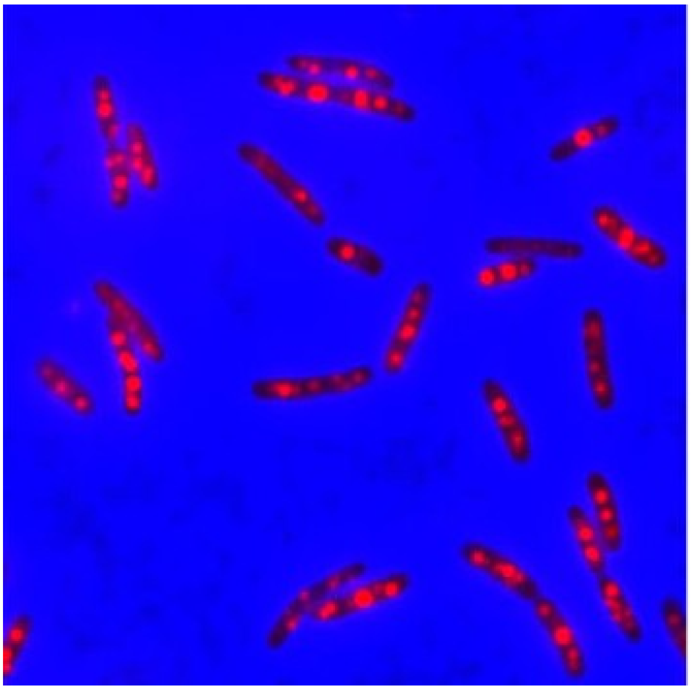
Biopolymers – raw materials for innovative medical products

Polyhydroxyalkanoates (PHA) are biodegradable biopolymers that are becoming increasingly important. Bioplastics are now used not only in everyday objects such as plastic bags and yogurt pots but also increasingly in the field of medicine, which is why intensive research into medical devices made from biodegradable polymers such as PHA has been going on for quite some time.



Fluorescence image of bacteria cells (Ralstonia eutropha) that can accumulate large amounts of PHB. The cells were stained with Nile red, the PHB granules appear as red dots inside the cells.
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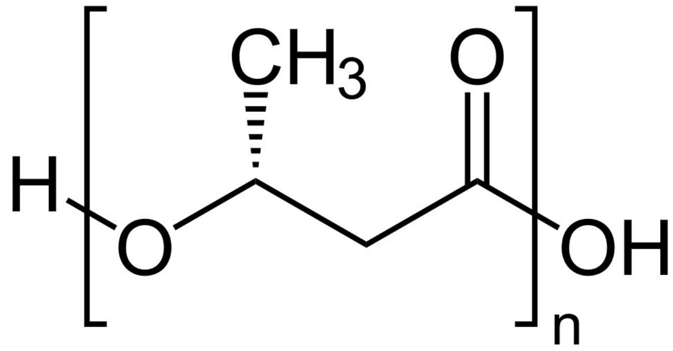
Every year, over 300 million tons of plastic are produced. The majority is polyester, which is produced from fossil fuels such as oil and gas. However, there is a growing demand for oil-saving, environmentally friendly products made from renewable resources. Nowadays, polyethylene is produced from sugar cane and polylactide from corn. The main benefit of bioplastics is that they save oil.

In addition to sugar cane and corn, polyhydroxyalkanoates (PHA) are also used as raw materials for bioplastics. They are natural storage materials accumulated by bacteria, fungi and some plants when they lack certain nutrients: more than 300 different microorganisms are known to synthesise PHAs. They are carboxylic acid polyesters with one or several OH groups. Three PHA groups can be identified based on the number of carbon atoms they contain: short-, medium- and long-chain PHAs. Thanks to their plastic-like characteristics, polyhydroxyalkanoates are already being used as the basis of many plastics. Polyhydroxybutyrate (PHB) is the most important of the PHA types used for bioplastics production.

