BIOPLASTICS SIMPLIFIED:
ATTRIBUTES OF BIOBASED AND BIODEGRADABLE PLASTICS

ISSUED FEBRUARY 2016

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The SPI Bioplastics Council would like to thank the following individuals for reviewing this document:

- Kate Lewis, Deputy Program Manager at the U.S. Department of Agriculture
- Erin Simon, Deputy Director, PSE, Sustainability R&D at World Wildlife Fund – Packaging at World Wildlife Fund

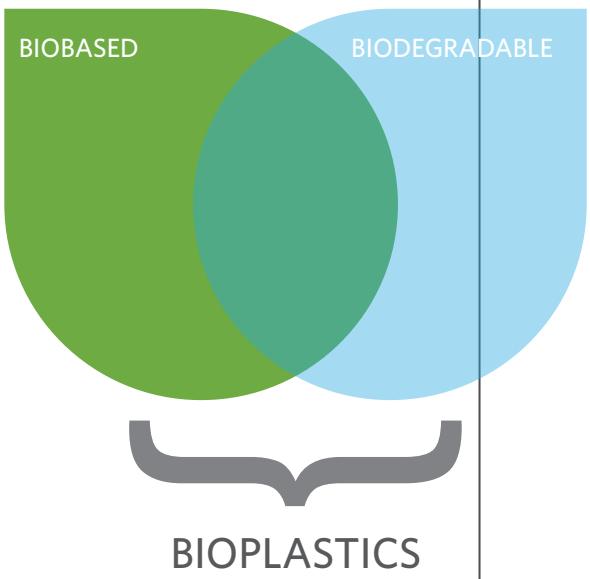
The reviewers provided a review of this document but did not have final approval of the document and do not specifically endorse the document. This page acknowledges their contributions.

INTRODUCTION

BIOPLASTIC:
partially or fully biobased and/or biodegradable

The term "bioplastics" describes a wide range of materials. This paper discusses the growing field of bioplastics, and how material innovations can offer environmental advantages. For a more comprehensive guide on these topics, please refer to the "Bioplastics Industry Overview Guide" published by the Bioplastics Division.[1]

The SPI Bioplastics Division defines "bioplastics" as "partially or fully biobased and/or biodegradable."[2] This definition is now accepted globally. A biobased bioplastic has some or all of its carbon produced from a renewable plant (or sometimes animal) source. Biodegradable plastics are those that degrade into carbon dioxide (CO_2), methane (CH_4), and water (H_20) through biological action in a defined environment and in a defined timescale. These environments include composting, anaerobic digestion, and marine and soil environments. A common misperception is that "biobased" and "biodegradable" are related. They are not. A bioplastic that is biobased may not necessarily biodegradable, and a biodegradable bioplastic may not be biobased.



In this fast-evolving landscape, it is important to note that company-specific claims that products include biobased content or are biodegradable must be made carefully, with due consideration of relevant scientific standards, as well as applicable federal and state regulations and guidance. Particular attention should be given to the U.S. Federal Trade Commission's (FTC) *Guides for the Use of Environmental Marketing Claims* (or *Green Guides*, at 16 C.F.R. Part 260), which clarify the FTC's position on biodegradability, compostability, and degradability claims, among others. Companies making biobased and biodegradable claims must ensure they have competent and reliable scientific evidence for the origin or degradability claims for their products. Qualifications may be necessary to assure that customers understand the claims and, if degradability is the claim, the conditions in which degradation can be expected to take place.[3]

[1] Additional information on the Bioplastics Industry Overview Guide can be found at spi.plasticsindustry.org/productdetails/?id=5dd835f6-2227-e511-93fb-00155dc2234b

[2] Additional information on the definitions used by the Division can be found at www.plasticsindustry.org/BioplasticsDivision/index.cfm?ItemNumber=13993&navItemNumber=13994

[3] A business-friendly summary of the Green Guides by FTC staff was issued in September 2012 and is found at www.ftcov/sites/default/files/attachments/press-releases/ftc-issues-revised-green-guides/greenguidessummary.pdf

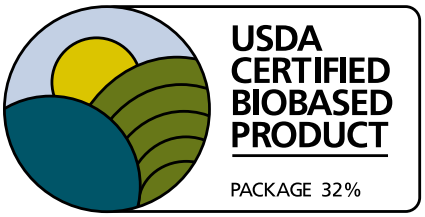
BIOBASED

A bioplastic that is biobased has some or all of its carbon produced from a renewable plant or animal source. "Renewable" is defined as a resource that is inexhaustible or readily replaced. The biobased content may be the polymer, filler, or an additive. A material is also considered to be biobased if produced in yeast, bacteria, or algae grown and cultivated with biobased feedstocks such as sugar or lipids as long as the source of carbon within them is partially or wholly from non-fossil origin (e.g. petroleum or natural gas.)

