

Market Study: Bioplastics

(4th edition)



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- Manufacturers of auxiliary products and additives
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In this brochure you will find the following information:

- An introduction on page 3
- A summary of the table of contents on page 4
- Following this, there are example pages from the study
- Please use the form on the last page to easily order your copy or a free reading sample!

For the fourth time already, Ceresana analyzes the global market for bioplastics. Currently, revenues of more than USD 2.6 billion are generated with these 'green' plastics. Bioplastics account for considerably higher growth rates than traditional standard plastics. Facing a rising demand and an increasingly broader range of applications, this trend will become even more significant. There are two material groups that are called bioplastics that do not necessarily have to be identical:

- biodegradable plastics that are compostable,
- biobased plastics that are made from renewable resources.

Biodegradable plastics can be made from renewable resources but also from fossil raw materials or compounds. Examples are cellulose ester, PLA, PHA, PCL, starch derivatives, and special copolyesters like PBAT and PBS. Biodegradable polyesters and polyvinyl alcohols are examples for bioplastics produced from crude oil. While biodegradable plastics account for the smaller share on global demand for bioplastics with 42%, they register the more dynamical volume growth of over 11% p.a. However, biobased plastics are not always biodegradable. The market for this group is dominated by counterparts of fossil products with similar characteristics, such as bio-PET and bio-PE based on sugar cane. The utilization of biobased materials creates a positive image for consumers and reduces CO₂ emissions and environmental impact at the same

time. Protection of the environment and of resources is increasingly often a decisive sales argument for producers. The present study analyzes how bioplastics consumption will develop on the individual sales markets. Demand is split by the applications packaging and films, bottles, loose fill materials, bags and sacks, automotive and electronics, and other applications. The most important sales sector is the packaging industry - from demand for bottles to films up to bags and sacks.

Besides a positive image, there are more advantages that explain the positive development of bioplastics compared to standard plastics. Especially for fresh products and perishable foodstuffs, packaging made of bioplastics is profitable: Fruit and vegetables remain fresh for a longer time due to the higher degree of breathability of biodegradable plastics. This ability is also an advantage in the production of hygiene films, e.g. in diapers. Legal framework, especially in packaging, supports an increase of global consumption of bioplastics. For instance, non-biodegradable plastic bags have already been forbidden in China, France, and a range of other countries.

The Study in Brief:

Chapter 1 provides a presentation and analysis of the bioplastics market – including forecasts up to 2023: Demand and production for each product type as well as revenues are given for the regions Europe, North America, Asia-Pacific, and Rest of the World.

Chapter 2 examines the 7 largest countries of the market in more detail. Data on demand for and revenues generated with bioplastics as well as current and future production capacities are provided. Demand for bioplastics is analyzed in detail, split by packaging and films, bottles, loose fill materials, bags and sacks, automotive and electronics, and other applications. Also, this chapter includes an analysis of demand split by types of plastics.

Chapter 3 thoroughly examines the application areas of bioplastics, for example the segment bags and sacks: This part provides data on development in Europe, North America, Asia-Pacific, and the rest of the world.

In chapter 4, demand and production of individual types of bioplastics are analyzed. Products covered include polylactic acid (PLA), starch-based bioplastics, other biodegradable plastics, bio-PE, bio-PET, and other non-biodegradable bioplastics.

Chapter 5 is a useful directory of producers of bioplastics, clearly arranged according to contact details, turnover, profit, product range, production sites, profile summary, product-specific information as well as existing and future capacities at individual production sites. In-depth profiles of 90 producers are given, including Anhui Wanwei, Braskem, FENC, NatureWorks, Novamont, Rodenburg Biopolymers, Solvay, Teijin, Toyota Tsusho, Vegeplast, and Wuhan Huali.

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Worldwide bioplastics revenues from 2007 to 2023 – split by regions

Ceresana



Example from chapter 1
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1.1.1 Demand and Revenues – Asia-Pacific

In 2015, Asia-Pacific processed about X million tonnes of bioplastics. Since 2007, market volume rose at an AAGR of X%. Japan is the largest individual market in this region; in 2015, its market volume of X million tonnes accounted for about X% of total regional demand. China ranked second with X%. The quantitatively largest share of non-biodegradable bioplastics is based on PET with a demand volume of X million tonnes in 2015. Market leader in the group of biodegradable bioplastics is PLA.

