The alternative: “bioplastics”

Plastic waste takes years to decompose and pollutes the environment. Nevertheless, plastics are an indispensable part of everyday life. It is therefore all the more important to find a meaningful alternative that is sustainable, environmentally friendly and has better properties and more functionality than conventional plastics. In addition, such an alternative should not be dependent in any way on fossil resources. Bioplastics are one potential solution.

The popularity of plastics is due to their positive properties - they are lightweight and have a very broad range of application in almost all areas of life and work - from packaging material to textiles, consumer goods, automotive and agricultural goods. Plastics are omnipresent. However, the disadvantage of plastics is the large quantities of energy, and thus high CO_2 emissions, needed to produce them. In addition, the consumption of fossil resources such as oil needs to be viewed critically due to scarcity and the rising price of fossil resources now and in the future. If inadequate waste management practices are also taken into account, the whole situation becomes significantly more alarming. It is not just a case of the proliferation of garbage patches in the oceans, but also the recent news that microplastics have now been found in the human gut and not just in the environment.

How much “bio” is there in bioplastics?

Overview of all plastics types (bioplastics and conventional plastics), classified according to raw material source (biobased or fossil-based) and functionality (biodegradable or non-biodegradable).

The term "bioplastic" is not protected, which is why there is no uniform definition. Basically, bioplastics can be distinguished from conventional plastics thanks to their carbon origin. Thus, the carbon needed to produce bioplastics comes from biogenic materials rather than fossil fuels such as petroleum.

Bioplastics are commonly classified according to chemical structure, and divided into two groups, drop-in bioplastics and novel bioplastics. Drop-in bioplastics have the same chemical structure as their fossil-based versions, which they can replace 1:1 and be integrated in established recycling streams. Novel bioplastics build on new chemical structures and therefore have other properties, which make it possible to develop further applications.

Various standards such as ASTM 6686, ISO 16620, EN 16785 or DIN SPEC 91236 can be used to classify biobased products such as bioplastics. Certification companies such as DIN CERTCO (Germany) are responsible for reviewing these standards.

Certification bodies such as DIN CERTCO carry out certification procedures and assign bioplastics labels such as “DIN-tested biobased” or "biobased%" to characterize the amount of biomass contained in a product. According to DIN CERTCO, biobased plastics are grouped into quality grades of 20-50 percent, 50-85 percent or <85 percent biobased carbon[9,10]. Thus, a proportional biomass content of 20 percent is all that is required for products to be eligible for the “biobased” label. The truth content and ecological significance of the DIN CERTCO label are therefore rather limited. No statements are made as regards the source of raw materials. From an ecological point of view, however, this is extremely important.

Biodegradable bioplastics that can be degraded by microorganisms under aerobic (in the presence of oxygen) or anaerobic (in the absence of oxygen) conditions into various metabolic products are a very interesting group of bioplastics. In principle, under certain conditions, they can therefore be degraded in the environment. From an ecological and recycling point of view, this would be the best way. Nevertheless, this is not an invitation to freely dispose of bioplastics in the environment. It is important to keep in mind that degradation efficiency actually depends heavily on the bioplastic material and on specific environmental conditions. As they degrade, bioplastics initially disintegrate and enter the environment as plastic fragments, which are at the root of the microplastics problem we are facing. It can take a long time for the material to completely degrade.

Will bioplastics replace conventional plastics?

Bioplastics account for about 2 percent of the global plastics market, and the annual growth rate is similar to conventional plastics at 3 to 4 percent[3]. In absolute terms, global bioplastics production is expected to increase from 2.1 million tonnes in 2018 to 2.6 million tonnes in 2023[4]. Compared to the annual production capacity of 335 million tonnes[7] of conventional plastics, the share of bioplastics in the global plastics market seems like a drop in the ocean. Low oil prices, political support that is slow to manifest itself and limited market access are all reasons for the relatively small increase in bioplastics production.