Bioplastics in medical application

Up until now, polyethylene glycol (PEG) and silicone have been the main plastic materials used for medical products. However, they are increasingly being replaced by plastics that are biodegradable and biocompatible. This means that they can be degraded in the body without causing dangerous immune reactions.



Important and commonly found polyhydroxyalkanoate: 3-hydroxybutyrate
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The company ITV Denkendorf Product Service GmbH (ITVP) uses materials such as glycolide, lactide, caprolactone and trimethylene carbonate to manufacture medical products. Absorbable, biocompatible plastics such as these are used as surgical suture material, wound dressing foils, membranes for covering burn wounds, and for vascular prostheses. Lactide, which is mainly used for producing absorbable polymers, fulfils a number of requirements. It is biodegradable, biocompatible, and produced from renewable resources such as corn. It therefore not only meets the demands of medical technology, but also saves fossil fuels.

Polyhydroxyalkanoates – biological, biocompatible, biodegradable

Polyhydroxyalkanoates are also biodegradable, just like polylactides. In addition, PHAs are biocompatible, and do not trigger immunological reactions in the human body. Bacterial fermentation is currently the major PHA production method in industry. PHA biopolymers are enzymatically degraded in the human body. PHA biopolymers have already been tested for their suitability as drug matrix or microcapsules. The degradation of the microcapsules enables the sustained release of drugs over a specific period of time. Chemotherapeutics, vaccines and antibiotics can be packaged into minute particles, so-called nanoparticles, and released at a predetermined site in the body. The controlled release of drugs is of key importance for toxic (chemotherapeutics) or sensitive drugs, which must exert their effect only at a particular site in the body, rather than affecting the entire body. The use of PHA-based nanoparticles appears quite promising for use in cancer therapy and the controlled release of drugs at a specific site in the body.

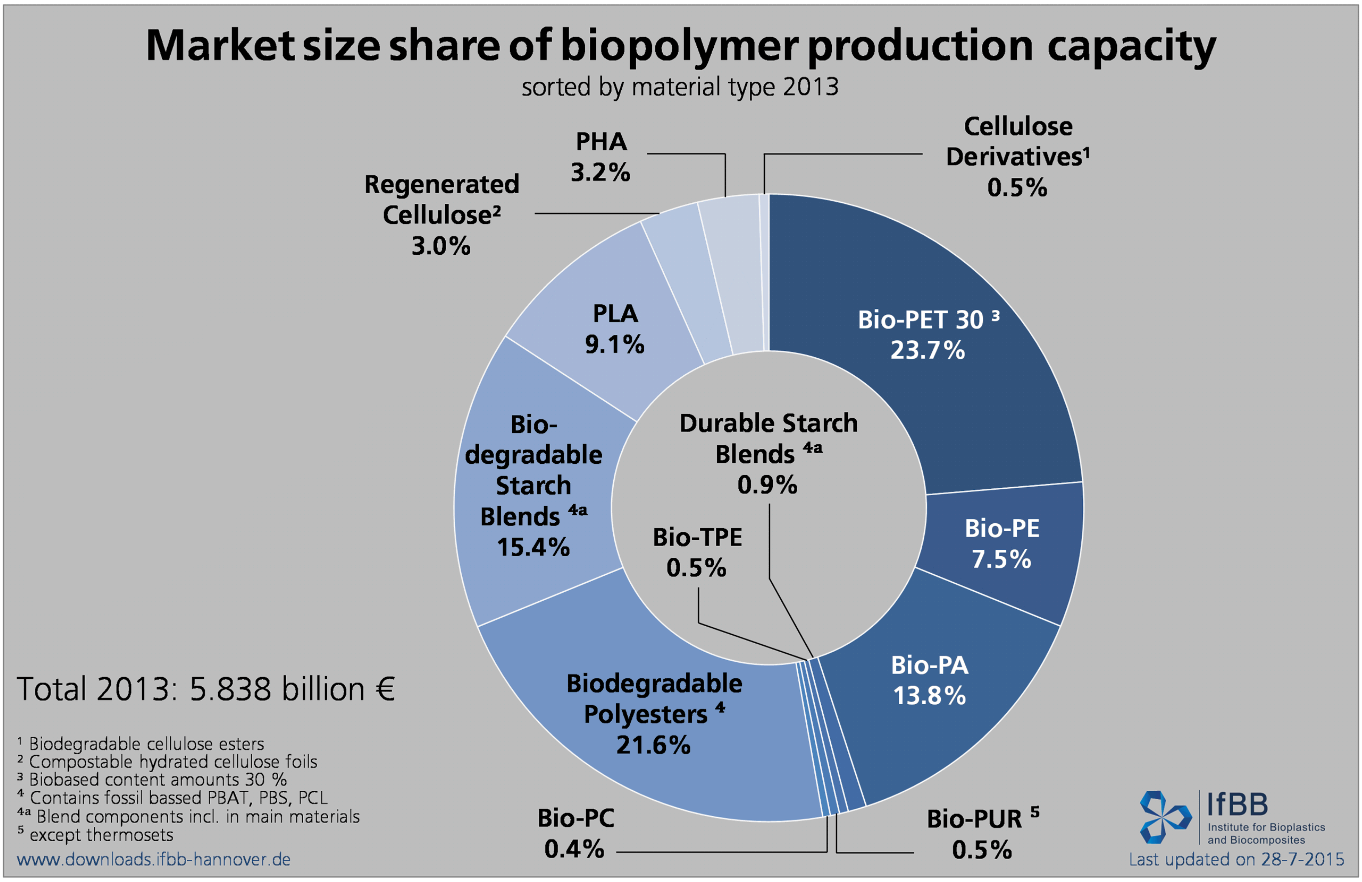
Germany’s largest textile research centre, the Institute for Textile and Process Engineering in Denkendorf (ITV), deals with the regeneration of nerves and, in cooperation with the ITVP, the NMI Natural and Medical Sciences Institute in Reutlingen, and the BG Hospital in Tübingen, has developed a nerve guidance channel that guides regenerating neurons to the muscle and supports their regeneration. Oil-based polymers consisting of trimethylene carbonate and caprolactone were used in this project.

