



BIOPLASTICS SIMPLIFIED:

ATTRIBUTES OF BIOBASED AND BIODEGRADABLE PLASTICS

FALL 2020



The PLASTICS Bioplastics Division would like to thank the following individuals for reviewing this document:

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In this report, the term biodegradable may be used to discuss polymers. Biodegradable properties vary depending on many factors specific to the finished product, constituent polymers, and intended conditions of use and disposition. Any claim that a finished product is biodegradable or compostable (e.g., home/industrial compostable, marine/soil biodegradable, or anaerobic digestible) must be supported by relevant, competent, and reliable scientific evidence. PLASTICS has not independently examined each claim and has relied on thirdparty information.

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INTRODUCTION

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.

The globally accepted definition developed by the industry of “bioplastics” is “biobased and/or in some way biodegradable”. A biobased bioplastic has some or all of its carbon produced from a renewable source. Biodegradable bioplastics are those that degrade into biomass, carbon dioxide (CO₂) and water through biological action in a defined environment and in a defined timescale. These defined environments include composting, anaerobic digestion, and marine and soil environments. Terms such as “biobased”, “biodegradable”, etc. have more detailed scientific and legal definitions that will be expanded upon in later sections of this document.

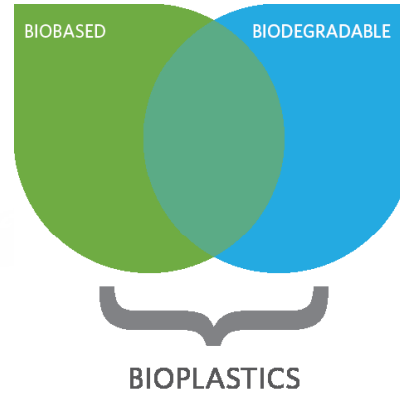
In this fast-evolving landscape, it is important to note that company specific claims that products include biobased content and/or are biodegradable must be made carefully, with due consideration of relevant scientific standards, as well as applicable federal and state regulations and guidance. Particular 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 other degradability claims, among others. States and other localities may have additional requirements for labeling and marketing bioplastics. Companies making biobased and/or 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.¹



