Buyer's Guide

An Introduction To

BIOPLASTICS & INJECTION MOLDING

PRECISION MOLDED PLASTICS

INTRODUCTION

As the interest in environmentally friendly business and consumer practices increases, so does the desire for novel approaches and greater efforts towards addressing the issues surrounding plastic manufacturing, usage, waste, recycling and management. As part of that discussion, the term bioplastics is being used more frequently. What exactly does the expression mean, what are the issues and options associated with it, and how does it fit into a modern ecologically-sound commercial framework? As with most complex topics, the answers are somewhat complicated and are not unanimously agreed upon, although we attempt to review the basics in this guide.

FACTORS

To begin with, there are two main factors associated with bioplastics. While often used somewhat synonymously, they actually are distinct concepts. The difference between the two ideas is fairly straightforward, as one deals with what can be referred to as the **beginning-of-life** of a material, with the other covering the **end-of-life** of a product.

BIOBASED

The first factor related to bioplastics is whether the material is **biobased**, which means the source is a **biomass** or that some or all the raw materials have a biological origin (i.e., plant or animal material). In other words, the source has a non-fossil origin. According to the U.S. Department of Agriculture (USDA), "Biobased content is how much 'new' or recent organic carbon is in an object or substance, compared to the amount of 'old' organic carbon it contains." Put slightly differently, "the term biomass covers all materials of biological origin, apart from fossil materials and/or those incorporated into geological formations." (Information Document 536 (EN) – 19.10, TUV Austria.) Thus, biobased products provide an alternative to conventional petroleum-derived products.

Basically, this refers to **renewable resources** (those that naturally can replenish themselves), as opposed to **nonrenewable resources** (those that are limited in supply and cannot be used sustainably), which include oil, natural gas, coal, and nuclear energy. Oil, natural gas and coal collectively are referred to as **fossil fuels**, which were formed from dead plants and animals over millions of years - hence the USDA's reference to "new" vs. "old."

BIODEGRADABLE

The second aspect of bioplastics is whether the substance is **biodegradable**. As defined by the International Union of Pure and Applied Chemistry (IUPAC), biodegradation is the "breakdown of a substance catalyzed by enzymes [macromolecules] *in vitro* [in a laboratory] or *in vivo* [in a living body]." Generally speaking, a material is biodegradable "only if microbes [i.e., microorganisms or microscopic organisms] in the environment can break it down and use it as a food source." Further, whether and to what extent a material is biodegradable depends on its molecular structure and not on its source. More specifically for our purposes here, a biodegradable plastic is "a plastic in which all the organic carbon can be converted into biomass, water, carbon dioxide, and/or methane via the action of naturally occurring microorganisms such as bacteria and fungi, in timeframes consistent with the ambient conditions of the disposal method."

Additionally, although often used interchangeably, the terms biodegradable and compostable mean somewhat different things. While biodegradable means that a substance can decompose by bacteria or other living organisms, a **compostable plastic** is defined by the ASTM as "a plastic that undergoes degradation by biological processes *during composting* to yield carbon dioxide (CO2), water, inorganic compounds, and biomass at a rate consistent with other known compostable materials and that leaves no visible, distinguishable, or toxic residue." (Emphasis added.) Thus, all compostable materials are biodegradable, but not all biodegradable materials are compostable. Additionally, most compostability definitions refer to industrial or commercial composting facilities, although some include home composting programs.

TYPES OF BIOPLASTICS

Using the two elements of biobased and biodegradable, there can be three different types of bioplastics.

1) Biobased Plastics. Resins that are biobased are derived in whole or in part from **organic materials** from plants or animals (i.e., a biomass). Not all biobased plastics are biodegradable.

2) Biodegradable Plastics. Plastics that are biodegradable can be chemically broken down by microorganisms in the environment within a limited period of time. Also, note that some biodegradable plastics have a non-biobased source, like petroleum, contrary to popular belief.

3) Biobased and Biodegradable Plastics. Some bioplastics are both biodegradable and are partially or wholly made from a biobased source.

BIOCOMPOSITES

Another type of material included within the category of bioplastics are compounds or composites containing a combination of substances.

A **composite** is a material that is produced from two or more constituent materials having different physical or chemical properties. Further, a **biocomposite** is formed by polymers derived from renewable (i.e., having a biological origin) and nonrenewable materials. In addition, composites usually include a combination of resin (a matrix or binding agent) and a fiber reinforcement, which can consist of either natural or synthetic fibers. Biocomposites generally contain a petroleum-based plastic and an organic filler, although some combine natural fibers with biobased or biodegradable resins. Further, natural fibers include wood fibers (recycled and non-recycled) and non-wood fibers, including straw, bast, leaf, seed, fruit, and grass.

