Compostable Plastics 101

AN OVERVIEW OF COMPOSTABLE PLASTICS

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An increasing number of products labeled with terms such as "biobased," "biodegradable," and "compostable," are being developed for expanded applications. Many of these are targeted towards food service uses where they may help facilitate the collection of food scraps for composting. Composters may or may not be involved in the discussion of whether or not a food scrap collection program accepts these materials, however, composters are being asked to accept these materials or even promote the use of these materials. As the number of food scrap collection and composting programs across the U.S. increases,[1] stakeholders need to address some of the questions surrounding the use and acceptance of these materials at commercial composting facilities. This paper provides an overview of the compostable plastics industry by defining basic terms, outlining the characteristics of compostable plastics, and highlighting the challenges and opportunities presented by these plastics. It is our hope that the paper will answer some key questions and foster an intelligent dialogue as these programs move forward.

INTRODUCTION

Oil and natural gas are the major raw materials used to manufacture most plastics.[2] Replacing petroleum-based plastics with plastics made from renewable raw materials, such as plants, reduces our dependence on fossil fuels. Replacing petroleum-based plastics with plastics designed to degrade, biodegrade, or compost can provide even more environmental benefits.

Biobased and compostable plastics, also known as bioplastics, hold the potential to reduce dependence on fossil fuels, foster the development of more sustainable products, and increase the diversion of food waste from landfills. However, bioplastics also present challenges and create uncertainty for a wide array of stakeholders. Inconsistencies in product labeling and a lack of accepted definitions for industry terms cause confusion for consumers upon purchasing and when discarding the products. Improperly sorted bioplastics can contaminate recycling streams, contaminate feedstock for composting operations, or end up buried in a landfill. Inconsistent rates of decomposition from product to product can impede commercial composting operations.

Compostable Plastic: Plastic that undergoes degradation by biological processes during composting to yield CO2, water, inorganic compounds, and biomass at a rate consistent with other known compostable materials and that leaves no visible, distinguishable, or toxic residue.[3]

[1] Rhodes Yepsen, "U.S. Residential Food Waste Collection And Composting," BioCycle 50, no. 12 (2009): 39.
[2] American Chemistry Council, "Life Cycle of a Plastic Product," http://www.americanchemistry.com/s_plastics/doc.asp?CID=1571&DID=5972 (accessed March 30, 2011).
[3] ASTM Standard D6400, 2004, "Standard Specification for Compostable Plastics," ASTM International, West Conshohocken, PA, 2004, DOI: 10.1520/D6400-04, www.astm.org.

Bioplastics comprise less than 1% of the plastics in use today,[4] but the plastics industry's desire to reduce its reliance on fossil fuel, combined with consumers' increasing demand for environmentally benign disposable products are predicted to spark explosive growth in bioplastics production. The growth in bioplastics demand is expected to increase by 35-40% annually between 2009 and 2013.[5] As the bioplastics and compostable plastics industry rapidly expands, all players involved in their life cycle need to be in conversation if this industry is going to meet its potential for greater sustainability.

DEFINING BIOPLASTICS AND COMPOSTABLE PLASTICS

The word bioplastics can cause confusion because it holds two meanings. Bioplastics can refer to the following:

1. "Where the material comes from": A plastic made from a biobased origin such as corn, sugar, or starch, as opposed to a fossil-based carbon source. Biobased plastics are also called "plant-derived" or products that are derived from "new carbon" or "organic carbon," or "renewable carbon."

2. "Where the material goes after use": A plastic that biodegrades in some time frame that is relevant, meaning it will decompose in closer to a year than 1,000 years, which is a normal rate for fossil fuel-based plastics.

Did you know? The first plastic ever made was a bioplastic called Parkesine that was invented in the mid 19th century and was made from cellulose.[6]

There is a common misconception that the terms biobased and biodegradable are interchangeable. Not all biobased plastics will biodegrade. Many biobased products are designed to behave like traditional petroleum-based plastic, and remain structurally intact for hundreds of years. As the mainstream plastics industry faces higher petroleum feedstock pricing, extreme price volatility, and increased demands to provide plastics offering a lower environmental burden, industry players are developing and offering biobased versions of their current products (e.g. Polyethylene/PE and Polyethylene terephthalate/PET). These materials are chemically identical to the existing petroleum-based products (i.e, the same molecule is being produced), with the only difference being that the building blocks, or monomers, from which the polymer is manufactured are shifting to biobased origin. Notable examples most recently include Coca Cola's bio-PET (partially biobased), and Braskem's fully biobased polyethylene (PE). These materials meet definition # 1 above.

[4] European Bioplastics, "Bioplastics at a Glance," http://www.european-bioplastics.org/index.php?id=182 (accessed March 30, 2011).
[5] Melissa Hockstad, "Bioplastics Find Fertile Ground for Growth," Trade and Industry Development, http://www.tradeandindustrydev.com/industry/plastics/bioplastics-find-fertile-ground-growth-4526 (accessed March 30, 2011).
[6] American Chemistry Council, "The History of Plastic," http://www.americanchemistry.com/s_plastics/doc.asp?CID=1102&DID=4665 (accessed April 5, 2011).