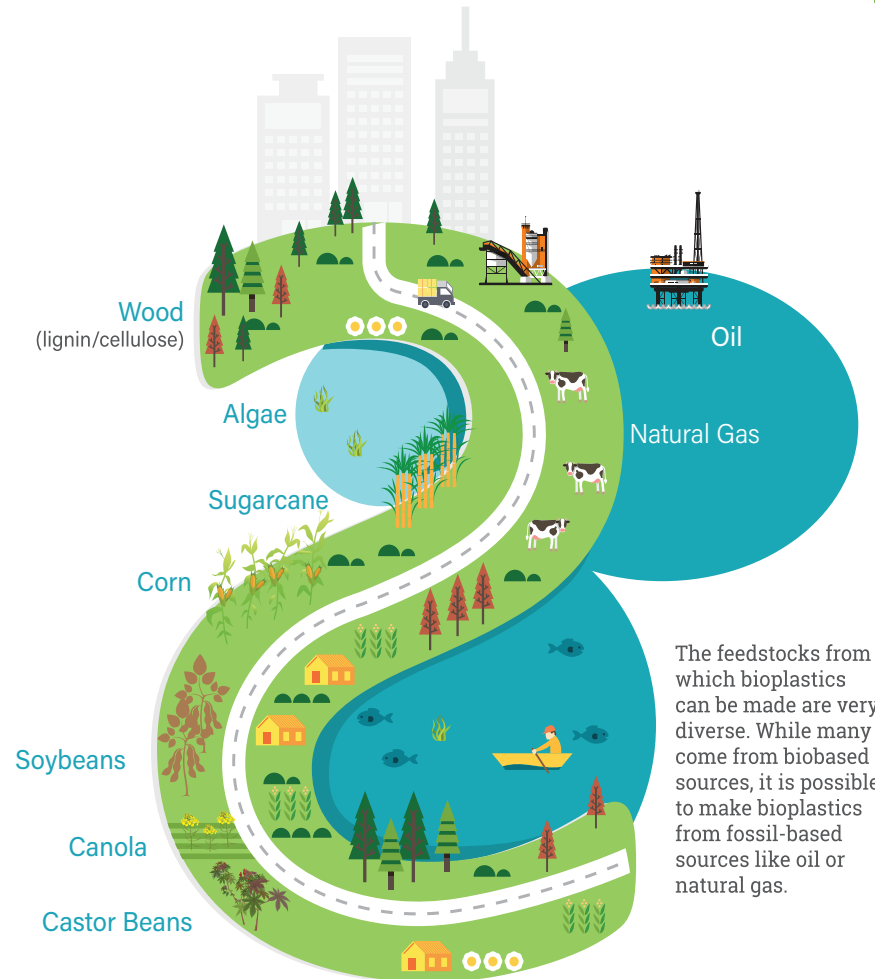


BIOPLASTIC:

partially or fully
biobased
and/or
biodegradable



What can BIOPLASTICS be made of?



BIOBASED

A bioplastic that is biobased has some or all of its carbon derived from a renewable 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 sourced (e.g., not feedstocks that are petroleum or natural gas.)

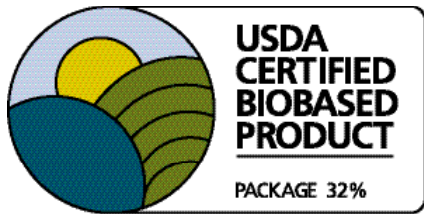
Presently, most biobased bioplastics are sourced from plant-based raw materials coming from traditional crops like corn and sugar cane. However, research is ongoing to move to second and third generation feedstocks including agricultural, forest, and municipal waste, as well as algae and other biobased feedstocks not coming from food sources. Bioplastics are increasingly being derived from these non-food sources through cellulosic sugars and triglycerides contained within them.

The biobased content of a bioplastic can be reported in several ways. The most common methods are as the percent of the weight that is renewable resource content and the 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 mandatory federal purchasing requirements, and a voluntary labeling initiative for biobased products, similar to the USDA Organic Program.² The percent biobased carbon content refers specifically to organic carbon and is measured using the ASTM D686³ test method specification. For further discussions on the differences between biobased carbon content and renewable resource content, please refer to the PLASTICS Bioplastics Division’s “Understanding Biobased Carbon Content”⁴

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)⁵ or other data gathering and analysis tool that broadly assesses environmental benefits and burdens.

