GO!PHA
Global Organization for PHA

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Polyhydroxyalkanoates (PHA)
An emerging and versatile polymer platform

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The emerging Polyhydroxyalkanoates (PHA) class of polymers (the PHA-platform) consists of a large variety of polymers that are quite different in nature and performance, just like most other polymer platforms, e.g. polyamides or polyethylenes.

Polyhydroxybutyrate or PHB is bio-benign. It was the first known product of the PHA-platform and appears in nature for more than 3 billion years already as a valuable part of the metabolism in plants, animals and humans, providing energy and nutrition. It is produced by micro-organisms from sugars, starches and cellulosics. However, PHB found in nature has a too low molecular weight to use it in several manufacturing processes for making plastic parts.

Today, 9 different PHA product families are produced through fermentation using many different sources of feedstock, like solid waste, waste water, gas effluents (like carbondioxide and methane), waste cooking oil, sugars, cellulosics, vegetable oils, etc. This helps to set up after-use value chains for a circular economy.

Among these product families are PHB, PHBV, PHBH and others. They cannot simply replace each other since each of them span a different range of properties:

- Molecular weights ranging between 300,000 and 1,000,000 kD;
- Polymer melt temperatures for the crystalline products ranging between 60 and 170 °C;
- Tensile modulus ranging between <10 and >1,000 MPa;
- Tensile yields ranging between <1 and 45 MPa;
- Elongations ranging between <1% and >1,000%;

This is a clear demonstration that one cannot simply talk about PHA as a single product.

One unique property all these PHA product families possess is their biodegradable behaviour in soil, in water, in aerobic and anaerobic conditions and when subjected to bacteria or fungi, albeit that the pace of degradation also depends on the PHA-product composition, the part thickness and other external conditions. In essence biodegradation of PHA products are tunable to suit individual requirements, where biodegradation times depend on the form factors and the external conditions. This versatile biodegradation behaviour ensures that no PHA-micro-plastics will remain in the environment over time.

Also, amorphous PHA products have been developed and introduced to the market, in addition to crystalline PHA-products. Of course, they are used for entirely different applications. All these PHA product families cannot yet fully substitute fossil-based polymer families, but they can partly substitute most of them, so the accessible market for PHA-platform products is very large and they could become as large as many of the fossil-based polymers they would replace.

Straight PHA-products and compounds & formulations containing PHA-products have been demonstrated to perform equally well or better in more than twenty different product/market-combinations. Several of them are already commercial. They are implemented in products that require properties similar to fossil-based polymers like PE, PP, PS, PC/ABS or PET. Many of the products made from PHA-polymers take advantage where marine and/or soil degradability is a required property, like exfoliants in cosmetic products, inner liner for water bottles, compounds for home compostable plastic bags or for mulch films. There are many more examples here. However, PHA-polymers are also used for several durable applications, like the use for design-furniture, eye-glasses, electrical switches or automotive interior.

PHA-polymers can also be used as building blocks for thermoset materials (PUR and unsaturated polyester resins) and many are under development, as we speak, although they still need to be commercialized. Also, the use of an amorphous PHA-polymer for adhesives and glues has been successfully demonstrated. These efforts demonstrate the versatility of PHAs as a new polymer platform.

Initially the market price of the new PHA-polymers was high, given its development learning curve. This limited the market penetration. However, several producers and developers of these new PHA-polymer families already indicate that price is a matter of time and scale. The PHA-materials will become cost-competitive as these product families' applications proliferate and mature.

The industry started to work on the new PLA-platform in the 1980s and today these products are in the early-growth phase of the S-curve. The new PHA-platform started in the 1990s and is about a decade behind the PLA-platform in this respect. The many construction projects that are going on to build capacities for several different PHA-product families around the globe demonstrate the progress this new polymer platform makes. •

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The Global Organization for PHA is a member-driven, non-profit initiative to accelerate the development of the PHA-platform industry. Polyhydroxyalkanoate polymers (PHAs) provide a unique opportunity as a solution for reducing greenhouse gases and environmental plastics pollution, and establishing a circular economy, by offering a range of sustainable, high-quality and natural products and materials based on renewable feedstocks and offering diverse end-of-life options.

GO!PHA provides a platform for creating and sharing experiences and knowledge and to facilitate joint development initiatives.

Become a member or sponsor to start sharing, contributing and collaborating to accelerate the PHA-platform industry.

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