Another common misconception is that all petroleum-based plastics remain structurally intact for hundreds of years. Some petroleum-based plastics can compost. For example, the chemical company BASF's product Ecoflex is manufactured from petroleum feedstock and is readily compostable, but not biobased[7]. It is important to note that plastics can also be created by blending biobased raw materials with petroleum-based raw materials, so a plastic can be partially biobased. To summarize, plastics are created from three common sources of raw material:

1. Petroleum-based resources (oil and natural gas)
2. Biobased resources (plants)
3. Blending of petroleum-based and biobased resources (i.e. a 50% biobased product)

The raw material from which a plastic is created does not dictate if a plastic will biodegrade or compost. Figure 1 provides a grid depicting beginning of life plastic content and end-of-life characteristics for a variety of existing plastic types listed mainly by acronym. It shows end of life characteristics do not depend on the amount biobased content used to create a product.

		"Where it Goes" End of Life	
"Where it Comes From" Beginning of Life		Neither Biodegradable nor Compostable	Biodegradable / Compostable
	Hi Biobased Content	•PA 11 •Bio-PE	•Ingeo •Mirel •TPS
	Some BioBased Content	•Bio PTT, bio PET •PA 6,10 •Conventional Plastic / /Bioplastic Blends	•AAC/Starch Blends •AAC/Ingeo Blends
	Fossil Based	•Conventional Plastics •PE, PP, PS, PET, ABS, PC, PVC	•AAC/Aliphatic – Aromatic copolyester •PBS

FIGURE 1. PLASTICS DIVERSITY (SOURCE: SPI BIOPLASTICS COUNCIL)

With biobased plastics being designed to exhibit a tremendous range of characteristics similar to that of petroleum-based plastics, and some being created from blending petroleum and biobased material, the distinction between bioplastics and conventional petroleum-based plastics is becoming blurred[8].

[7] Ramani Narayan, "The Science behind Compostable Plastics and the ASTM Standards," Lecture, 2011 US Composting Council Conference, Santa Clara, CA, January 26, 2011.
[8] Steve Davies, "Overview and context, types of materials (compostable vs biodegradable vs recyclable)," Lecture, 2011 US Composting Council Conference, Santa Clara, CA, January 26, 2011.

COMPOSTABLE PLASTICS

As bioplastics and compostable plastics increase in the marketplace, effective end-of-life management has become increasingly important. Bioplastics designed to be recycled need to be segregated for processing, and bioplastics designed to biodegrade in certain environments need to be delivered to the appropriate environments, such as composting facilities. End-of-life management is the arena where composters need to be involved in the stakeholder discussions in order to identify methods to make the system work for their individual operations. Of particular concern for commercial composters is whether the materials they take into their facilities will compost in an appropriate timeframe.

All organic matter will eventually biodegrade. This includes petroleum products and derivatives such as plastic products. However, the rate of biodegradation of different organic materials can vary on an exponential scale. Therefore, the term biodegradable is essentially meaningless without being tied to a specific timeframe and environment.

Biodegradation: The degradation of material from naturally occurring microorganisms over a period of time.[9]

Without further description based on time and environment, the term biodegradable does not distinguish between a product that biodegrades in the soil in a thousand years, and one that biodegrades in a compost pile in 180 days. By refining the definition of biodegradable with environmental conditions, and timeframes, we can create a useful tool for understanding how a product will perform in different end-of-life scenarios.

Degradation: A deleterious change in the chemical structure, physical properties, or appearance of a plastic.[10]

A plastic product designed to biodegrade does not necessarily compost. Plastics are designed to biodegrade in specific environments, including a marine environment, sunlight, soil, and some are intended to be properly managed at an industrial compost facility.

A compostable plastic is defined by the standards association ASTM International (ASTM) as "a plastic that undergoes degradation by biological processes during composting to yield carbon dioxide (CO_2), water, inorganic compounds, and biomass at a rate consistent with other known compostable materials and that leaves no visible, distinguishable, or toxic residue."

According to the Federal Trade Commission (FTC), a biodegradable product is one that in its entirety will "*completely break down and return to nature, i.e., decompose into elements found in nature within a reasonably short period of time (one year)*[11] *after customary disposal"*.[12]

[9] ASTM D6400.

[10] ASTM Standard D833, 2008, "Standard Terminology Relating to Plastics," ASTM International, West Conshohocken, PA, 2008, DOI: 10.1520/D0883-08, www.astm.org.

[11] Federal Trade Commission, "Proposed Revisions to Green Guides: Summary of Proposal," (Washington, DC: October 10, 2010), http://www.ftc.gov/os/2010/10/101006greenguidesproposal.pdf (accessed March 30, 2011).

The ASTM defines biodegradable plastic as "*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.*"[13]

While helpful in terms of labeling for product content, these simple definitions do not offer any guidance for composting. The ambiguity surrounding the term biodegradability is why California law prohibits the use of the term biodegradable or degradable on any bag, cup or food service ware container and only permits the use of the term compostable on such containers if the containers meet a certain standard designed by the ASTM called the ASTM D6400 standard, which is further described below.