AND MORE!
Learn more about bioplastics:
plasticsindustry.org/bioplastics

BIOBASED BIOPLASTIC: plastic partially or fully based on renewable resources



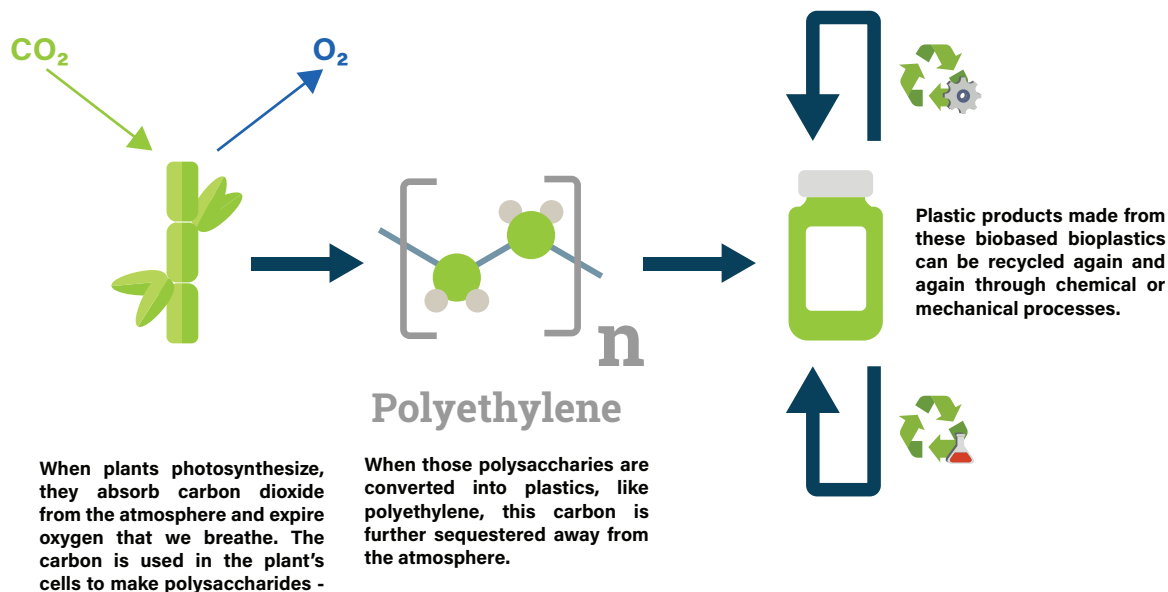
USDA Certified Biobased Product Label

Bioplastics produced from biobased polymers can perform the same as the same polymer produced from a fossil source. Examples of commonly non-biobased 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-sourced equivalents because those properties are driven by the polymer chemical structure rather than by the source of the carbon. They are also sometimes called “drop-in replacements” for fossil-sourced equivalents.

Biobased bioplastics typically lead to a reduction in the material's carbon footprint relative to fossil-based equivalents. As illustrated in Figure 1, this happens because the biobased carbon content is typically CO₂ 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.⁶ A soda or bottle made from biobased PET or PE can be recovered and recycled through the standard recycling infrastructure without any issues.

Biopolymers Lifecycles and Sustainability Attributes



BENEFITS INCLUDE
REDUCTION OF:



Figure 1. Biobased Polyethylene as an example of a biobased biopolymer which is recyclable.