Presently, most biobased bioplastics are sourced from plant-based raw materials coming from traditional crops like corn and sugar cane. However, much research is ongoing to move to second and third generation feedstocks including agricultural, forest, and municipal waste, as well as algae and other non-food biobased feedstocks. Bioplastics are increasingly being derived from these non-food sources through cellulosic sugars and triglycerides contained within them.[4]

The biobased content of a bioplastic can be reported in several ways. The most common is as a weight-percent renewable resource content. The second most common is as a percent biobased carbon content in the bioplastic. This measurement is the basis for certification under the USDA BioPreferred Program, a federal program that promotes the purchase and use of biobased products via a) mandatory federal purchasing requirements, and b) a voluntary labeling initiative for biobased products, similar to the USDA Organic Program.[5] The percent biobased carbon content refers specifically to organic carbon and is measured using the ASTM D6866[6] test method specification. For further discussions on the differences between biobased carbon content and renewable resource content, please refer to the SPI Bioplastics Division's "Understanding Biobased Carbon Content".[7]

BIOBASED BIOPLASTIC:
plastic partially or fully based on renewable resources



USDA Certifed Biobased Product Label

[4] See Society of the Plastics Industry's Bioplastic Council white paper titled "Development of Biobased Plastics Independent of the Future of Biofuels" issued August 2013

[5] For more information on the USDA BioPreferred Program and about getting a biobased product certified, go to www.biopreferred.gov/BioPreferred/

[6] ASTM D6866 "Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis". Note that the FTC refused to accept the performance of ASTM D6866 as adequate substantiation for compostability claims, doubting that laboratory conditions adequately mirrored real-world conditions. Nonetheless, the FTC has not taken any action to preclude such references. Given that California specifies ASTM D6866 (and others) as the standard to be met for compostability claims, the key is to assure that any tests are relevant to the specific composting conditions and accurately assess the performance of the actual product, including thickness, dimensions, etc, in those conditions.

[7] Issued February 2012

What can BIOPLASTICS be made of?

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Potential benefits of biobased bioplastics are numerous. The specific benefits of a particular bioplastic, from an overall environmental standpoint, should be determined through a life cycle assessment (LCA)[8] or other data gathering and analysis tool that broadly assesses environmental benefits and burdens. Typical benefits can include:

- reduction of fossil fuel usage;
- reduction of carbon footprint; or
- reduction of global warming potential (GWP),
- or any combination thereof.

Bioplastics produced from biobased polymers can perform the same as the same polymer produced from a fossil source. Examples of commonly fossil-based polymers with partially or fully biobased equivalents are: polyethylene (PE), polyethylene terephthalate (PET), and several types of polyamides. These bioplastics have the same property and processing characteristics as their fossil-based equivalents because those properties are driven by the polymer chemical structure rather than by the source of the carbon.

Thus, biobased bioplastics also typically lead to a reduction in the material's carbon foot print relative to fossil-based equivalents, depending on the feedstock and the cultivation techniques. To be confident that a biobased bioplastic has a carbon footprint benefit over fossil-based alternative, an assessment must be done which considers these factors. This happens because the biobased carbon content is typically CO_2 captured from the atmosphere through plant growth. This also leads to reduction of the GWP associated with the biobased bioplastic.

Biobased plastics that are not compostable or otherwise biodegradable are ideal for applications such as durable goods and items that are highly recycled.[9] A soda or water bottle made from biobased PET or PE can be recovered and recycled through the standard PET bottle recycling infrastructure without any issues.

BENEFITS INCLUDE
REDUCTION OF:

[8] For further explanation of LCAs, see the SPI Bioplastics Council publication titled "Life Cycle Analysis Primer: What, Why and How" issued February 2012

[9] As with traditional petroleum-based plastics, bioplastics from biobased polymers without fillers are the easiest and most likely to be recycled while the bioplastics produced from polymer blends or through biobased fillers in traditional polymers may be difficult to recycle or may contaminate the existing recycling stream.

BIODEGRADABLE

Biodegradable plastics are those that completely degrade through biological action into carbon dioxide, methane, and water in a defined environment and in a defined timescale. These environments include composting, anaerobic digestion, and marine and soil environments. The FTC and various local authorities have specific requirements regarding biodegradation claims. If composting facilities are not available to a substantial majority of consumers likely to use the end products (at least 60%), qualifications must be made to clarify the probable availability of composting facilities to consumers.

Compostable items are those that biodegrade typically in an industrial composting environment. Compostable bags and food service items have helped make food waste collection programs around the world successful by increasing the amount of food waste diverted from the landfill waste stream. Many residential food scrap programs rely on compostable bags to facilitate participation. Special events, conference centers, and sports arenas increasingly use compostable food service items to simplify food scrap collection and work toward zero-waste goals.

Other biodegradable bioplastic applications include soil and marine biodegradability. Soil biodegradability is useful for agricultural and landscaping applications including mulch films, which can be tilled into the field after use instead of being removed and landfilled. Marine biodegradability is useful in products that are designed for use in salt or fresh water environments. However, biodegradation should not be considered to mitigate or solve littering.