PHAs have also been investigated for their ability to promote nerve regeneration in the spinal cord. Scientists have shown that a scaffold made of PHA promoted cell division, cell adhesion and differentiation. PHAs have also been shown to have an outstanding effect in tissue regeneration. Since these investigations are still at the basic research stage, a great deal of work is still needed before polyhydroxyalkanoates are ready for use in medical technology.

Polyhydroxyalkanoates have a hard time on the market

Biodegradability and biocompatibility gives PHAs advantages over other biopolymers. However, PHAs are difficult to process and production costs are relatively high. Due to the high raw material and process costs and relatively low production volumes, PHAs find it hard to keep up with better known bioplastics such as polylactide. In 2013, only 3.2% of the entire global biopolymer production capacity was used for producing PHAs. Statista[1] indicates that in 2011, biopolymers generated a total turnover of a total of 3.44 billion euros, and that 39.4% of these biopolymers were used for producing packaging materials. Revenues of 13.7 billion euros are expected for 2016, which means that the use of bioplastics will increase. The IfBB (Institute for Bioplastics and Biocomposites) expects that Bio-PET will have the largest bioplastics market share. According to Statista, bioplastics will mainly be used for producing plastic bottles.

It is assumed that PHA production will decrease. Successful production of bioplastics from polyhydroxyalkanoates will only be possible when factors such as PHA production rate, yield, quality and size of production facilities are increased. At present, PHA-based plastics are niche products that are only used when biopolymers such as polylactide cannot be used.



