The SPC Position against Biodegradability Additives for Petroleum-Based Plastics

The Sustainable Packaging Coalition's position against currently available additives intended to result in biodegradation of petroleum-based plastics

Introduction:

The Sustainable Packaging Coalition (SPC) takes a material neutral, lifecycle-oriented approach to packaging sustainability with a goal of enabling and encouraging a more sustainable economy for all materials. Central to this approach is the idea that packaging materials must be benign at their end-of-life and also recoverable as feedstock for new product. Achieving those outcomes requires an understanding of package design and the usefulness of novel technologies. To this end, the SPC has evaluated the use of biodegradability additives for conventional petroleum-based plastics. The SPC found that these additives do not offer any sustainability advantage and they may actually result in more environmental harm. It is the conclusion of the SPC that these additives should not be used, and the SPC takes a formal position against biodegradability additives for conventional petroleum-based plastics.

Current Inability to Enable Compostability:

Though the characteristics of biodegradability suggests that nutrients will beneficially return to the environment at the material's end of life, compostability is the superior and preferred indicator of a material's ability to result in nutrient renewal and reuse. Compostability is a material's ability to successfully undergo a managed process that controls biological decomposition and transformation into a stabilized organic matter within a specified period of time.[1] The characteristic of biodegradability in itself does not mean that the material will break down in a reasonably useful amount of time, nor that it will result in any soil-enriching bio-material. To beneficially complete the natural biological cycle, biodegradation should occur in a managed and controlled environment, such as an industrial composting operation, and the material must biodegrade in a manner that is non-toxic and harmless to human health and the environment in order to be considered compostable. Petroleum-based plastics made with the currently available biodegradability additives do not break down in such a manner; to date, these additives have not enabled any plastics to become fully compostable.

There is much work remaining to generate the understanding that compostability is the true indicator of environmentally beneficial biodegradation. Marketing any non-compostable material to consumers as being beneficial due to its biodegradability may be misleading and detrimental to efforts intended to advance compostable packaging.

1 ASTM D6002-96, Standard Guide For Assessing The Compostability Of Environmentally Degradable Plastics, ASTM International, West Conshohocken, PA, 1996, www.astm.org

Potential Negative Impacts on Recyclability:

It is important that we maximize the opportunity for the most beneficial end-of-life scenarios for petroleum-based plastics because petroleum extraction and manufacturing processes carry significant environmental investments. Petroleum-based plastics have two inherent attributes that make them ideal for recovery: their high embodied energy content qualifies their value for controlled energy recovery, and their exceptional durability renders them ideal for recycling.

Biodegradability additives, by design, are intended to compromise that exceptional durability. Although additive manufacturers claim no unwanted effects on the material's recyclability, satisfactory evidence does not exist. The SPC supports the position statements of the Association of Postconsumer Plastics Recyclers (APR)[2] and the National Association for PET Container Resources (NAPCOR)[3], and advises manufacturers of biodegradability additives to submit to APR's testing standards before claiming any absence of adverse effects on recyclability. The SPC questions the concept of using additives that are fundamentally designed to compromise the structural integrity of a recyclable material, although a peer-reviewed test proving the benign nature of biodegradability additives on the recycling processes would be welcomed.

Release of Unwanted Greenhouse Gas Emissions:

When organic materials undergo biodegradation,[4] their carbon content is chemically transformed to one or more greenhouse gases.[5] The principal type of greenhouse gas depends on the conditions in which the material biodegrades. If abundant oxygen is present, the material biodegrades aerobically and generates primarily carbon dioxide, whereas in an oxygen deficient environment, biodegradation occurs anaerobically and the principal gas generated is methane. Different additives are engineered to cause degradation[6] to occur in different environments. Most commonly, biodegradability additives are designed to work in every environment while some are designed only for oxygen-rich environments.