STANDARDS FOR BIODEGRADABILITY AND COMPOSTABILITY

ASTM and other organizations have developed specific tests that can help with disposal guidance by establishing whether bioplastics will biodegrade in certain environments. The ASTM certification method entails first setting standard test methods that detail how a test should be performed on a particular product. Then the ASTM sets a standard benchmark as a pass/fail point to be met using the related test method. A laboratory must follow ASTM test methods to determine if a product meets the ASTM Standard.

There are currently twenty-three active standards for testing the biodegradability or biobased content of plastics listed on the ASTM website. For identification purposes, these test methods and pass/fail standards are assigned numbers. Some key test methods and standards that relate to compostability are listed below.

- **D5338**: A standard for testing how products will biodegrade in a composting facility. This standard does not provide a pass/fail specification, but instead defines the test method to do so. For the equivalent pass/fail, see the D6400 standard specification.

- **D6400**: A set of three tests, including D5338, that must meet pass/fail criteria for the compostability of a plastic in an industrial composting facility. A product that passes this standard specification can claim to be compostable.

- **D7081**: A pass/fail standard for the compostability of a plastic in a marine environment, such as the ocean. A product that passes this specification can claim to be "biodegradable in marine waters and sediments."

[12] 16 CFR 260.7b (1998).
[13] ASTM D883.

Table 1 provides examples of the different ASTM bioplastics biodegradation standards by environment. Industry professionals, such as commercial composters, often use these test results in order to identify biodegradable products that they can accept at their facilities.[14]

Table 1 - ASTM Standards for Biodegradation[15]

Environment	*Standard Test Method*	*Biodegradation Standard Specification*	*Can Plastics Claim Biodegradation with Standard?*
Industrial Compost	D5338	D6400	Yes
Marine	D6691	D7081	Yes
Home Compost	None	None	No
Anaerobic Digestion	D5511	None	No
Active Landfill	In Development	None	No

ASTM D6400 Standard Specification outlined

D6400 has three basic provisions that govern how a product must perform in a simulated compost environment:

1. First, the product must physically disintegrate to the extent that it cannot be "readily distinguishable" from the finished compost product.
2. Second, the product must actually biodegrade (be consumed by microorganisms) at a rate comparable to known compostable materials.
3. Finally, the product cannot have adverse impacts on the ability of the compost to support plant growth.

The full D6400 standard specification contains expanded and detailed requirements for each of these three basic provisions. All of these detailed requirements must be met in order for the product to pass and each test requires following an ASTM standard test method. For example, D5338 is the standard test method required for the 2nd provision above.

[14] Interview by Scott Smithline, Californians Against Waste.
[15] Davies, "Overview and context, types of materials (compostable vs biodegradable vs recyclable)."

IDENTIFYING COMPOSTABLE BIOPLASTICS

In order to label a product as ASTM D6400 compliant, a product manufacturer must have the product tested by a laboratory that follows proper ASTM test methods. The Biodegradable Products Institute (BPI) is an active trade association that provides independent third party verification to ensure that a product has been tested by a laboratory that uses proper ASTM methods and has met the pass/fail criteria for the 3 tests of D6400. BPI created a label to help identify products that they have verified meet the ASTM D6400 standard specification. The BPI Compostable label shown in Figure 2 is widely recognized throughout the industry as representing that a product passes D6400. In California, plastic bags and food packaging items (including utensils) labeled as compostable are required to demonstrate compliance with D6400.[16] In addition, starting in July of 2011, compostable plastic bags in California will be required to meet explicit labeling requirements, as per California Code 42357.5.[17]

FIGURE 2. BIODEGRDABLE PRODUCTS INSTITUTE'S COMPOSTABLE LABEL

BIOBASED PLASTICS

Biobased: A product that is composed of biological products or renewable domestic agricultural or forestry materials.[18]

The term "biobased" refers to the source, or origin of the organic carbon content of consumer products and industrial input materials. It is most commonly used to indicate if products are made from biomass-derived carbon sources, such as plants, instead of petroleum sources that are formed over geologic timeframes (fossil carbon). The significance is that once we use carbon, much of it is released back into the atmosphere again as CO_2. Use of fossil sources of carbon creates a net increase in atmospheric CO_2, whereas the use of biobased carbon provides the opportunity to reduce the amount of additional anthropogenic CO_2 that is released into the atmosphere. In addition, biobased products can be produced from renewable sources compared to the inherently limited quantity of fossil fuels.

[16] California, *California Public Resource Code*, § 42355.
[17] California, *California Public Resource Code*, § 42357.5.
[18] United States. *Farm Security and Rural Investment Act*, *U.S. Code,* vol. 9, sec. 9002 (2002).

As mentioned previously, whether or not a product is biobased is not an independent indicator of whether it is biodegradable. While the two terms are somewhat related, biobased content is no guarantee of biodegradability.

There are no universal standards for the use of the term biobased. Therefore, the term does not guarantee any minimum amount of biobased material used to create a product. Products marketed as "biobased" may be nearly 100% biobased, or they may contain only token amounts of biomass-derived materials. However, when it is used in a scientific capacity, biobased is a technical assessment of the quantity of biobased material in a product and can be expressed as an exact amount by percentage of biobased content.