Nevertheless, demand for sophisticated bioplastics, applications and products is increasing and the bioplastics market is therefore growing steadily. Drop-in bioplastics constitute the largest proportion of the bioplastics market. Bio-PET, bio-PE and bio-PA alone account for 48 percent of the bioplastics market[4]. Bio-PE production capacities are expected to further increase in the future. Great news is also expected from a new bioplastic - PEF (polyethylene furanoate). PEF is 100% biobased and displays better barrier and thermal properties than bio-PET. This bioplastic is expected to gain ground in the market and partly replace organic PET, especially in the packaging field. PEF is expected to be placed on the market in 2023.

In future, novel bioplastics such as PHA and PLA are expected to have the greatest innovative strength and market growth. Their new functional properties open up new fields of application that go beyond the scope of conventional plastics. The production capacity of PHA is expected to quadruple in the next 5 years, while that of PLA is expected to double by 2023[3]. One of the reasons for this development is that these bioplastics are not linked to the price pressure driving oil prices down, as there are no conventional counterparts. However, success also largely depends on how quickly these bioplastics can be established on the market. Political and public backing can also accelerate this development.

Are bioplastics in competition with our food?

Examples of bioplastics applications.
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As the bioplastics market gets bigger, a central debate is competition with food production, in particular regarding land use for the cultivation of the plants required for bioplastics. According to recently published data, approximately 0.8 million hectares were used in 2018 to grow biomass for producing bioplastics. This is less than 0.02 percent of the approximately 5 billion hectares of land available for agriculture worldwide[5,6]. It is such a small area that there is currently no competition with food production. Opportunities to avoid further conflict between land use for food and bioplastics production and simultaneously improve the sustainability of bioplastics can be found in the use of marginal land (areas not suitable for food production) as well as residual and co-products from agriculture and forestry. The University of Hohenheim is working on such a "second generation bioplastic". Here, chicory roots, which are currently disposed of after harvest in composting facilities or biogas plants, are being used to produce hydroxymethylfurfural (HMF) - one of the basic ingredients in the plastics industry of tomorrow[8].

Are bioplastics really more environmentally friendly?

The answer to the question is neither a definite 'no' nor a definite 'yes'. The initial results of life cycle assessments show that bioplastics can economise on the use of fossil fuels and release less CO_2. However, they contribute to a greater extent to eutrophication (nutrient input into an ecosystem) and the acidification of soils.

Another issue that could significantly improve the sustainability of bioplastics in future is their disposal. Currently, we do not have waste management procedures and good recycling infrastructures that allow the recycling of bioplastics, especially biodegradable ones. So they will often go to waste incineration plants, which allows the recovery of energy.

Basically, bioplastics can be recycled. Due to identical characteristics, drop-in bioplastics such as bio-PE and bio-PET can be integrated into established recycling streams of conventional plastics. Completely new ways of recycling and reuse are needed for biodegradable bioplastics such as PLA and PHA. Theoretically, due to their properties, they can also be used for composting and fermentation.

In practice, however, the proper reuse and recycling of bioplastics looks quite different. Due to the uncertainties in earnings and profits power plant operators are facing and due to inadequate sorting and processing technologies, bioplastics are mostly removed and go to waste incineration plants rather than being processed further or recycled. Biodegradable bioplastics are often considered impure because they affect the quality of stable plastic recyclates, which may in turn affect marketability. However, it cannot be excluded that micro- and macro-plastics may enter the environment, since the biodegradation of biodegradable bioplastics under process conditions and the residence time in industrial plants is often insufficient for complete degradation. Nevertheless, there is at least one advantage. If biobased plastics are removed and combusted, significantly less CO_2 is released than with conventional plastics. More specifically, only as much carbon is released in the form of CO_2 as was previously bound in the biogenic material, provided the carbon in the bioplastic comes entirely from renewable raw materials[1,2].

Nevertheless - better transparency for plant operators, but also for consumers, is needed to make the disposal system as efficient as possible. When the bioplastics volumes increase, the separate collection and sorting of biobased plastics might become economically viable.

Conclusion

Bioplastics will not be the solution for the large plastic waste patches in the oceans. However, they can be a sustainable alternative to conventional plastics if biodegradability can be further improved and if waste and disposal infrastructures are adapted to bioplastics. Until then, combusting bioplastics is still better than producing no bioplastics at all. Second generation bioplastics produced from waste and residues could also cool down the discussion about land use and competition with feed and food.

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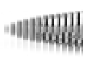

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