Biodegradability of plastics through industrial composting or other means provides alternative means for disposal of products. Biodegradability is complimentary to recycling. An ideal life cycle for a biodegradable plastic is to be recycled as much as possible and then, when the material properties have degraded beyond usability, the material is submitted for biodegradation in an appropriate industrial composting or other facility. They can also be used in disposable food contact products, such as bags or plates, to promote the diversion of food waste from landfills to composting.

The use of "degradable additives" such as oxodegradable additives are sometimes used to cause traditional plastics to fragment into smaller pieces. The resulting fragments are claimed to eventually undergo biodegradation. For some plastics, recycling, composting and waste management experts have expressed concern that these treated products do not meet their environmental promises because the resulting fragments are not comprised entirely of materials known in nature.[10]

BIODEGRADABLE BIOPLASTIC:
plastic fully degraded by natural biological activity

[10] For more information on the SPI Bioplastics Division's position on degradable additives, see the SPI Bioplastics Division paper "Position Paper on Degradable Additives", issued January 2013

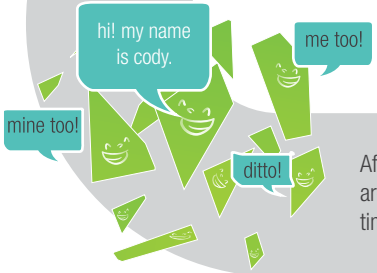
How BIODEGRADATION WORKS

Cody, the Compostable Cup's Journey

Meet Cody, a compostable plastic cup. Some people think that his life is over once he's empty. But Cody's journey doesn't stop there.

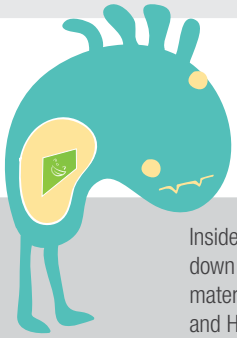
Once Cody is composted along with leftover food and yard waste, he is carried to the industrial composter.

At the composter, Cody is shredded with the other organic material into smaller pieces.

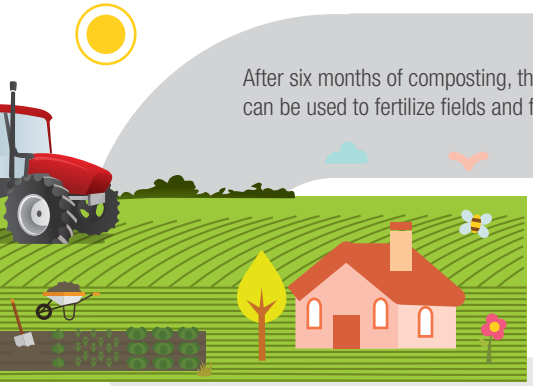


After being shredded, Cody and friends are piled into a big mound where heat and time further break them down.

The tiny pieces of plastic are consumed by fungi and bacteria as food.



Inside the cell, enzymes work to break down the plastic for energy and raw materials. Simple molecules such as CO_2 and H_2O are excreted as byproducts.



After six months of composting, the resulting mulch can be used to fertilize fields and flower beds.

Eventually, those plants could even be used to make another Cody.

Types of Biodegradation:

- Anaerobic
- Industrial Composting
- Home Composting
- Soil
- Fresh Water
- Marine Water

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BIOPLASTICS

originate from a renewable resource

are biodegradable

are renewable and biodegradable

OVERLAP BETWEEN BIODEGRADABLE AND BIOBASED BIOPLASTICS

While biodegradability and biobased content are two distinct features of bioplastics, they are not mutually exclusive. In other words, some bioplastics have just one of these attributes, like a biobased water bottle that can be mechanically recycled with conventional PET, while other bioplastics may be both biobased and biodegradable. These bioplastics allow an end user to enhance the value proposition. For instance, if a biobased AND compostable bioplastic is used to make compostable food waste collection bags, then the product may offer both beginning-of-life (BOL) and end-of-life (EOL) environmental benefits.

To complicate matters, a bioplastic that is biobased and compostable in the raw form may lose compostability or biodegradability in a finished product. This can occur when a biobased and compostable bioplastic resin is used for a durable application, compounded with other materials to reach the desired specifications, and therefore loses the ability to be compostable. If a product is a bioplastic out the outset but not compostable or biodegradable as a finished product, standard principles of advertising substantiation, which require reliance on competent and reliable scientific evidence of the claimed environmental performance, will preclude promoting the product as degradable/compostable in its finished form.

CONCLUSION

Bioplastics can be both biobased and biodegradable. However, it is also possible for bioplastics to be only biobased or only biodegradable. The two properties are independent but can often be achieved in the same bioplastic. As such, bioplastics have a broad range of properties and characteristics and thus ways in which they can be used.

FOR MORE INFORMATION:
plasticsindustry.org/bioplastics

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