ASTM D6866 is the industry standard test for measuring the biobased carbon content of bioplastics. The test utilizes radio carbon dating and is able to distinguish between atmospheric carbon recently absorbed by plants, and carbon from fossil sources.[19] The test method first measures the amount of carbon in a product that is biobased, and then it divides that by the total amount of carbon (biomass based and fossil based) in the product. The resulting percentage is the biobased carbon of the product. However, all inorganic product constituents (such as metals, glass and minerals) are explicitly excluded from the ASTM D6866 calculation, and this can lead to confusion.

A biobased advertising claim that specifies a percentage based on ASTM D6866 may not mean what the average consumer thinks it does. For example, if a product is comprised of half plastic and half inorganic materials (glass, metals, water, other minerals), as long as the plastic ingredients are 100% biobased, the entire product will be considered 100% biobased. This may lead a consumer to send the product to a composting facility under the dual misconception that the product is entirely biobased and biobased equates to compostable.

INDENTIFYING BIOBASED PRODUCTS

Without industry standards, biobased products are hard to identify. Currently, the FTC Green Guides only address use of terms regarding "renewable materials." Further, out of deference to the U.S. Department of Agriculture's BioPreferred Program,[20] the FTC does not intend to include guidance on the term biobased in its revised Green Guides.[21]

The USDA BioPreferred Program is a voluntary biobased product labeling program that allows manufacturers to label their products as "USDA Certified Biobased Product." In some cases they will also receive preferred status in federal procurement processes. This program is the most comprehensive labeling program under development regarding the use of the term "biobased."

[19] ASTM Standard D6866, 2010, "Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis," ASTM International, West Conshokocken, PA, 2010, DOI: 10.1520/D6866-10, www.astm.org.

[20] U.S. Department of Agriculture BioPreferred Program, "BioPreferred," http://www.biopreferred.gov/ (accessed March 31, 2011).

[21] Federal Trade Commission, "Proposed Revisions to Green Guides," (Washington, DC: October 10, 2010), http://www.ftc.gov/os/fedreg/2010/october/101006greenguidesfrn.pdf (accessed March 30, 2011).

On the USDA's website, there are currently over 5,000 products registered under the BioPreferred program.

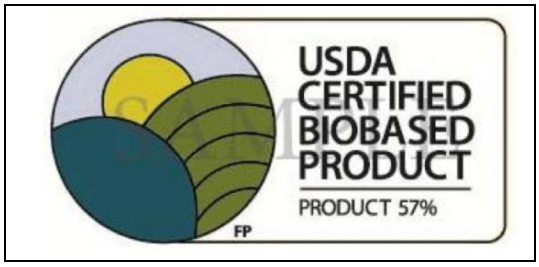

FIGURE 3. USDA CERTIFIED BIOBASED PRODUCT LABEL

Before using the label, manufacturers will have to submit evidence to the USDA that their product meets or exceeds USDA standards for the amount of biobased content for that product category.[22] For items that do not fall within a product category defined by the USDA, there is a minimum standard of 51% biobased content.[23] The USDA will require manufacturers using the label to show the actual biobased percentage of the product, and has proposed using ASTM D6866 as the test method to determine biobased content.[24]

The USDA maintains a searchable BioPreferred catalog. An example of a product found in the catalog is TaterWare 6400 Series Cutlery. This product is listed as having 58% biobased content and is described as being "Made from a GMO and petroleum-free potato starch resin" and being designed to degrade 100% in a commercial composting setting.[25] The catalog does not indicate what the remaining non-biobased 42% of the product is made from.

Another product in the catalog is LC Industries Biobased Flatware, which listed as "50% plant based" and "50% special grade polypropylene." [26] The catalog claims the cutlery will "degrade by 50% under correct composting environments".[27] In this case the product would likely be labeled 50% biobased and would be above the minimum 48% minimum standard for cutlery. To the extent the product contains additional non-organic constituents, the biobased percentage would not be affected. The impact of this biobased labeling cannot be certain, but it seems likely that many of the products with it will be perceived by consumers to be compostable.

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[22] U.S. Department of Agriculture BioPreferred Program, "Product Certification," http://www.biopreferred.gov/Labeling.aspx (accessed March 30, 2011).
[23] U.S. National Archives and Records Administration, Office of the Federal Register, "Voluntary Labeling Program for Biobased Products," *Federal Register* 74, no. 146 (July 31, 2009): 38298.
[24] U.S. National Archives and Records Administration, Office of the Federal Register, "Voluntary Labeling Program for Biobased Products," *Federal Register* 74, no. 146 (July 31, 2009): 38311.
[25] U.S. Department of Agriculture BioPreferred Program, "BioPreferred Catalog Product: TaterWare '6400 Series' Cutlery," http://www.catalog.biopreferred.gov/bioPreferredCatalog/productDetails?ID=37286 (accessed March 30, 2011).
[26] U.S. Department of Agriculture BioPreferred Program, "BioPreferred Catalog Product: Biobased Flatware," http://www.catalog.biopreferred.gov/bioPreferredCatalog/productDetails?ID=13732 (accessed March 30, 2011).
[27] Ibid.