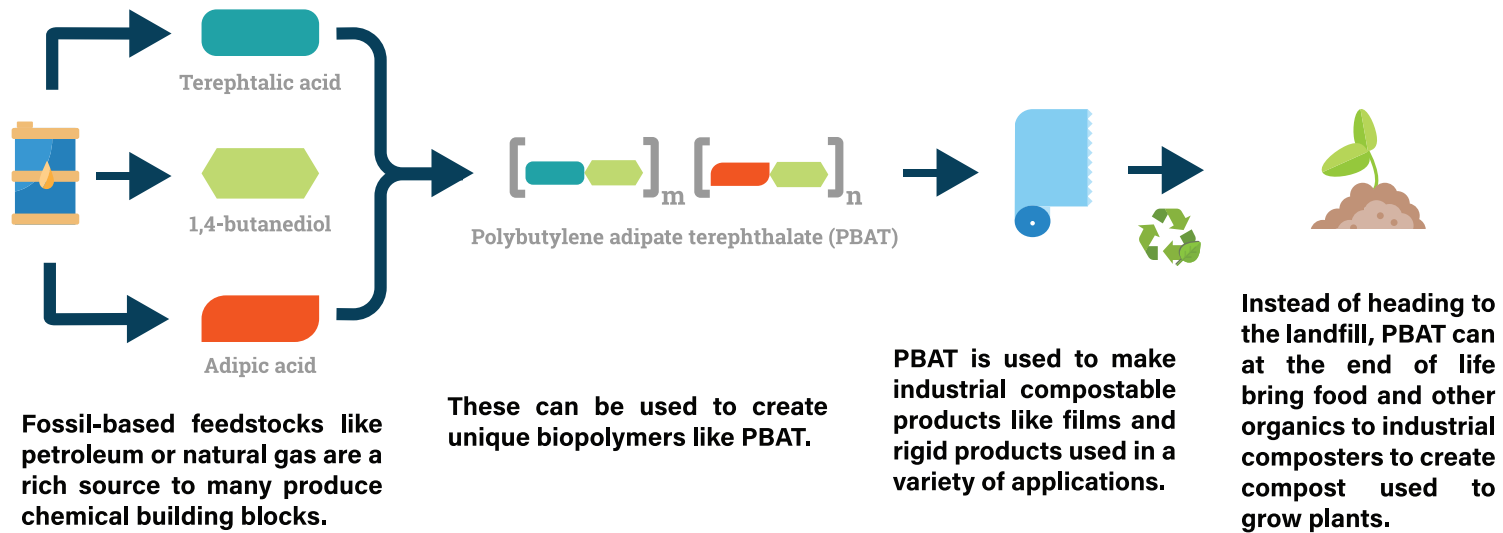
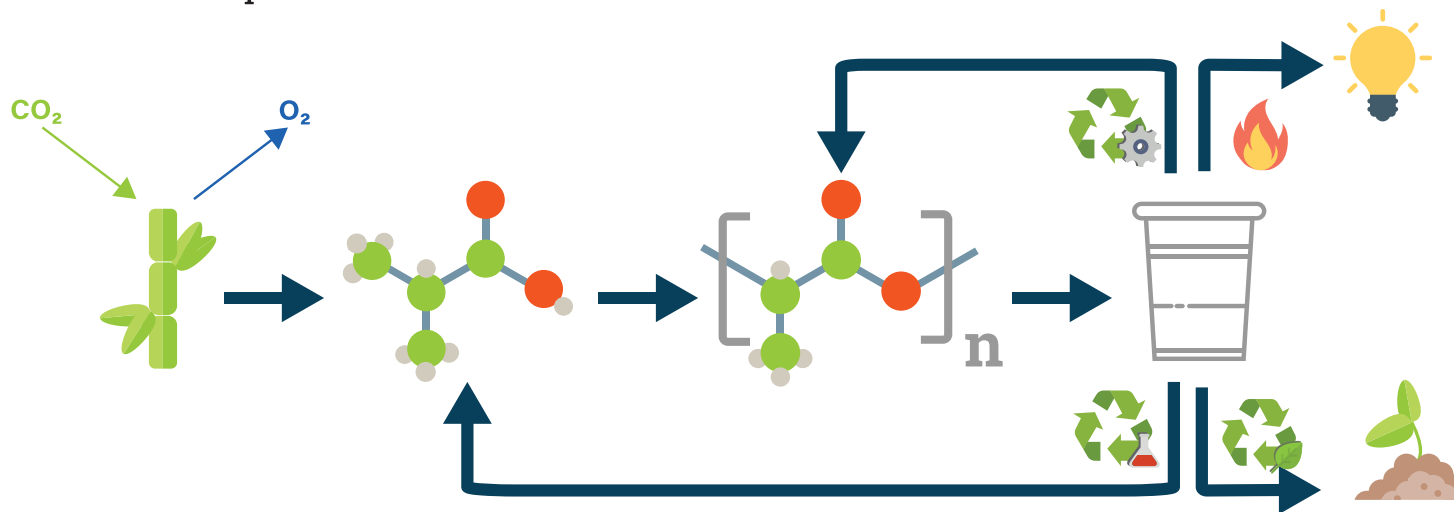


Figure 2. Polybutylene adipate terephthalate as an example of a fossil-based biopolymer which is compostable.



BIODEGRADABLE



BIODEGRADABLE BIOPLASTIC:

plastic fully degraded by
natural biological activity

Biodegradable plastics are those that completely degrade through biological action into biomass, carbon dioxide (CO₂), and water in a defined environment and in a defined timescale. These environments include industrial and home composting, anaerobic digestion, and marine and soil biodegradation. The FTC and various local authorities have specific requirements regarding biodegradation claims.

Figure 2 illustrates how biodegradable biopolymers like PBAT can be made from a fossil sources. These biopolymers can be used to make industrial compostable products like films or rigid packaging. Instead of heading to the landfill, at the end of use can bring food and other organics to industrial composters to create compost used to grow plants.