RECYCLING PLASTICS

Another important topic included within the discussion on bioplastics is that of recycling. According to the CalRecycle Glossary of Waste Prevention Terms, the term **recycling** means "using waste as material to manufacture a new product. Recycling involves altering the physical form of an object or material and making a new object from the altered material." Correspondingly, the ASTM defines **recycled plastic** as "those plastics composed of postconsumer material or recovered material only, or both, that may or may not have been subject to additional processing steps of the types used to make products such as recycled-regrind or reprocessed or reconstituted plastics."

Generally speaking, there are three end-of-life options for recycling plastics - mechanical recycling, chemical recycling, and organic recycling. Mechanical recycling basically consists of melting plastic waste, which does not alter the molecular structure of the material. Chemical recycling modifies the plastic with the use of a chemical agent or process. Finally, organic recycling involves the disintegration of plastic materials in a municipal or industrial composting facility via aerobic (composting) or anaerobic (biomethanization) treatment. The output of these recycling efforts often consists of bioplastic granules that can be used to make plastic products (thus becoming a beginning-of-life option), thereby completing the circular recycling process or loop.

Additionally, according to the US Environmental Protection Agency (EPA), "The ability of biobased plastics to be recycled varies. Some forms of biobased plastic cannot be recycled together with petroleum-based plastics due to chemical structure incompatibility, while other biobased plastics may have compatible chemical structures that allow for recycling together with petroleum-based plastics."

TESTING & CERTIFICATIONS

In the United States, there are certain standards, legal requirements and labeling guidelines relating to the different kinds of bioplastics.

BIOBASED PLASTICS

Because some bioplastics are not entirely made from a biomass, there are two approaches to analyzing their composition. First, you can look at the "**biobased content**, based on the amount of biomass in a product, taking account of the four key components: carbon, hydrogen, oxygen and nitrogen; The bio-based content is expressed as a percentage of the overall weight of the product in question." Alternatively, "the **biobased carbon content** is focused on carbon and is generally expressed as a percentage of the carbon the product contains (organic carbon or total carbon)." (See ASTM D6866 and ISO 16620-1:2015.)

To determine the biobased content of a product and whether it can be certified as such, the USDA uses the requirements set forth in ASTM D6866. Additionally, as part of its BioPreferred program, the USDA maintains a voluntary labeling initiative where businesses may display the **USDA Certified Biobased Product** label on products that meet the USDA criteria for containing a verified amount of renewable biological ingredients (i.e., biobased content).

COMPOSTABLE BIOPLASTICS

In California and in some other states, it is illegal to use the term "biodegradable" in marketing claims related to plastic products, because the expression often is used to describe items that do not meet ASTM standards for compostability and, therefore, are contaminants for composters. In addition, for a label to state a product is "compostable" or "marine degradable," that product must meet the applicable ASTM standard.

In the United States, for plastics to be considered compostable, they must be certified according to ASTM D6400 (or ASTM D6868 for biodegradable coatings). As stated by the standard, "The purpose of this specification is to establish standards for identifying products and materials that will compost satisfactorily in commercial and municipal composting facilities." D6400 specifies three criteria for compostable plastics: (1) Disintegration; (2) Mineralization or Inherent Biodegradation; and (3) Safety considerations. It also creates labeling requirements for compostable materials.

Regarding labeling, the Biodegradable Products Institute (BPI) has created a compostable logo to place on products that meet the applicable ASTM specification. The BPI is the only third-party verification of ASTM standards for compostable products in North America. In addition, the Federal Trade Commission (FTC) has adopted the Guides for the Use of Environmental Marketing Claims or the Green Guides, which govern the marketing of environmentally friendly products and the use of certifications, seals and claims regarding the attributes of the associated products.

PURPORTED BENEFITS

Although a consensus does not appear to exist, there are many claims regarding the present and potential benefits of bioplastics. Some of the commonly discussed ones include:

- They save fossil resources by using biomass.
- Many are biodegradable.
- Bioplastic production consumes less fossil energy.
- Bioplastic production has fewer carbon dioxide emissions.
- Bioplastic production can help reduce dependence on imports and may create jobs and export opportunities.
- Use of bioplastics results in a reduction of our carbon footprint.
- Bioplastic usage reduces the global warming potential.
- Biobased products help us increase our use of renewable resources, while decreasing our use of on-renewable resources, such as petroleum.
- There is an alleged decrease in environmental toxicity.
- There is a potential reduction in litter and in the amount of trash sent to landfills.
- Bioplastics are cost-comparative, readily available, and perform as well or better than their petroleum-containing counterparts.
- The bioplastics industry is making a strong effort to use agricultural residues (cellulosics), other waste streams, and feedstocks that do not compete with food markets.