Market size share of biopolymer production capacity in 2013.
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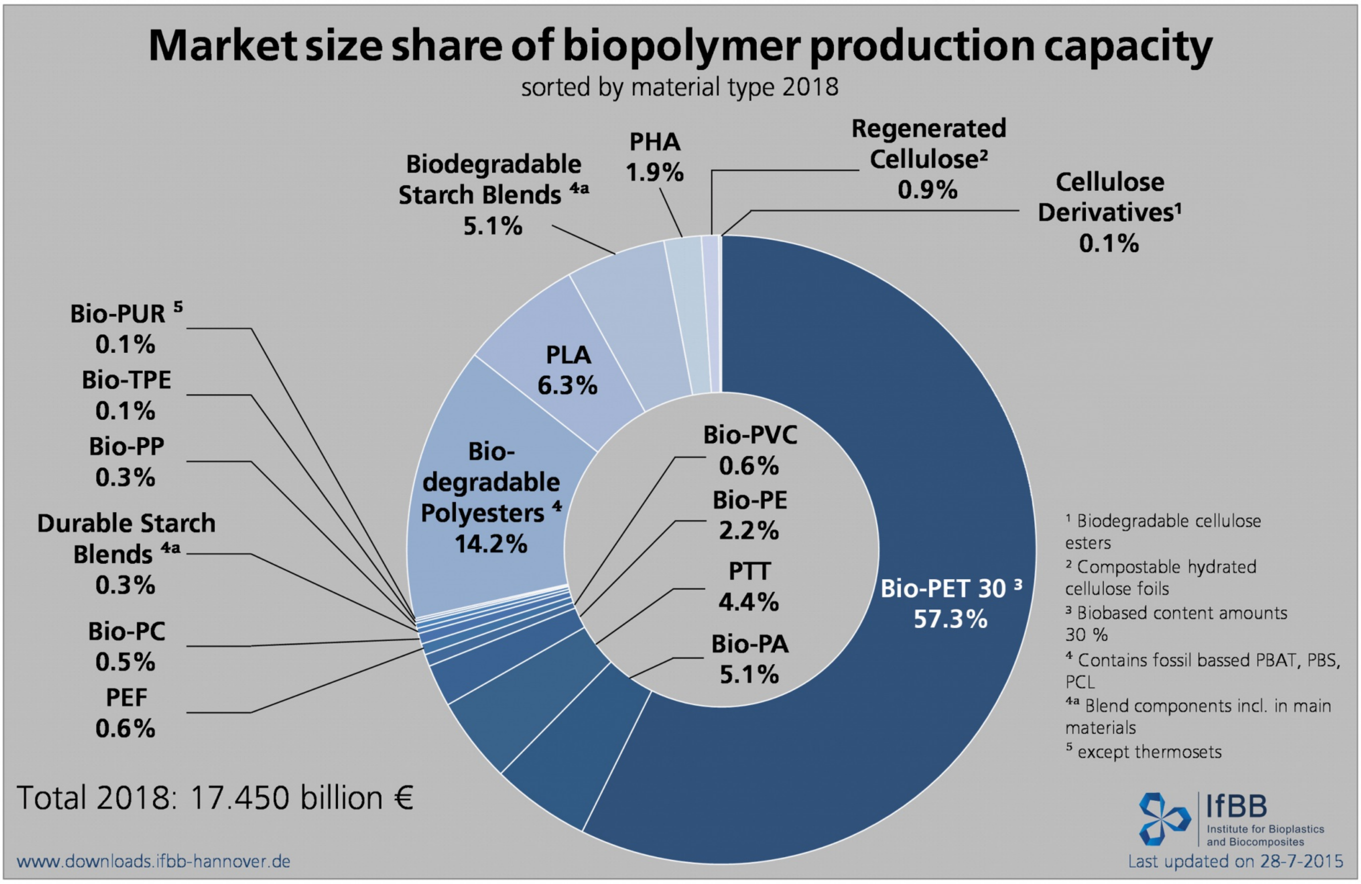
[1] Statista: Biopolymer market - revenue distribution

[2] IfBB - Biopolymer Platform



Anticipated market size share of biopolymer production capacity in 2018.
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Article

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Further information

- IfBB - Institute for Bioplastics and Biocomposites
- IfBB - Biopolymer Platform
- Statista: Biopolymer market - revenue distribution

The article is part of the following dossiers

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medical technology

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