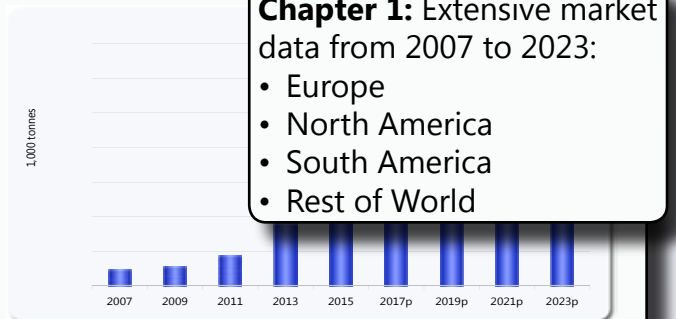
in 1.000 tonnes	2007	2009	2011	2013	2015	2017p	2019p	2021p	2023p	2015 - 2023
PLA	X	X	X	X	X	X	X	X	X	X% p.a.
Starch	X	X	X	X	X	X	X	X	X	X% p.a.
Other (biobased)	X	X	X	X	X	X	X	X	X	X% p.a.
Other (non-biobased)	X	X	X	X	X	X	X	X	X	X% p.a.
Total Biodegradables	X	X	X	X	X	X	X	X	X	X% p.a.
PE	X	X	X	X	X	X	X	X	X	X% p.a.
PET	X	X	X	X	X	X	X	X	X	X% p.a.
Other Non-biodegradables	X	X	X	X	X	X	X	X	X	X% p.a.
Total Non-biodegradables	X	X	X	X	X	X	X	X	X	X% p.a.
Total	X	X	X	X	X	X	X	X	X	X% p.a.

Table: Demand for bioplastics in Asia-Pacific from 2007 to 2023 – split by types of bioplastics

The bioplastics industry in Asia-Pacific is still in the initial stages of development, yet, we forecast the highest growth rate for this region. Several Asian-Pacific countries have introduced new guidelines which promote the increased use of biobased materials. A continued growth of population, in Southeast Asia in particular, in combination with a broader middle class, is likely to result in increasing acceptance of and thus demand for bioplastics. As bioplastics are used in an only small number of end applications so far, the growth potential is considerable.

2.1.1 Germany

Demand for bioplastics in Germany amounted to approximately X tonnes in 2015. Consumption had thus risen by an average of X% p.a. since 2007. We expect market volume to continue to increase at an average growth rate of X% p.a., amounting to approx. X million tonnes in 2023. Revenues generated with bioplastics in Germany totaled EUR X million in 2015. Market value is projected to increase at an average rate of X% p.a. until 2023.



Graph: Demand for bioplastics in Germany from 2007 to 2023

The bioplastics industry in Germany has seen considerable advancements in both supply and demand during past years. Because of their advantageous characteristics and their image, the innovation potential of bioplastic products offer a good opportunity to remain competitive in the long run. The federal government supports the utilization of renewable resources in the production of plastics. A network of expertise was established. This network is supposed to develop the missing knowledge in regard to properties and processing of bioplastics.

In 2015, the Fraunhofer Institute was able to develop a packaging concept which does not need any fossil raw materials and does not compete with food production. The compostable films that were developed by the institute are made of waste material and

algae-based biomass. For the new bioplastics, researchers use algae made of biomass waste of the biodiesel production of which they extract polylactic acid as a basis for the bioplastics. They add nanoscale fibers and fillers made of banana or almond peel or fishing waste such as chitin of crustacean to improve the characteristics of the material. Production and range of bioplastics have significantly increased during past years, as a result of expanded capacities in Germany. For example, BASF increased its production capacity for bioplastics based on petrochemicals in the past eight years. Besides increases in capacity, there were also market entries in Germany. Amynova Polymers GmbH owns a X tonnes bioplastics facility in Bitterfeld-Wolfen. BIOTEC GmbH & Co. KG operates a X tonnes per year TPS facility in Emmerich. The company produces resins that are completely or partially made of renewable plant resources such as potato starch. Uhde Inventa-Fischer operates a pilot plant for PLA in Guben. This plant has a capacity of X tonnes per year. Biomer uses PHB to manufacture polyesters and Akro-Plastic GmbH offers a polyamide 6,10 made from renewable resources, consisting of up to 70% of castor oil seeds. Nevertheless, even some German bioplastic plants have to be shut down, mainly due to high costs and difficult financing. Small and medium-sized producers especially carry the risk of liquidity shortages, due to their high investments in research and product development in the past. This particularly impacts companies that are planning to expand capacities in the near future. For instance, BIOP Biopolymer Technologies AG, a manufacturer of bioplastics based on starch, had to go into insolvency in 2014. However, these expansions are essential to lowering product costs on the long-term.