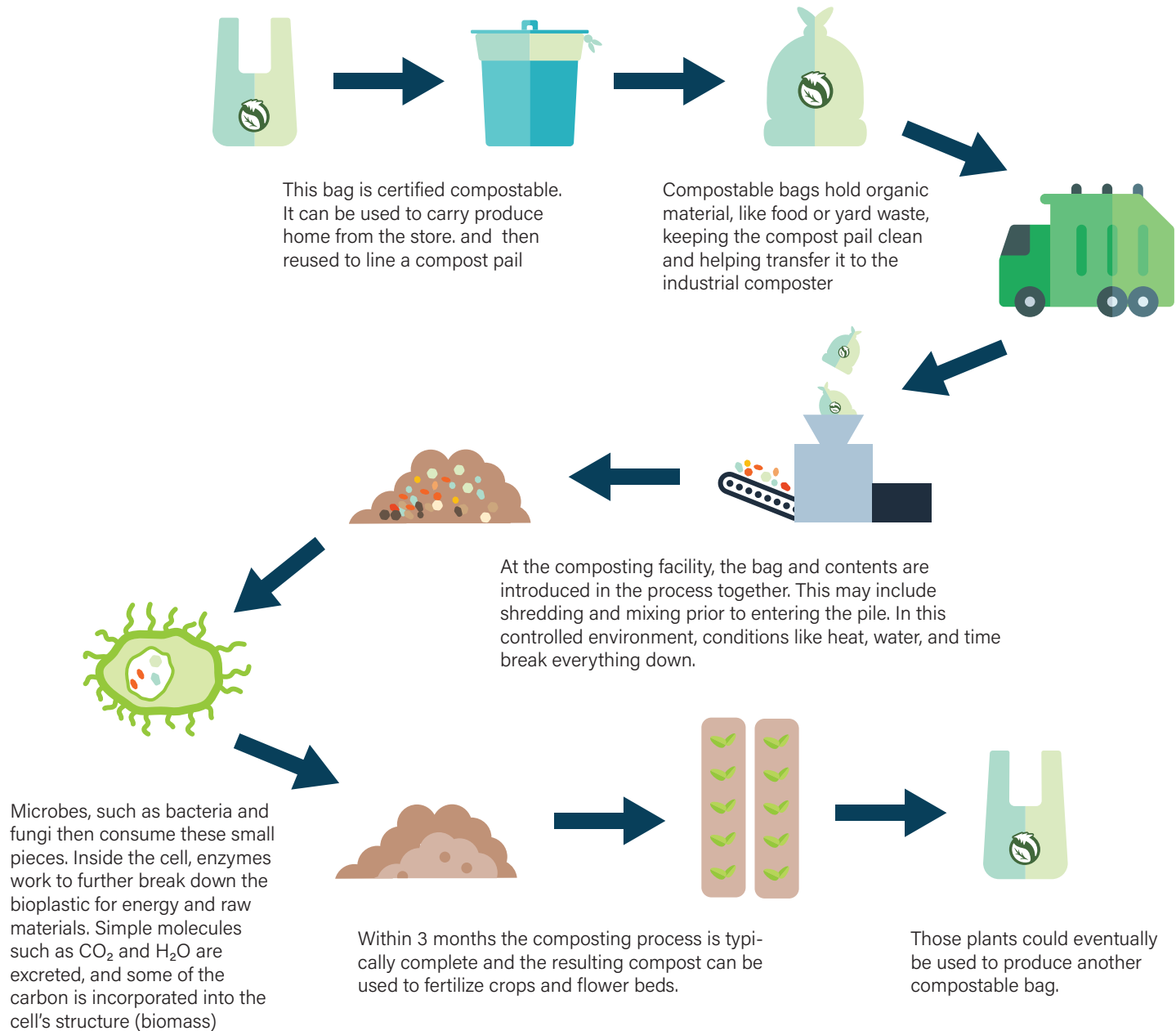
Other biodegradable bioplastic applications include soil and marine biodegradability. Soil biodegradability is useful for agricultural and landscaping applications including mulch films, which can be tilled into the field after use instead of being removed and landfilled. Marine biodegradability is useful in products that are designed for use in salt or freshwater environments. However, no form of biodegradation should be considered as a solution littering.