POSSIBLE ISSUES

In addition to the intended benefits of bioplastics, some people have expressed concerns regarding their impact on the environment or regarding their alleged advantage over other materials. Some of those issues include the following:

- Questions have been raised about the relative toxicity of bioplastics to conventional plastics.
- Some non-biobased plastics are biodegradable.
- Some biobased plastics are non-biodegradable.
- Bioplastic production consumes fossil energy and has carbon dioxide emissions.
- Bioplastics production results in pollutants, due to the fertilizers and pesticides used in growing the crops and the chemical processing needed to turn organic material into plastic.
- Bioplastics have some impact on food supply and availability.
- Most bioplastics can be broken down by microorganisms and become part of the natural world again in a short period of time, only if they are collected and composted in a carefully controlled, high-temperature industrial composting facility — and there aren't many of those, especially in developing countries where the problem of plastic pollution is most severe.
- If bioplastics end up in landfills, as many do, without enough oxygen to break them down, they can last for centuries and release methane, a potent greenhouse gas.
- If bioplastics are thrown into the environment, they pose threats similar to other plastics.
- Many experts believe the solution to plastic waste mainly lies not in developing better bioplastics, but in overhauling the world's economy to recycle far-greater quantities of plastic than currently are being reused.

To make these kinds of determinations, many analysts perform a Life Cycle Assessment (LCA), which is a data gathering and analysis tool that broadly assesses environmental benefits and burdens of a product. This approach is utilized by the EPA, for example. The procedures followed for an LCA often are those contained within the 14000 series of the International Organization for Standardization (ISO).

INJECTION MOLDING

Bioplastics can be used in many of the same ways as other plastics - for packaging, parts, components, disposables, durable goods, etc. Additionally, they can play a role in products associated with many different industries, such as agriculture, automotive, medical, food and beverage, and consumer goods.

When it comes to injection molding, bioplastics can have unique characteristics and perform in ways distinct from petroleum-based plastics. Thus, while the same general principles apply, to achieve quality, injection molded, bioplastic parts efficiently and consistently, some different approaches may need to be taken when building molds and certain modified processes utilized when manufacturing parts.

However, adequate experience working with these materials can result in producing parts historically thought to be achievable only by using traditional plastics. For example, Precision Molded Plastics manufactures bioplastic parts with durable living hinges (as shown in the image at the top of this article), which generally need to be made from polypropylene. Further, maintaining a good, working relationship with bioplastic manufacturers can be indispensable during the research and development phase of a new project using bioresins.

CONCLUSION

The awareness of environmental issues and desire to adopt ecologically friendly business and lifestyle approaches is widespread and growing. As part of this trend, attention has been focused on plastic usage and waste management. Consequently, many in the public and private sectors have worked on developing sophisticated recycling systems. In addition, research into biobased and biodegradable materials and the manufacturing and utilization of bioresins have increased. While a complete consensus about the potential benefits of these materials may not exist, using bioplastics, coupled with greater recycling methodologies and adoption, may assist in achieving a cleaner world, a healthier population, and a better tomorrow.

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NOTICE

This guide is intended to give a relatively academic and objective, although brief, summary of the topics and considerations related to bioplastics. It was not written or published to advocate for any specific viewpoint or for the use of any particular type of materials.

Virtually all products impact the environment. Accordingly, Precision Molded Plastics makes no express or implied claims regarding the biomass content, the biodegradability, or any environmental attributes or benefits of any of the products with which it is associated, or of bioplastics in general, or of any comparative advantage of bioplastics to other materials, and any such information must and should be obtained directly from the plastic resin manufacturers.

For more information, go to https://www.usda.gov, https://www.energy.gov, https://www.epa.gov, or https://www.calrecycle.ca.gov.

Precision Molded Plastics is an ISO certified, vertically integrated, plastic injection molding company that builds custom molds and tooling, manufactures parts and products, and performs a variety of secondary and finishing operations all under one roof. As such, we have been a trusted supplier of Fortune 500 companies in the medical, aerospace, electronics, food and beverage, construction, and other industries for over forty years.

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