Bioplastic production in significantly larger volumes requires agricultural land that is only partially available in Germany. The lack of space for the cultivation of useful plants is another obstacle for the expansion of capacities in the segment bioplastics in Germany which is why we do not expect any increases in capacity in the upcoming eight years.

German processors utilized more completely biodegradable plastics than non-biodegradable plastics in 2015. Within the group of biodegradable plastics, products based on starch accounted for the largest share. In 2015, about X tonnes of these products were processed.

in 1.000 tonnes	2007	2009	2011	2013	2015	2017p	2019p	2021p	2023p	2015 - 2023
PLA	X									
Starch	X									
Other Biodegradables	X									
Total Biodegradables	X									
Total Non-biodegradables	X									
Total	X	X	X	X	X	X	X	X	X	X% p.a.

Table: Bioplastics demand in Germany from 2007 to 2023 – split by types of bioplastics

The most important sales market for bioplastics in Germany was the segment packaging and films in 2015. Manufacturing of bottles ranked second at a considerable distance, but consumed more than the segment bags and sacks. Within the next eight years, we expect demand for bioplastics in the segment packaging and films to develop the most dynamically by approx. X%. The lowest growth rates are anticipated for the segment bottles.

On the German market for packaged food, plastic packaging continues to replace other materials such as glass or metal. This can be observed, for example, in the sauces and dressings, snacks, or edible oil segments. Additionally, more and more products that were formerly offered in unprocessed form are now sold as ready-made meals and are often packed in plastic containers. In Germany, the high quality of packaged food and its packaging is becoming more important. The market is characterized by a large number of innovations and product launches.

3.1.5 Automotive and Electronics

Demand for bioplastics in the segment automotive and electronics amounted to approx. X million tonnes in 2015. Compared to 2007, this translates into a growth rate of X% p.a. We forecast that the processing volume for bioplastics in the sector automotive and electronics will continue to increase until 2023. That year, approx. X million tonnes will be processed. This compares to approx. X million tonnes when compared to 2015.



Graph: Worldwide bioplastics demand in automotive and electronics from 2007 to 2023 – split by regions

In cars especially, plastics can help to save resources, avoid environmental pollution, and to reduce CO₂ emissions. Advantages plastics offer to manufacturers of cars are reduced weight, sound insulation, corrosion resistance, good processability, and good insulation properties. Compared to conventional plastics, bioplastics offer new technological properties in regard to haptics, gas permeability, antistatics or density and thus open up new technological possibilities.

Durable bioplastic products, e.g. injection molded parts made from PLA and PHA, were among the first products to be used in automotive and electronic applications. Examples are thermosets, natural fiber-reinforced thermoplastics, and foams. The

Chapter 3: Detailed data for the use of bioplastics in:

- Packaging and Films
- Bottles
- Loose-Fill Applications
- Bags and Sacks
- Automotive & Electronics
- Other Applications

objective in these applications is not only to facilitate the recycling of old cars, but also to make use of renewable resources. Starch blends can be applied as filler material in car tires to replace the thread compound silica, which improves wear characteristics and reduces rolling friction, consequently lowering fuel consumption.

By now, the use of biobased, non-degradable polyamides in technical components such as air filter systems or containers of cooling water has become more common as well. Other possible applications of bioplastics include: dashboards, covers for seats and airbags, steering wheels, mats for floors and luggage compartments, bumpers and spoilers, splash guards, and other stable plastics parts for both interior and exterior. Many components of cars can already be made from bioplastics. Progressive development will result in biobased foams being used in seats, head or arm rests. In 2014, Mazda Motor Corporation developed a new bioplastics for vehicle exteriors. Non-degradable bioplastics are also utilized in the electronics industry. They are processed in, for example, keyboards, casings for mobile phones, vacuum cleaners, computer mice, components for headphones, navigation systems, notebooks, and tablet computers. This sector does not utilize bioplastics for their biodegradability, but in order to work with a raw material base that remains stable on the long term by using durable, reliable materials.