Aerobic biodegradation of petroleum-based plastics:
When most biodegradable materials biodegrade in an oxygen-rich environment, they complete a benign, naturally occurring net-carbon-neutral lifecycle. This is because biodegradable materials tend to be bio-based, meaning their carbon content was recently sequestered from

2 The Association of Postconsumer Plastic Recyclers. "APR Position Statement on Degradable Additives Use in Bottles, Forms, and Films". 11 April 2013. Accessed on 16 July 2015. http://www.plasticsrecycling.org/images/pdf/about/Position_Statement/Degradable_Additives_Position_Statement_4-11-13.pdf

3 National Association for PET Container Resources. "Degradable Additives to Plastic Packaging: A Threat to Plastic Recycling". 15 February 2013. Accessed on 16 July 2015. http://www.napcor.com/pdf/Degradable%20Additives%20to%20Plastic%20Packaging%202-15-2013.pdf

4 Defined as the transformation of a substance into new compounds through biochemical reactions or the actions of microorganisms such as bacteria, per the U.S. Geological Survey Glossary. Page Last Modified March 4, 2014. Accessed July 15, 2015. http://water.usgs.gov/nawqa/glos.html.

5 U.S. Environmental Protection Agency. Landfill Methane Outreach Program: Basic Information. Last Update May 28, 2015. Accessed July 15, 2015. http://www.epa.gov/lmop/basic-info/index.html.

6 Biodegradability is a nuanced version of degradability, which more broadly refers to a material's ability to chemically change by heat or sunlight in such a way that alters the material's structural integrity (clouding and fragmenting) and properties.

atmospheric carbon dioxide. When those materials biodegrade and transform their carbon content into carbon dioxide emissions, the environment shows no net loss or gain of carbon dioxide over the short lifecycle of the material.

Petroleum-based plastics, however, are not bio-based, and the addition of biodegradability additives does not change that characteristic. The carbon content of petroleum-based plastics, although originally sequestered from the atmosphere, is considered *fossil* carbon,[7] which is formed in past geological timeframes and resides in long-term, underground storage. The short-term carbon cycle maintains a balanced transfer of carbon between the atmosphere and the biosphere (terrestrial and marine) and does not generally include fossil carbon.[8] Therefore, when a petroleum-based plastic biodegrades in an aerobic environment, such as it would as terrestrial litter, it results in the release of previously dormant fossil carbon into the atmosphere and biosphere. These avoidable emissions would not occur if the material remained intact for more beneficial end-of-life uses through reuse or recovery.

Anaerobic biodegradation of petroleum-based plastics:
Petroleum-based plastics generate a substantially larger amount of avoidable human-induced greenhouse gas emissions if they are allowed to biodegrade in an oxygen-deprived environment, such as a landfill. In addition to carbon dioxide, biodegradation in anaerobic conditions generates methane, which is vastly more potent than carbon dioxide in the global carbon cycle.[9] Even landfills that capture and beneficially use landfill-generated methane have greenhouse gas profiles that are net harmful, as the gas capture systems operate with limited efficiency and the harm caused by the portion of greenhouse gasses emitted to the atmosphere outweighs the benefit of using the captured portion of methane to offset conventional fossil fuel usage.[10] Conversely, petroleum-based plastics not designed to biodegrade anaerobically will remain mostly inert in landfill environments, storing their fossil carbon and preventing it from re-entering the atmosphere indefinitely. Landfills are one of the least desirable end-of-life destinations for any material, but the harmful consequences of encouraging an otherwise inert material to biodegrade anaerobically should be avoided.

Generation of Fragmented "Micro-Litter" and Contribution to Pollution:

Most additives are designed to fragment petroleum-based plastics into small pieces in order to make it sufficiently available to the microorganisms that perform biodegradation. These fragmented micro-pieces remain invisible to the naked eye, yet their effects as micro-litter can

7 U.S. EPA. *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM): Landfilling Chapter*. Last Update 21 April 2015. Accessed on 3 August 2015. http://epa.gov/climatechange/wycd/waste/downloads/landfilling-chapter10-28-10.pdf

8 Sulzman, Elizabeth W. "The Carbon Cycle (2000)." Global Change Instruction Program of the University Corporation for Atmospheric Research. Page 8. Accessed on 3 August 2015. http://www.ucar.edu/communications/gcip/m2ccycle/m2pdf.pdf

9 The U.S. EPA estimates that the pound for pound comparative impact of methane on climate change is 25 times greater than carbon dioxide over a 100-year period. U.S. Environmental Protection Agency. "Overview of Greenhouse Gases: Methane Emissions". Last Updated on 21 July 2015. Accessed on 31 July 2015. http://epa.gov/climatechange/ghgemissions/gases/ch4.html

10 GreenBlue. *Assessing the Greenhouse Gas Impacts of Biodegradation in Landfills*. 2011. Accessed on 4 August 2015. http://www.http://www.sustainablepackaging.org/Uploads/Resources/spc_biodegradation_in_landfills.pdf

be detrimental. Beyond the well-documented environmental impacts of micro-pollution, the marketing of biodegradable petroleum-based plastics as being less detrimental to the environment may contribute to improper end-of-life disposal and pollution.