The USDA program illustrates how difficult it is to design labeling programs that provide complete, easily understood product information. According to the FTC proposed Green Guides, a significant number of consumers believe that biobased products are likely to be biodegradable.[28] Unfortunately, the USDA's BioPreferred program may unintentionally mislead consumers and result in commercial composters receiving products not designed to compost.

CONFUSED CONSUMERS AND COMPOSTERS

Consumers believe that bioplastics are better for the environment due to sustainable feedstocks and the potential for reduced manufacturing and production impacts. Another key benefit is the potential to decrease our ecological footprint by creating additional end-of-life management options such as composting and closed loop recycling. In order to realize these benefits, however, product claims and performance must adhere to accepted standards, and consumers must be accurately informed about the proper disposal options of biobased plastic products.

There are well-established scientific methodologies for measuring how much of a product comes from a renewable source and if the product will biodegrade in different environments (i.e. composting facility, ocean, anaerobic digestion facility, etc.) However, there are no uniformly accepted metrics or "pass/fail" standards for the use of these terms as advertising claims in the marketplace. In many cases there is evidence that consumers' common understanding of these terms differs from that of the industry's.[29]

For municipal and institutional consumers, the expansion of organics diversion programs is considered one of the primary benefits associated with the use of compostable plastics. The use of compostable serviceware for events and compostable plastic bags to facilitate collection of food waste make compostable plastics a key resource for program planners to understand.

For many food waste diversion programs that utilize curbside pickups every week, a problem for many residents is how to collect their food wastes from the kitchen, since plastic bags are not allowed the compost bins. In the absence of compostable bags, what results is that many customers use plastic bags and contaminate the compost stream, use paper bags, or they don't compost at all. Studies have shown that the use of compostable bags can increase the amount of food waste diverted.[30]

The potential that large scale programs will drive the need for composting capacity and technology makes it critical to help these stakeholders understand the characteristics and impacts of compostable bioplastics from which they can select. Consumers, especially large scale buyers such as municipalities and institutions need to be educated about the characteristics of the

[28] FTC, "Proposed Revisions to Green Guides," 146.
[29] Ibid.
[30] Dave Douglas, "Utilization of BPI Approved Compostable Bags for the Advancement of Residential Source Separated Organics (Kitchen) Diversion – Canadian Case Studies Experience & Lessons Learned," Lecture, 2011 US Composting Council Conference, Santa Clara, CA, January 26, 2011.

compostable plastics they are interested in using, and to take current limitations related to product standards and identification into consideration. As illustrated in Figure 4, the ability to use labeling as a tool is made more complicated by non-standardized and interchangeable use of terms such as biodegradable, degradable, and compostable, or starch-based, plant based, and made from "renewable" materials.

FIGURE 4. COMPETING TERMINOLOGY "100% COMPOSTABLE BAG," "100% COMPOSTABLE," "100% BIODEGRADABLE;" "BIODEGRADABLE PLASTIC."

The regulation of the use of these terms varies by term, and in some cases by state. The Federal Trade Commission Green Guides address the use of many of these terms. California has prohibited the use of the term biodegradable on plastic bags and food containers because plastics made from biobased sources that are marketed as "biodegradable" generally require being placed in a specific environment to properly biodegrade, and simply saying "biodegradable" may imply the material will break down in a landfill. [31]

In many ways, compostable plastics demand and production are developing faster than the public regulatory agencies that support this industry, creating a disconnect between plastics manufacturers, consumers, regulators and commercial composters. This disconnect has presented stakeholders with no well-established regulatory regime, no commonly accepted lexicon, and significant challenges to overcome in order to bridge the gap between consumer expectations, end-of-life processor needs and product performance in various composting environments Standardization of terminology and enforcement will be important for helping consumers and composters make educated choices about biobased products and interim steps such as onsite testing of materials for compostability at specific sites may be needed to limit the operational impacts of compostable plastics while standardized metrics are being implemented.

[31] California State Legislature, Assembly, "Recycling: plastic and paper carryout bags," AB 1998 (February 17, 2010) http://www.leginfo.ca.gov/pub/09-10/bill/asm/ab_1951-2000/ab_1998_bill_20100217_introduced.html (accessed March 31, 2011).

MEETING THE CHALLENGES

A compostable plastics symposium was held at the 2011 U.S. Composting Council Conference (USCC). A key feature of the day-long symposium was an exercise where small groups of stakeholders in the compostable plastics industry were invited to examine the issues, identify other potential stakeholders, and suggest next steps to address the challenges that were recognized throughout the day's proceedings. The following five key challenges were identified for further discussion by the small groups, and the following sections summarize the discussion notes created during the symposium.

