BIODEGRADABLE PLASTICS

background for discussion: *Is there a role for Biodegradable Plastics in Agriculture?*

Lois Levitan, January 2014

Biodegradation. Biodegradation happens when bacteria, fungi or other microorganisms consume microscopic energy-containing fragments of materials. Biodegradation is happening when wood rots, food scraps decompose, and biodegradable plastics fall apart and disappear. When biodegradation occurs in the open air or in a well-managed compost pile with plenty of oxygen[1], the carbon that is "eaten" oxidizes to carbon dioxide (CO_2). Where oxygen is scarce, as in a landfill, both CO_2 and methane (CH_4) are produced.

The *biodegradability* of a material is assessed by measuring the fraction of total carbon that is consumed by microorganisms within some set period of time. There is a growing consensus that 90% biodegradation is a threshold indicator that a material is completely biodegradable. [2]

Degradation. Materials also degrade to varying extents when they are exposed to heat, light, moisture, or chemicals–processes called thermolysis, photolysis, hydrolysis, and polymer degradation. These degradation processes are not biodegradation but they also break long-chain molecules into smaller pieces that may eventually be consumed by microorganisms.

The rate of degradation by any of these processes differs depending on temperature and moisture as well as on exposure to sunshine, oxygen, and chemicals. For example, an organic material that is compostable in a temperature- and moisture-controlled industrial composting facility is likely to languish longer in a backyard compost pile or if simply left behind on a strawberry field. The reality that degradation rates are variable provokes confusion, controversy and (charges of) 'green washing'.

Bio-plastics. Bio-plastics (also called *bio-based plastics*) do not necessarily have biodegradable properties. They are simply plastics made from renewable materials—including orange peels, switchgrass, bacterial exudates, manure, corn, tapioca and sugar cane—rather than from petrochemicals (fossil fuels). Many of the first plastics on the market were bio-plastics, including celluloid made from cellulose and buttons made from milk casein. With higher petrochemical prices, there has been renewed interest in using bio-based feedstocks to make conventional plastic resins as well as to develop biodegradable resins. But no matter whether conventional resins such as LDPE are made from biological or petrochemical sources, they are chemically identical and have the same usability and recyclability characteristics. In other words, bio-based polyethylenes do not degrade more rapidly than those made from petrochemicals.

PLA and PHA resins. However, lots of effort is going into research, development and commercialization of bio-plastic resins that are claimed to biodegrade or compost. Best known in this category are the polyester PLA (polylactic acid), which is made by fermenting raw materials such as corn to produce lactic acid, and PHA[3], a polyhydroxyalkanoate biopolymer.

Agricultural plastic products made in part or entirely from PLA or PHA resins include Novamont's Mater-Bi® mulch film made from corn starch[4], BASF's Ecoflex® and its derivative Ecovio® (45% PLA)[5], and Metabolix® biopolymer Mvera films[6].

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[1] When oxygen is available the conditions are called 'aerobic'; oxygen-poor conditions are called 'anaerobic'.

[2] Information about the 90% standard is from the Biodegradable Products Institute's position paper *BPI Position on Degradable Additives*, 2010. http://www.bpiworld.org/BPI_Position_on_Degradable_Additives.

[3] Basics of PHA. *Bioplastics Magazine*. March 2011. Hans-Josef Endres Andrea Siebert-Raths. 6(5):43-45. <Bioplastics_Magazine_03_11_Vol.6_S._43-45>.

[4] www.materbiagro.com/ing/materbi.html, http://www.novamont.com/default.asp?id=1798

[5] www.bioplastics.basf.com/ecoflex.html

[6] http://www.metabolix.com/Products/Biopolymers/Biopolymer-Films-Resin-Bags

Additives to conventional resins. Other purportedly biodegradable plastics are made by mixing an additive that catalyzes biodegradability with a batch of conventional plastic resin. Two types of additives are used: *oxo-additives* and *organic material additives*.[7]

A number of companies are producing **oxo-additives**; at least two are promoting their use in agricultural films: EcoPoly Solutions[8] and Symphony Environmental[9]. The Biodegradable Products Institute describes the oxo-additives as consisting of transition metals (such as cobalt, manganese, magnesium, iron and zinc) that "theoretically foster oxidation and chain scission in plastics when exposed to heat, air and/or light." The chain scission is intended to shorten long polymer chains to the point that the pieces are small enough to be consumed by microorganisms. BPI reports that hot, sunny, arid conditions promote breakdown of polymer chains, while moisture appears to retard oxidation, delaying onset of potential biodegradation.

BPI also reports that there is a lack of data to show that plastics with oxo-additives degrade in the anaerobic environment of landfills as claimed by some product manufacturers. However, BPI also notes that if any type of degradable plastics were to degrade under the anaerobic conditions of a landfill, they could generate fugitive emissions of methane, a greenhouse gas 25 times as potent as carbon dioxide. Thus BPI argues against landfilling any degradable plastic.

With **organic material additives**, a portion of the additive itself biodegrades, generating carbon dioxide or methane. The biodegradable portion is either natural material such as cellulose or starch or resins such as EVA or PVOH that biodegrade. BPI argues that no data show that the remaining 95-99% of the plastic will also biodegrade. Companies using various approaches to this technology include ECM BioFilms, BioBatch, and Green Films.[10]

The biodegradable additives to conventional resins have created a great deal of controversy in recycling circles, primarily out of concern that the purportedly biodegradable plastics are indistinguishable from products made from the same primary resin but without the additives. Thus they cannot be separated out in the recycling stream. The worry is that by recycling the biodegradable plastics into new durable products, the longevity and utility of the new products may be dangerously compromised.

Discussion questions. While there may be compelling reasons to be jubilant about plastics that will 'disappear' after being used in agricultural fields, questions such as the following raise issues about if, where and when use of biodegradables would be a 'best management practice':

- Are the biodegradable products as effective as non-biodegradable plastics in doing what they are supposed to do (*e.g.,* warm soil or reduce weed pressure without tearing)?
- Do the products biodegrade at the promised rate under all relevant conditions/circumstances?
- Is the degradation timeframe appropriate for the intended use? (*e.g.,* before next planting)
- Are biodegradable plastics appropriate for some agricultural plastic products but not others?
- What are comparative costs for the end user, considering both the purchase price and production-cycle costs?
- Are there environmental/health concerns about the breakdown products? (*e.g.,* the metals used in the oxo-additives and plastic fragments that remain)
- What happens when biodegradable products get mixed into the recycling stream?
- What about comparative environmental life-cycle costs? (*e.g.,* collecting and processing for recycling vs. energy and resource costs of a one-time use)

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[7] Some information about oxo-additive and all information about organic material additives is from the Biodegradable Products Institute's 2010 position paper *BPI Position on Degradable Additives*.

[8] http://www.ecopolysolutions.com/biodegradable_plastics/agriculture.aspx

[9] http://www.symphonyenvironmental.com/degradable/products/agricultural-film/

[10] http://www.ecmbiofilms.com/, http://www.beggandco.com/biobatch.php,
Green Films (from crustacean shells): www.maverickent.net/page4_S8GQ.html.