We expect numerous biobased products used in the automotive and electronics industries to be ready for mass production in the near future and, consequently, their prices to become more competitive compared to petrochemical components.

The prime sales market is Asia-Pacific that processed X million tonnes in 2015. North America ranked second, followed by Europe. The most dynamic development is projected for the automotive and electronics industry in Asia-Pacific. Consumption of plastics in this region will increase by X% p.a. until 2023. Above average growth rates are also expected for Europe.

4.2 Starch-Based Plastics

4.2.2 Production

Global output of starch-based plastics rose to X million tonnes between 2007 and 2015. Similar to demand, Europe accounts for almost two thirds of production as well. Asian-Pacific producers manufacture the second largest amount of starch-based bioplastics, followed by North America. Despite the by far highest growth rate of X% per year, Asia-Pacific will remain the second largest producer of starch-based plastics as the lead of European manufacturers is considerable. Global output is projected to increase by X% p.a. to approx. X million tonnes in 2023.

in 1.000 tonnes	2007	2009	2011	2013	2015
Europe	X	X	X	X	X
North America	X	X	X	X	X
Asia-Pacific	X	X	X	X	X
Rest of the World	X	X	X	X	X
Total	X	X	X	X	X

Table: Worldwide production of starch-based plastics – split by regions

The widespread use of starch-based plastics results from the well-developed possibilities of production and the good price-performance ratio of starch due to its large global supply. Manufacturers of starch plastics in Europe profit from close cooperation with upstream companies. Raw material supply from agriculture will continue to be one of the most important factors for the development of starch-based plastic production.

Chapter 4: Demand and revenues split by the products:

- Polylactic Acid (PLA)
- Starch-Based Plastics
- Other Biodegradable Plastics
- Bio-Polyethylene (Bio-PE)
- Bio-Polyethylene Terephthalate (Bio-PET)
- Other Non-Biodegradable Plastics

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Financial Key Data (in billion)

Year	Net Income	Total Revenues
2015/16	21.0	180.0
2014/15	13.7	9.3
2012/13	9.3	

Chapter 5: Data and facts on 90 producers, clearly arranged by:

- Financial key data
- Production sites
- Profile summary
- Product details

General Information about the Company

2015/16 sales divided by business segments

Segment	Percentage
Chemicals	26%
Functional Plastics	12%
Expandable Plastics	10%
Foodstuffs Products	7%
Life Science Products	8%
Electronic Products	19%
Synthetic Fibers and Others	18%

2015/16 sales divided by regions

Region	Percentage
Japan	61%
Asia	10%
North America	8%
Europe	16%
Other Areas	5%

Production Sites The company's production sites are located in:

- Takasago, Japan

- Osaka, Japan
- Shiga, Japan
- Kashima, Japan

Profile Summary Kaneka Corporation was established as a spin-off of Kanegafuchi Spinning Co., Ltd. in 1949. Kaneka's principal activities include the manufacturing and distribution of chemical products, synthetic resins, and plastic products. The company is listed on the Tokyo Stock Exchange and employed 3,400 people (9,376 including consolidated subsidiaries). Total assets in 2015/16 were about JPY 557 billion. The company's financial year ends in March. The company has 38 domestic subsidiaries as well as five overseas affiliates in Europe, 18 in Asia/Oceania and 4 in America. In 2015, the company entered a joint development agreement for the application of biopolymers with the German company Biotec GmbH. Both enterprises agreed to combine their development resources to create new bio-based compounds for application areas such as pharmaceutical capsules, extrusion and coated paper as well as cardboard, films and packaging solutions. Several of the company's facilities are certified according to ISO 9001 and ISO 14001 standards.

Specific Information about Bioplastics

Product Details Since 2011, Kaneka's PHBH is sold under the trade name AONILEX which is a bio-based biodegradable polymer. It is produced by microorganisms utilizing vegetable oils such as soybean, corn and palm oil as main source of carbon. Its mechanical properties are similar to those of polyethylene and polypropylene. It can be processed using either blow or injection molding. Fields of application are packaging, agricultural products, automobiles, and paper coating materials.

Associated Companies

Site / Plant - PHBH (c)
 Takasago, Japan

Chapter 5: Detailed profiles of the most important manufacturers, such as Anhui Wanwei, Braskem, FENC, NaturWorks, Novamont, Rodenburg Biopolymers, Solvay, Teijin, Toyota Tsusho, Vegeplast & Wuhan Huali.

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