Degradable plastics: the key to the plastics revolution?

How development, regulation and new logistics can overcome the hurdles to the market launch of sustainable plastics

The plastics industry is at a crossroads: degradable bioplastics offer a solution to the environmental problems caused by plastic waste. However, their market launch requires considerable investment in research, production and new logistics. Albrecht Läufer sheds light on the challenges and opportunities on the road to a sustainable plastics future.

Images of plastic-polluted oceans have been ubiquitous since the 1970s. On September 23, 2024, the US state of California filed a lawsuit against ExxonMobil, alleging that the company had deceived the public for decades by creating the impression that recycling could solve the problem of plastic waste and environmental pollution. Degradable bioplastics could offer a solution. In view of the enormous quantities of plastic - more than 400 million tons were produced in 2022 alone - it is essential to both strengthen recycling and reduce plastic consumption. It is equally important to promote the use of degradable bioplastics, especially in packaging and disposable products. The use of bio-based plastics would also help to reduce the CO_2 footprint - in the case of PLA by around 2.5 million tons of CO_2 per 1 million tons of plastic.

Market, economic potential and hurdles for bioplastics

The global plastics market is estimated to be worth US$ 712 billion in 2023;[1] at an annual growth rate of 4% (CAGR), it is expected to reach US$ 1050 billion in 2033. These sales are backed by annual production volumes of 367 million tons (2020) to 515 million tons (2030), i.e. the production volume will increase by around 150 million tons per year within 10 years.[2] The share of bioplastics is currently negligible at around 2 million tons.[3] In view of the overall market, however, the achievable market potential is huge!

Application-related hurdles can usually be solved through formulation. The biggest challenges for bioplastics are competition from established production; since 2010, US$ 180 billion has been invested in new production facilities[4]. These facilities have been written off.

The still too high production costs are an obstacle. Polylactic acid (PLA), the cheapest bioplastic, costs between €2.5 and €3 per kilogram, which is significantly higher than the price of conventional plastics, which are between €0.8 and €1.5 per kilogram. Added to this is the need for new logistics and regulatory hurdles, especially in Europe.

Bio-based and degradable plastics

Bio-based plastics are made from renewable raw materials and are degradable in different ways. Some fossil-based plastics are also degradable. Both are desirable:

"bio-based" for the lower CO_2 footprint, and "degradable" to avoid waste and microplastics.

Bio-PE and bio-PET are produced from sugar or starch using ethanol and are not degradable. PBS (polybutylene succinate) and PBAT (polybutyrate adipate terephthalate) are fossil-based but biodegradable. PLA (polylactic acid) is made from lactic acid, which is produced from sugar. PHA (polyhydroxyalkanoates) is produced directly by bacteria from bio-based raw materials. Both are biodegradable, with PLA degrading slowly depending on environmental conditions. Important: It disappears completely from the environment and is therefore not an eternal environmental burden! Microparticles made from PLA or PHA are also degradable![5]

Production and cost-effectiveness - challenges for development and scaling up

The production of bio-based plastics is technically complex and currently still too expensive. However, model calculations show that competitive manufacturing costs for bioplastics such as PLA can be achieved through process and strain improvements and the use of lignocellulose as a raw material.[6] The development of better processes and better production organisms is time-consuming and requires investment in pilot plants.

If we want to produce millions of tons of bio-based plastic, we have to switch from 1st-generation to 2nd-generation fermentation to protect the food chain, i.e. obtain the sugar from lignocellulose, i.e. from straw, bran, beet pulp, bagasse, wood residues and much more. Another alternative raw material is CO_2 from CCU processes.

Compared to petroleum-based production, this results in new logistics: straw and similar raw materials are not as easy to transport as petroleum. The conversion into intermediate products such as lactic acid or ethanol must take place close to the agricultural sector. The subsequent chemistry (polymerization) can take place at central chemical sites.

As with crackers in the petrochemical industry, lignocellulose requires pre-treatment. The steam explosion is not yet fully developed and other processes, e.g. Organosolv, are still in the early stages of development. This offers great market potential for inventors and plant manufacturers. There is also a need for development for downstream fermentation. Large enzyme manufacturers and several start-up companies are working on these topics, but more investment is still needed in these areas. Last but not least: biotechnical production processes require large quantities of water, which must be recirculated - another topic for process development.

Regulatory hurdles for the market launch in Germany and the EU

The EU's SUPD (Single-Use Plastics Directive) aims to reduce the use of single-use plastics. For example, the use of plastic, including bioplastics, in drinking straws is prohibited. Capri-Sun is currently campaigning to be allowed to use plastic again because cardboard straws are impractical.[7] Why are degradable bioplastics not allowed to be used here?

The EU's PPWR (Packaging and Packaging Waste Regulation) regulates the gradual reduction of packaging waste and the increase in the proportion of recycled material. It rightly requires plastics to have a recycling process. However, the PPWR puts the brakes on new plastics. The German NABIS (National Biomass Strategy) and the NKWS (National Circular Economy Strategy) aim to protect biomass, but residual materials may be recycled. Last but not least, the Waste Management Act restricts the use of plastics obtained from waste in food packaging. The application of the definition of waste to raw materials for fermentation needs to be reviewed.

Some players in the waste management industry fear that more non-degradable plastics will end up in organic waste as soon as more bioplastics are in circulation. This would disrupt recycling processes, which is why bioplastics are undesirable.

Recommendations for action

Promote the development of more cost-effective manufacturing processes for bioplastics.

Scaling: new processes require suitable pilot plants as infrastructure for start-ups and industry, with focused government funding.

Regulation and incentives: removal of regulatory barriers and incentives for increased use.

Networking of industries, new value chains: technologies from the sugar, paper or dairy industries, for example, can be further developed in the bioeconomy. The chemical industry should adapt to new basic chemicals such as ethanol and lactic acid, and generally to the use of nature's synthesis performance!

Conclusion

The world needs plastics because of their properties. However, further environmental pollution caused by plastics must be stopped. Bioplastics have the potential to do this. They can replace conventional plastics in many areas, reaching a market worth many hundreds of billions of euros. The necessary high investments in innovation, scaling and production, but also rethinking in new value chains from agriculture to chemistry require close cooperation between industries, politics and research.

Sources:

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[7] https://www.euwid-recycling.de/news/international/capri-sun-will-wieder-die-plastikstrohhalme-zurueck-300824/

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