Biodegradability of plastics through industrial composting or other means provides alternative means for disposal of products. However, some compostable plastics such as PLA can be formulated for more durable applications and have the potential for being recycled as long as they are separated from other traditional polymers such as PET, HDPE, PP, etc. It's anticipated that when greater volumes of PLA are available in the marketplace, it may become more cost-effective and there may be more interest in recycling this material.

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. Degradable additives have not been shown in peer reviewed academic literature to convert nonbiodegradable polymers. 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.⁷

Figure 3. Polylactic acid as an example of a biobased biopolymer which is compostable.

How Industrial Composting Works





“BIODEGRADABLE” VERSUS “COMPOSTABLE”

Compostable plastics are a subset of biodegradable plastics and are not synonymous with “biodegradable plastics.” Industrial 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.

List of Biopolymers

This list of biopolymers includes those that are commercially available or nearly commercially available. Not all grades of a polymer may meet the biodegradability noted; check with the material supplier for more information.

Polymer Abbreviation	Polymer Name	Biobased?	Biodegradable?
CAP	Cellulose Acetate Propionate	Yes	
CA	Cellulose Acetate	Yes	Yes
PA 10	Polyamide 10	Partially	
PA 1010	Polyamide 1010	Yes	
PA 11	Polyamide 11	Partially	Yes
PA 410	Polyamide 410	Partially	
PA 610	Polyamide 610	Partially	
PBAS	Polybutylene Adipate-co-Succinate	In Development	Yes
PBAT (ADIPIC ACID)	Polybutylene Adipate-Co-Terephthalate	Partially	YES
PBAT (azeliac acid)	Polybutylene Azaeli-Co-Terephthalate	Partially	YES
PBS	PolyButylene Succinate	Yes	Yes
PE	Polyethylene	Yes	
PEET	Polyetherester Terephthalate	Partially	
PEF	Polyehtylene Furanoate	In Development	
PET	Polyethylene Terephthalate	Partially	
PHA	Polyhydroxy Alkanoate	Yes	YES
PLA	Polylactic Acid	Yes	Yes
PP	Polypropylene	In Development	
PPA	Polyphthalamide	Partially	
PTT	Polytrimethylene Terephthalate	Partially	
TPC-ET	Thermoplastic Copolymer Elastomer	Partially	
TPS	Thermoplastic Starch	Yes	Yes
TPU	Thermoplastic Polyurethane	Partially	



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.

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, as seen in Figure 3 illustrates how some biopolymers are both biobased and in some way biodegradable, with contributions from the sequestration of carbon from photosynthesis as well as offering several options for renewal at end of life, including mechanically or chemically recycled, or by recovering captured energy.

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.

BIOPLASTICS



originate from a
renewable resource



are
biodegradable



are renewable and
biodegradable



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.



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Endnotes

- 1 A summary of the Green Guides by FTC staff was issued in September 2012 and is found at <https://www.ftc.gov/sites/default/files/attachments/press-releases/ftc-issues-revised-green-guides/greenguidessummary.pdf>
- 2 For more information on the USDA BioPreferred Program and about getting a biobased product certified, go to <https://www.biopreferred.gov/BioPreferred/>
- 3 ASTM D6866 "Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis" <https://www.astm.org/Standards/D6866.htm>.
- 4 Issued February 2012
- 5 "Life Cycle Analysis Primer: What, Why and How" February 2012
- 6 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 recycled or may contaminate the recycling stream.
- 7 For more information on the PLASTICS Bioplastics Division's position on degradable additives, see the paper "Position Paper on Degradable Additives"