1. Identification/Labeling Challenges
2. Enforcement/Legislation
3. ASTM Standards Need Refining
4. Consumer Education
5. National Organics Program (NOP) Impacts

IDENTIFICATION / LABELING CHALLENGES

In order to biodegrade, biodegradable plastics need to be placed into the end-of-life environment for which they were designed. If placed in the wrong environment, not only is a biodegradable plastic prevented from delivering many of its potential environmental benefits, but it can hinder the efforts of composters or recyclers. Composters and materials processing facilities need easily recognizable labels for appropriate sorting, and consumers need easily recognizable labels for appropriate source separation. Easily identifiable, clearly labeled products can facilitate proper end-of-life management of bioplastics. Consumers are currently overwhelmed with seemingly interchangeable terms and may not manage the product properly at the end of its lifecycle.

The ASTM D6400 standard specification sets a compostability standard for labeling plastics as compostable, with the BPI label providing 3rd party independent certification that products meet this standard. However identification challenges remain. Although ASTM D6400 provides a link between end-of-life processors, such as commercial composters, and the bioplastics brand owners who dictate how products are labeled, more formal communication between these two stakeholders is needed to resolve the product identification and labeling issue. Groups such as the Biodegradable Products Institute, SPI Bioplastics Council, Sustainable Packaging Coalition, and Sustainable Plastics Initiative can help facilitate communications.

The challenge for labeling is to allow consumers, collectors and processors (composters and recyclers) to be able to easily and readily identify compostable from non-compostable plastics. USCC workgroup cautioned that whatever requirements evolve from the discussion should be cost effective from the producer side because municipalities don't want to impede business. Brand owners need to be involved in the planning of labeling and identification standard setting Municipalities can't afford to have their composting streams not be accepted at facilities.

ENFORCEMENT/LEGISLATION

In order to satisfy consumers' demand for a more environmentally responsible plastic, brand owners are labeling their products as either compostable, biodegradable, or biobased. As mentioned previously, there is currently no enforcement or legislation at the federal level that requires such a label to be properly substantiated, or backed up by scientific tests. The Federal Trade Commission's Green Guides are an administrative interpretation of the law which specify guidelines for the use of environmental marketing, but they are not independently enforceable. However, the FTC may prosecute under Section 5 of the FTC Act, which prohibits unfair and deceptive practices, using the Green Guides as a basis for their case.[32] From the Green Guides' inception in 1992, the FTC has generally only taken legal action on one or two companies each year that are violating the guidelines.[33]

On the state level, California's Public Resources Codes (CPRC) Section 42359-42359.8 states that environmental marketing claims, such as compostability, are required to be substantiated by competent and reliable evidence. The CPRC identifies the ASTM standards as a method of providing such evidence to the public. Manufacturers are required to present documentation upon request by any member of the public that proves their compliance, in a form that is easy to understand and scientifically accurate.[34] The California Attorney General provides enforcement for a variety of consumer protection programs, and misleading labeling can be challenged as false advertisement[35] with violations resulting in fines of up to $2,000 per violation.[36]

Next steps identified at the USCC Conference included working with stakeholder organizations in California to support the existing legislation, and investigating the expansion of the California Public Resources Code to other states. The groups also mentioned increasing public education about labeling and standards on a national level, and coordinating and consolidating reporting of labeling violators as actions to investigate. Organizations to work with include the FTC, the National Advertising Department, the U.S. Environmental Protection Agency, BPI (for national forum), and CalRecycle.

ASTM STANDARDS NEED REFINING

The viability of compostable plastics in the marketplace depends in large part on their performance at commercial compost facilities. Yet there are still many unanswered questions regarding the ability of compostable plastics to biodegrade at composting facilities, as well as potential impacts they may have on the marketability of the compost product.

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[32] Federal Trade Commission, "Reporter Resources: The FTC's Green Guides," http://www.ftc.gov/opa/reporter/greengds.shtm (accessed March 30, 2011).
[33] Traci Watson, "'Green' claims by marketers go unchecked," *USA Today*, June 24, 2009, Washington section, News section.
[34] California, California Public Resource Code, § 42355.
[35] California Department of Consumer Affairs, "Consumer Resources and Referral Guide," http://www.dca.ca.gov/publications/guide/comptable/cmpltba.shtml (accessed March 16, 2011).
[36] California, California Public Resource Code, § 42358a.

While D6400 is currently the most recognized standard for determining compostability, there is growing concern that D6400 certification is not an adequate indicator for whether a product will compost at potentially diverse commercial compost facilities. At the heart of this concern is the 180 day timeframe specified for biodegradation. Many commercial compost facilities are completing their process in well under that time. In fact, of the composters interviewed for this project, none reported a process longer than 120 days—and most were under 100 days.[37] This inconsistency between operational trends in the industry and the ASTM standard must be addressed to maintain relevancy of the standard for composting operations.

As an example of a possible solution, this standard could be enhanced by creating multiple test methods, to test biodegradability that would be based on different operating conditions common to commercial composting facilities.

CONSUMER EDUCATION

Consumers without a basic knowledge of composting and the difference between biobased and biodegradable are unlikely to properly manage bioplastic products. A consumer may send a bottle labeled as "biobased" to a compost facility, place the bottle in a regular recycling bin, send it to a landfill, or even toss it on the ground believing it will decompose like the corn or potato from which it was made.

