An efficient use of resources for packaging needs to ensure the protection of the packaged goods (photo: VectorMine/Shutterstock.com)

EU research project BIOnTop

Research and development of more sustainable packaging concepts

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Packaging is primarily intended to protect the packaged goods in order to save resource-intensive and sensitive products such as food from loss and to avoid associated CO_2 emissions. A packaging material must have sufficient mechanical and barrier properties, depending on the specific sensitivity of the foodstuff, to meet the requirements during transportation, sale and use by the consumer. Furthermore, packaging should be designed in a material-efficient manner and be environmentally friendly as well as recyclable and degradable, according to the wishes of the general public. In reality, this wish is usually not yet fulfilled when plastic packaging is concerned. At present, only a small proportion of 15.6% (Plastikatlas, 2019) of the plastic waste produced in Germany is recycled, most of it is incinerated or ends up in landfills. Parallel to the public interest in reducing packaging waste, the European Commission is pursuing the goal of reducing the use of plastics and increasing their recyclability in the "European Strategy for Plastics in Closed Substance Cycle Waste Management". By 2030, all plastic packaging should be recyclable, and companies are called upon to set themselves sustainability targets. Plastic packaging should be reusable or easy to

The InnoCamp Sigmaringen, where research projects on sustainable packaging concepts are being carried out in the near future. (architektenwerkgemeinschaft weinbrenner.single.arabzadeh)

recycle in order to minimise the amount of plastics entering the environment, especially marine waste (European Commission, 2018).

Many foods, including most dairy products, are packaged in multi-layer composite films or polystyrene, often with ethylene vinyl alcohol (EVOH) co-polymers to provide sufficient flavour and oxygen barrier properties. It seems that a decision has to be made whether one wants a material-efficient thermoplastic composite material that cannot be recycled, or can only be recycled to a limited extent, or mono-materials that can be recycled but are mostly not material-efficient and provide less barrier properties (Kaiser et al., 2017).

Research into more sustainable packaging materials as an alternative to petrochemical plastics has already been investigated in several research projects, including the completed EU projects "Wheylayer" and "Thermowhey". These projects showed that certain biopolymers have a high potential to provide sufficient barrier properties as coating materials to produce different types of packaging such as trays and blisters. Sustainable whey coatings were developed that showed improved barrier properties, suitable to replace expensive polymers such as EVOH and thus increase recyclability. For example, it has been shown that trays coated with whey protein have improved oxygen barrier properties to meet the requirements of modified atmosphere fresh meat packaging (Schmid et al., 2011). The barrier properties of packaging materials are decisive for the protection of the packaged foods, but the mechanical properties as well as those relevant for processing must also be taken into account. For example, the EU project ThermoWhey has developed formulations with whey protein coatings with improved thermoformability and processing properties that are suitable for the production of cups and trays.

Building on the previous research results, the current EU research project BIOnTop (Grant Agreement Number GA 837761) is researching innovative, fully bio-based and recyclable packaging and textiles with the aim of developing a more environmentally friendly alternative to the plastic packaging currently produced from crude oil. The 4-year research project, which started in 2019, is being carried out by 21 teams of experts from industry and science. These include representatives from trade associations, research institutes, the mechanical engineering sector and food and packaging companies from 8 EU countries.

In the project, thermoplastic composite materials for trays and foils are to be developed, which are suitable for packaging in modified atmosphere such as dairy products or personal care products. To this end, the BIOnTop project is pursuing various strategies to optimise biopolymers to meet the requirements of MAP packaging. The following goals are being pursued with the bio-based packaging alternatives; they shall

- Have tailor-made properties
- Have optimized barrier properties
- Enable new end-of-life options
- Consist of bio-based polymers
- Have a coating with residual protein-based materials.

Polylactic acid (PLA)-based films are used for this purpose. PLA-based plastics are produced from biomass and are the most researched synthetic biopolymers with promising properties for use in sustainable packaging concepts (Auras et al., 2010). The optical and mechanical properties of PLA films are comparable to conventional polyester films. Furthermore, PLA-based plastics can already be produced on an industrial scale and account for a considerable share of 13.9% of global bioplastics production capacity, as of 2019 (European Bioplastics). PLA-based plastics are thus among the most promising biobased packaging materials. However, PLA films are not suitable for products with a medium to long shelf life or for sensitive products. Especially the low oxygen and water vapour barrier properties of PLA films are insufficient to protect sensitive food, cosmetic or pharmaceutical products. In order to achieve good oxygen barrier properties, an EVOH layer is commonly used. However, these composites are not recycla-