The main argument in favor of degradability additives is centered on their purported ability to slowly dissolve over time and counteract the persistence and volume of petroleum-based plastics in the environment. While litter is a serious issue in need of a more robust mitigation and prevention strategy, it is the SPC's view that the creation of a material designed to be viewed and characterized as "litter-friendly" or environmentally beneficial is a severe step in the wrong direction. A study conducted by Keep America Beautiful[11] shows that consumers are more likely to litter when the item is marked as being "biodegradable", which is counterproductive to the concerted efforts of industry and NGOs to change littering behavior and ingrain a practice of recycling, or at the least, responsible disposal.

It is well known that terrestrial litter is likely to migrate, either by human or natural means, into a marine environment. Many additives designed to enable biodegradation in terrestrial conditions are not designed to be effective in marine conditions facing wider variability in temperature, microbial and nutrient availability, and exposure to sunlight in open oceans.[12] However, a 2006 study by the American Chemistry Council concluded that when a consumer sees the word "biodegradable" on a package, about 80% of consumers believe that the package will completely decompose regardless of the environment in which the package is disposed.[13] In a marine environment, any fragmentation of petroleum-based plastic will exacerbate its harmfulness as pollution.[14]

The most recent standard for the biodegradability of plastic materials in marine environments require that plastics must have converted at least 30 percent of their carbon content into carbon dioxide within six months.[15] Studies conducted by the Chico Research Foundation at California State University have shown that plastics with oxo-degradable additives[16] did not successfully biodegrade in marine environments. Even if these materials did successfully biodegrade into benign compounds within the six months required by the testing standard, fragmented plastics will transport through oceans and have many opportunities during that time to impact aquatic organisms through ingestion or entanglement.[17] Whether or not biodegradation successfully

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11 Keep America Beautiful. "Littering Behavior in America". January 2009. Accessed on 15 July 2015. http://www.kab.org/site/DocServer/KAB_Report_Final_2.pdf?docID=4581

12 Tosin, Maurizio et al. "Laboratory Test Methods to Determine the Degradation of Plastics in Marine Environmental Conditions." *Frontiers in Microbiology* 3 (2012): 225. *PMC*. Web. 16 July 2015. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3380294/

13 American Plastics Council. *Biodegradable and Compostable Study*. September 2006.

14 Narayan, Ramani. "Fundamental Principles and Concepts of Biodegradability - Sorting through the facts, hypes, and claims of biodegradable plastics in the marketplace. BioPlastics magazine, vol. 4, January 2009

15 ASTM D6691-09, Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials in the Marine Environment by a Defined Microbial Consortium or Natural Sea Water Inoculum, ASTM International, West Conshohocken, PA, 2009, www.astm.org

16 California State University, Chico Research Foundation. "Performance Evaluation of Environmentally Degradable Plastic Packaging and Disposable Food Service Ware - Final Report." JUne 2007. Accessed on 3 August 2015. http://www.calrecycle.ca.gov/Publications/Documents/Plastics/43208001.pdf

17 Mosko, Sarah. "Bioplastics: Are They the Solution?". Algalita Marine Research & Education. Accessed 15 July 2015. http://www.algalita.org/bioplastics-are-they-the-solution/

occurs in these various environments and conditions,
petroleum-based plastics should not be designed to encourage fragmentation.

Conclusion

The SPC sees ample opportunities for the sustainable use of petroleum-based plastics. This material can be considerably advantageous due to its technical performance characteristics, light weight, and viability in established recovery practices. The SPC disagrees with the idea that biodegradability additives contribute any enhancement to the sustainability of petroleum-based plastics. The SPC seeks to continue the collective work of industry and NGOs to achieve the beneficial end-of-life solutions necessary for the sustainable use of plastics, and the SPC will continue to monitor technologies that affect key characteristics of all packaging materials. Barring significant advancements, the SPC's position is firmly against the use of any biodegradability additive in any petroleum-based plastic.