Consumer education on bioplastics should start with explaining the basics, such as the difference between biobased and biodegradable. Most consumers are not familiar with composting so consumer education should start with composting basics, and be aligned with well-respected non-governmental organizations such as USCC, National Research Council, and Sustainable Packaging Coalition to support packaging details. Then collaborative efforts should tackle education from a broader standpoint and plan the best method to educate the general public.

NOP IMPACTS

The U.S. Department of Agriculture National Organics Program (NOP) was created to ensure the credibility of the USDA Organics label by setting rules and regulations concerning the certification of organic products.[38] One rule requires compost feedstock to be free of non NOP-authorized synthetics in order to be classified as organic. However, third-party certifiers of compost as an organic input are debating whether or not compostable plastics are acceptable synthetic substances. Despite no definite ruling from the NOP, some compost certifiers are determining that compost from facilities that accept compostable plastics does not meet USDA organic standards.[39] To further complicate the organics certification issue, the Canadian Organics program and the European Organics program both accept biodegradable plastic

[37] Interviews by Scott Smithline, Californians Against Waste.
[38] U.S. Department of Agriculture, "Agricultural Marketing Service – NOP: Who We Are," http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateA&navID=NationalOrganicProgram&leftNav=NationalOrganicProgram&page=NOPNationalOrganicProgramHome&acct=AMSPW (accessed March 16, 2011).
[39] Dan Sullivan, "Compostable Plastics and Organic Farming," *BioCycle* 52, no. 3 (2011): 25.

products in their feedstock. Both of these programs have an equivalency agreement with the US, meaning organic products from Europe and Canada may be sold in the US, and vice versa.[40]

At the heart of the debate is whether or not the processes used to create compostable plastics cause them to be classified as unacceptable synthetics. If the NOP decides these processes disqualify bioplastics as a feedstock for organic certified compost, commercial composters who produce organically certified material will need to either invent a means to economically remove bioplastics from feedstock, or refuse any source of material that includes bioplastics.

Currently, there is a coalition of composting plastics industry stakeholders who are developing a strategy to engage the NOP in order to classify plastics that meet ASTM D6400 (those which compost readily in a commercial setting) as an allowable synthetic. While the process for petitioning the NOP for inclusion on their list of allowable synthetics is fairly straightforward, a significant amount of information is needed and the petition handling by NOP staff can be lengthy – often two to three years.[41] There is reasonable cause for concern that a ruling by the NOP may not result in a desirable outcome.

Next Steps

Compostable plastics are being introduced into the waste stream at a rapid rate. Many composters may already be receiving small amounts of compostable plastic without a specific collection program, even if they don't accept food scraps. The number of residential green material composting programs that allow residents to add food scraps to yard trimmings collection is also on the rise in California. Sooner or later most large scale composting facilities will likely be asked to accept food scraps, and with it an indeterminate amount of compostable plastics.

This illustrates the urgency for the composting and compostable plastics industry to address challenges such as labeling, consumer education, enforcement, and better standards, as well as potential impacts from the NOP.

Next steps have included and will include the following:

- Presentations and audio recordings from the USCC Compostable Plastics Symposium have been posted on the USCC website
- Symposium action items have been taken to USCC Board
- Development and posting of this Resource Paper you are reading
- Hold Compostable Plastics Roundtable at the BioCycle 2011 Conference to continue work started at the USCC Compostable Plastics Symposium

[40] Ibid.
[41] NatureWorks, "NatureWorks Presentation," Lecture, April 15, 2010.

PREDOMINANT BIOPLASTIC RESINS:

Biobased plastics are an extremely diverse group of plastics, exhibiting a tremendous range of characteristics similar to that of petroleum-based plastics. With very few petroleum-based plastic products meeting ASTM D6400, biobased resins dominate the compostable plastic market.

There is no single classification system or methodology for characterizing biobased plastics. Depending on the inquiry, biobased resins can be grouped according to similarities in production feedstock, production processes, polymer performance characteristics, or end of life management options.

This section is designed to provide a brief summary of the predominant types of biobased plastics that are actively being marketed by product manufacturers as compostable. The categories below are representative of the different types of bio-based plastics based primarily on production feedstock and production processes. In some cases a particular type of resin is dominated by one manufacturer. In others, there may be multiple manufacturers manufacturing in each category. The examples are provided for illustration purposes only.

It is important to note that each manufacturer may make dozens of different variations, or grades of each resin type, catering to different end users and applications. For example, a manufacturer may have one resin line for thermoforming, one for injection molding, and yet another for sheet extrusion. In addition, resin lines may change depending on whether the final product requires food compatibility, compostability, etc. It is common practice for all of these types of biobased plastics to be blended with colorants, petroleum-based plastics or plastic additives, or other biobased plastics or plastic additives.

POLYLACTIC ACID

Polylactic Acid, or PLA, is probably the most commonly recognized bioplastic. The primary manufacturer of PLA is Natureworks, LLC. NatureWorks is a wholly owned subsidiary of Cargill and markets their PLA under the brand name Ingeo. Natureworks facility in Blair Nebraska has capacity to produce 300 million pounds of Ingeo resins per year[42]. Ingeo products are among the most prevalent in the compostable plastic marketplace.