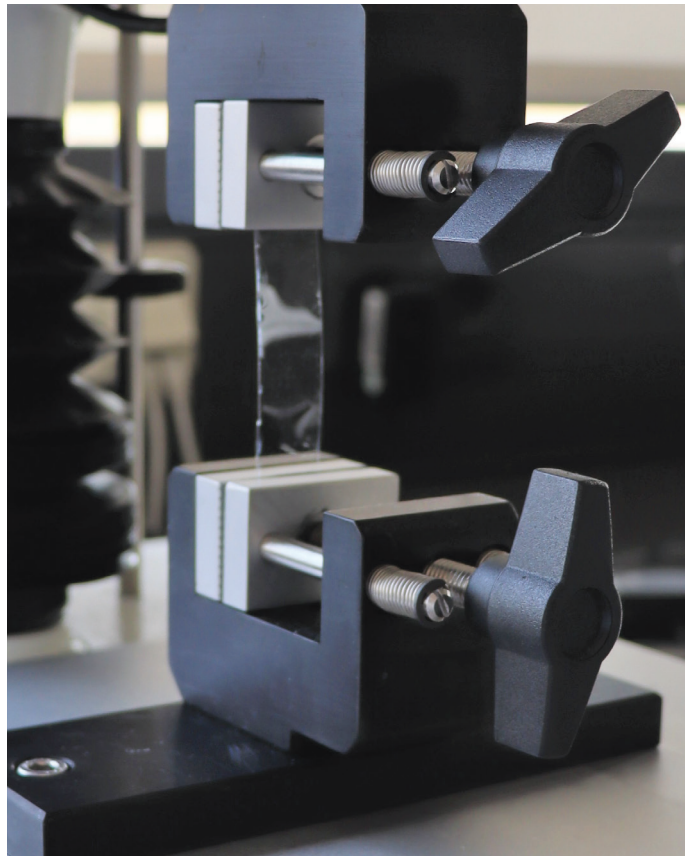
ble. Thus, PLA-based films are modified by new coating technologies in order to have comparable barrier and processing properties as petrochemical-based plastics. These new coating technologies are being developed by a research group for Biopolymer Processing and Functionalization BPF at the Sustainable Packaging Institute SPI of the Albstadt-Sigmaringen University of Applied Sciences, headed by Dr. Corina Reichert, as part of the BIOnTop project. In future, research at the Sustainable Packaging Institute SPI will take place in new laboratories and pilot plants at InnoCamp Sigmaringen, which are optimally designed for research into sustainable packaging concepts.

The aim of the BIOnTop project is the development of coatings made of bio-based materials such as fatty acids or proteins from side streams during food production. Thereby, thermoplastic PLA films shall get a water-repellent coating by means of nanoscale surface functionalisation with fatty acids ("fatty acid grafting"). In order for the fatty acids to be coated onto the PLA film, a protein coating layer is used to provide sufficient reactive groups.

The coating will first be tested with whey proteins on PLA films, as whey proteins have been very well researched, followed by coatings with materials from side streams of the agri-food industry. In addition to facilitating fatty acid coating, protein coating is expected to increase the oxygen barrier properties of the PLA film, as has already been shown for whey protein isolate coatings on plastic films (Stäbler & Schmid, 2016). Whey protein coatings showed comparable oxygen barrier properties to an EVOH (44%) layer in earlier research (patent WO2,013,014,493). Whey proteins or proteins in general therefore have the potential to replace EVOH in multilayer films and thus represent a bio-based sustainable coating alternative.

If successful, the developed bio-based multilayer films will be scaled up to pilot plant and industrial scale and finally the physical and sensory parameters will be evaluated in packaging and storage tests. This type of bio-based packaging made from renewable materials will be designed in such a way that they can be used and recycled cost-efficiently, which already works excellently on a laboratory scale (Cinelli et al. 2016). Various end-of-life scenarios are being researched and optimised for a holistic view of packaging. In the BIOnTop project, the focus will be on ensuring that sustainable packaging can be processed in existing waste recycling plants or that they are even seawater degradable.

The holistic development of bio-based packaging and textiles in the EU research project BIOnTop is intended to make a decisive step towards more sustainable, recyclable and marketable packaging.



PLA film in a tensile testing device. These bio-based films will be coated with bio-based material to enhance the oxygen and water vapour barrier properties (photo: University of Albstadt-Sigmaringen)

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