plastics was also studied by means of ecotoxicological tests with different species involved depending on the target environment, such as plants (phytotoxicity), earthworms, *Daphnia Magna* (limnic invertebrate), algae and marine invertebrate.

The results showed no relevant effect on phytotoxicity. Test on earthworms did not affect mortality rates, but the presence of plastic particles promotes their downward movement and, in some cases, leads to a significant decrease of reproduction ability. No acute toxicity toward algae and marine invertebrate was reported, except in the case of PHBV-based material for toys application. In addition, 2-methylnaphtalene has been detected during leaching test on PLA-based mulch film. The substance is toxic to aquatic organisms and may

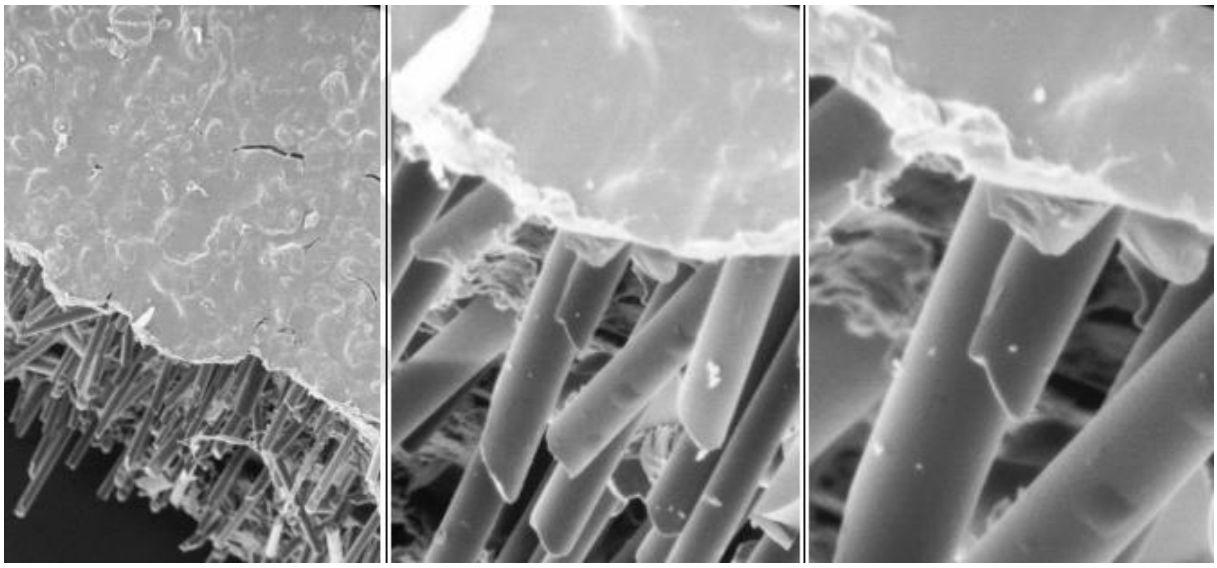

Image 4: Samples examined under a Scanning Electron Microscope (Source: TICASS).

cause long-term effects in the aquatic environment.

Overall, these results show promising future use of bio-based materials developed in the project as a viable alternative to conventional plastics, due to their chemical and physical resistance. If on one hand, good shelf-life and durability are necessary features to guarantee the quality of the final product, then on the other hand, the degradation undergone by the material during its life is an advantage in its disposal, ensuring easier biodegradation. But finding the right balance between material performance and its sustainability in terms of environmental impact and waste management is quite a challenge! Based on the encouraging results of round I of testing activities, the compounds will be modified to improve biodegradability and reduce eco-toxicity effects, maintaining shelf-life and quality of final products. The "improved" bio-based prototypes will be tested in round II with the aim of developing environmentally friendly and sustainable bio-based biodegradable prototypes which may compete in their versatility with conventional plastics, contributing to the shift towards independence from fossil-based resources. The preliminary results of the final testing round are expected to be announced by the end of 2022.

Improving formulations to increase performance of bio-based plastics

By Pauline Moreau (NaturePlast, France)

In order to replace conventional plastics with bio-based and biodegradable alternatives, the new compounds must be as adaptable and provide the same range of possible applications. In the BIO-PLASTICS EUROPE project several applications were chosen to explore the versatility of the developed bio-based and biodegradable plastics. The formulation of materials not only relies on the strengths of the selected biopolymers, but also adds specific functional additives to limit their