Ingeo is derived in a two step process that starts with fermenting the dextrose derived from a simple hydrolysis of corn starch. The product of the dextrose fermentation, lactic acid, is the basic building block of the Ingeo polylactide family of plastics. Lactic acid is further treated to create an intermediary monomer product called lactide, which is then polymerized through a process called ring opening polymerization to form Ingeo.

Examples of Ingeo Products as shown in Figure 5 include WorldCentric products, such as their cold cup, cutlery and Frito Lay's compostable SunChips bag).

[42] Ibid.

FIGURE 5. EXAMPLES OF PLA/INGEO PRODUCTS: WORLDCENTRIC CUP, WORLDCENTRIC CUTLERY, SUNCHIPS BAG

POLYHYDROXY FATTY ACIDS (POLYHYDROXYALKANOATES, OR PHA)

Polyhydroxy fatty acids are the basis of a bioplastic made from the anaerobic digestion of starch. The predominant manufacturer of PHA at this time is Tellus, which is a joint venture between Archer Daniels Midland Company and Metabolix. Tellus currently has capacity to produce 110 million pounds per year of Mirel at their plant in Clinton, Iowa. A second similar plant is currently under development. Tellus markets their product under the brand name Mirel. Much like NatureWorks PLA, Mirel is currently produced from corn derived starch.

However, in the case of Mirel, the corn sugars are fed into commercial fermentation systems where a proprietary strain of microbes digest the sugar and produce Polyhydroxyalkanoates, or PHA. PHA is an intracellular byproduct of the bacteria, meaning the bacteria actually create the plastic within their cells. The PHA is then harvested through the destruction of the bacteria and is separated from the microbial cell matter and formulated into Mirel resin.

Mirel is currently available for a number of end-uses including food related and agricultural compostable plastic products. Mirel is unique in the marketplace because in addition to being compostable, in some instance Mirel can also pass ASTM D7081 which is the standard specification for marine degradability.

Examples of Mirel Products shown in Figure 6 include BioTuf compostable bags Target gift and SoilWrap compostable potting containers

FIGURE 6. EXAMPLES OF MIREL/PHA PRODUCTS: BIOTUF BAGS, TARGET GIFT CARDS, SOILWRAP CONTAINER

THERMOPLASTIC (COMPLEXED) STARCH:

The third major group of biobased compostable plastics is called thermoplastics. These plastics are derived from blending processed starch from a number of plant based products such as corn, with other plastics (biobased and/or petroleum-based). One of the largest thermoplastic starch producers is Novamont. Novamont's biopolymer is sold under the name Mater-Bi. Mater-Bi has been on the market in one form or another for almost 20 years.

Much like PLA, or PHA, thermoplastic begins its life as starch. But instead of fermenting the starch, thermoplastics take advantage of starch plastic like polymer nature. The starch is first heated to destroy, or open up its inherently weak polymer structure. Then the starch is blended with complexing agents which are other polymers that reform with the starch creating a stronger biobased plastic.[43]

Examples of Thermoplastic/Mater-Bi Products as shown in Figure 7 include BioBags, Lecce Pens, and Bioware cutlery.

FIGURE 7. EXAMPLES OF MATER-BI PRODUCTS: BIOBAG, LECCE PEN, BIOWARE CUTLERY

[43] Catia Bastioli, *Handbook of Biodegradable Polymers* (Billingham: Smithers Rapra Press, 2005), 268.

RESOURCE LIST:

Cedar Grove Test Results: http://www.cedar-grove.com/acceptable/Accepted%20List.asp

> Cedar Grove operates several composting facilities in Washington. In order to determine which types of bioplastics will compost in their facility, Cedar Grove requires each product to go through a compostability test. The results of these tests determine which products they will accept into their feedstock.

San Diego Test Results: http://www.jgpress.com/archives/_free/002141.html

> San Diego has conducted their own compostability tests to determine which types of bioplastics will compost in their facilities. However, these tests are not as thorough as the ones at Cedar Grove. The tests were done to give facility operators a general idea of what types of plastics they could accept.

Manufacturers of Bioplastics:

- Ingeo: http://www.natureworksllc.com/
- Mirel: http://www.mirelplastics.com/
- Mater-Bi: http://www.novamont.com/default.asp?id=504

Associations:

- US Composting Council: http://www.compostingcouncil.org/
- SPI Bioplastics Council: http://www.plasticsindustry.org/BPC/
- Biodegradable Products Institute: http://www.bpiworld.org/
- European Bioplastics: http://www.european-bioplastics.org/

ASTM Standards: http://www.astm.org/

Legislation:

- State of California
  - Plastic bag labeling: http://codes.lp.findlaw.com/cacode/PRC/1/d30/3/5.7/s42355
  - Misleading advertising: http://codes.lp.findlaw.com/cacode/BPC/1/d7/3/1/1/s17508
- Federal
  - FTC Green Guides: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=7f009d682600cd3c94b95d8805038628;rgn=div8;view=text;node=16:1.0.1.2.24.0.5.7;idno=16;cc=ecfr

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