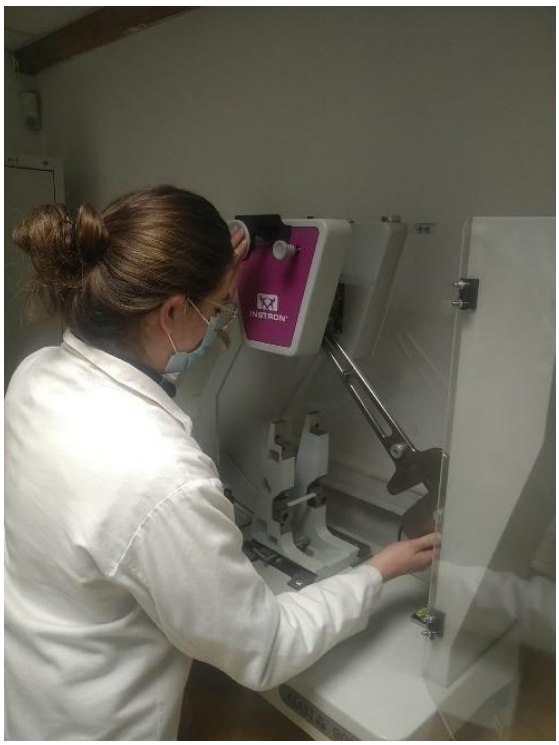

Image 5: Charpy impact test on a test bar (Source: NaturePlast).

weaknesses. Round I of tests managed to gather preliminary results on first modified materials. Round II is now being prepared.

The first application NaturePlast is developing, in collaboration with other project partners, is a rigid toy made of PHA. This biopolymer has the ability to biodegrade in multiple environments without releasing harmful substances. However, the tests carried out in round I showed that the material remains fragile which is not desirable for a toy that will be put in the hands of small children.

That is why NaturePlast has studied the effect of various biobased and/or biodegradable additives to increase flexibility and impact resistance of the neat material. Addition of components such as plasticizers enable the material to be softened, which has been demonstrated by carrying out impact resistance tests (such as the Charpy impact test) on small samples. As a next step, specific tests will be carried out during round II to assess the addition of new plasticizers and additives in PHA and to make sure that they have not increased the harmfulness of the material.

Optimizing bio-based materials in order to meet market needs

By Aleksi Palmroth and Ari Rosling (Arctic Biomaterials, Finland)

For companies to switch production to bio-based biodegradable plastic alternatives, their implementation must be economical. This can be achieved by keeping the production process in mind when developing novel materials. In the BIO-PLASTICS EUROPE project, Arctic Biomaterials (ABM) has developed bio-based and biodegradable composites for reusable cutleries and rigid packaging applications. The proprietary degradable glass fibers of the company enable rigid and temperature resistant materials with composting as an additional end-of-life alternative.

The materials produced by the company were thoroughly characterized by the project partners during the first test round. Based on these tests, a new development round has just begun. Ari Rosling (R&D Director at ABM) is pleased with the latest developments and says that the company is now optimizing the materials to satisfy the market needs: “We have received a lot of useful and interesting results and feedback from the project partners. For example, our novel materials have shown no signs of toxicity or other adverse effects in plants or brine shrimps. We now have a solid ground for developing the formulations further. The new iteration round is done to enable more economical materials with even faster injection molding cycle times. These things are crucial for penetrating the market. And that is of course our aim.”

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The latest development steps of the materials are about to be finalized, after which the samples will be produced and distributed to the project partners to start testing round II. At the same time, companies manufacturing injection molded cutlery will be invited to test these novel materials as a proof-of-concept.

Image 6: Arctic Biomaterials focuses on strong biodegradable materials reinforced with degradable glass fibers (Source: Arctic Biomaterials).

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Save the date: upcoming events at BIO-PLASTICS EUROPE in 2022

"The management of organic waste and bioplastics in historic Italian cities"
5th HISCAP event: 4th May at 10:30 am (CET)

From January 2022 in all Italian municipalities, it is mandatory to provide for the separate collection of organic waste. Together with food residues, biodegradable and compostable plastic packaging, certified EN 13432 bioplastic bags, fruit and vegetable packaging, plates, glasses and disposable tableware made of compostable material must also be collected. The implementation of this obligation in Italy precedes similar commitments that will be introduced in the rest of the EU beginning of 2024 by two years.

How has Italy become the avant-garde in the management of organic waste in Europe? The separation of organic waste is a practice that the country has started to introduce since 1993, when the first dedicated collection services were launched. Today, after almost thirty years, many cities, including historic ones, have achieved important results in quantitative and qualitative terms.

Registrations will open soon. More information will be posted on the BIO-PLASTICS EUROPE website: https://bioplasticseurope.eu/news-events

Thank you for reading! We hope that you have enjoyed this fifth edition of the newsletter and that you will follow us in the future! If you still have not done so, please feel free to subscribe to our newsletter at:

www.bioplasticseurope.eu

Sincerely yours,

The BIO-PLASTICS EUROPE Team

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 860407.
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