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BIODEGRADABILITY OF THE TWIRL'EM ECOLO BAGS

THE SITUATION

There is growing concern about the effects of plastic on the environment. Causes of concern are, among others, the persistence of conventional plastic in the environment due to long decomposition time (100 to 400 years)[1] and the amount of waste associated with poor plastic end-of-life management. Consumers in all fields are striving for solutions and biodegradable options are now available for the sampling industry.

BIODEGRADABLE PLASTIC

A biodegradable plastic is a degradable plastic in which the degradation results from the action of naturally occurring microorganisms such as bacteria, fungi, and algae[2]. Biodegradation reactions may involve both aerobic and anaerobic mechanisms[3,4]. Some polymers degrade in only a few weeks, while others may take several months.

There has been confusion with the term biodegradability being used liberally to designate compostability, yet biodegradable is not necessarily compostable. Compostable plastics are materials for which complete degradation is achieved at a specified rate (less than 6 months) through the process of composting. Compostability is a sub-set of biodegradability. The **Twirl'em Ecolo bag** is biodegradable, but not compostable.

Some confusion also exists about the term bioplastic. Bioplastics are plastics that are biodegradable, biobased or that feature both properties. Biobased plastics are not always biodegradable and biodegradable plastics are not always biobased[5]. To illustrate this distinction, European Bioplastics has provided a simple two-axis model that encompasses plastic types and possible combinations (Figure 1)[6]. The **Twirl'em Ecolo bag** is a bioplastic in that it is biodegradable. However, it is not biobased.

The biodegradability of plastics depends on the raw materials, the chemical composition and structure of the final product, as well as on the environment under which the product is expected to biodegrade[5]. When a plastic is not inherently biodegradable, blending with other biodegradable polymers or additives can promote biodegradability[3,4]. One particular approach is to add additives that enhance the biodegradation of polymers by allowing microorganisms to utilize the material as a source of energy. This is the approach behind the **Twirl'em Ecolo bag**.

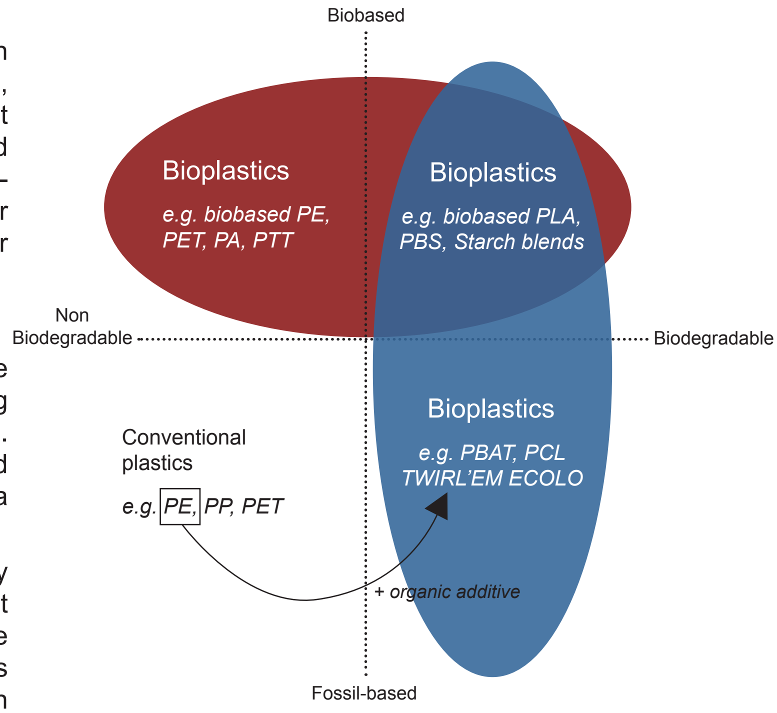

Figure 1. Material coordinate system of bioplastics. Reproduced from[6] with modification to include the Twirl'em Ecolo bag.

BIODEGRADABLE ADDITIVES

Biodegradable additives expedite the rate of degradation by attracting microorganisms to the polymer. One type of biodegradable additives is organic additives that promote enzyme-mediated degradation (or depolymerisation) of the plastic material back to smaller molecules. Microbial involvement in the degradation process is evidenced by production of gaseous carbon.

Organic additives are typically added in small amount to a conventional carrier resin such as polyethylene (PE)[7]. As such, organic additives allow transforming conventional plastics into bioplastics (fossil-based biodegradable plastics) (Figure 1, arrow). This is the approach behind the **Twirl'em Ecolo bag**, where low density polyethylene (LDPE) is enriched with an additive promoting enzyme-mediated degradation.

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TESTING FOR BIODEGRADABILITY

Because sampling bags are soiled at the end of their utilization, they cannot be recycled and are disposed of as regular waste. To reflect that, biodegradability was tested according to anaerobic test methods mimicking anaerobic digesters and landfills.

ASTM D5511 is a test method that determines the degree and rate of anaerobic biodegradation of plastic materials in high-solids anaerobic conditions such as anaerobic digesters treating municipal solid waste. In brief, the test materials are exposed to a methanogenic inoculum derived from anaerobic digesters operating only on pretreated household waste. The anaerobic decomposition takes place under high-solids (more than 30 % total solids) and static non-mixed conditions. This test method yields a percentage of conversion of carbon in the sample to carbon in the gaseous form.

ASTM D5511 is expected to resemble the environment of high-solids **anaerobic digesters** operated under optimum conditions. It offers a rapid and reproducible way to evaluate the biodegradability potential of a substance.

ASTM D5526, in turn, is a test method that covers determination of the degree and rate of anaerobic biodegradation of plastic materials in an accelerated-**landfill** test environment. Here, the test materials are mixed with pretreated household waste and exposed to a methanogenic inoculum derived from anaerobic digesters operating only on pretreated household waste. The anaerobic decomposition occurs under dry (more than 30 % total solids) and static non-mixed conditions. This test method yields a percentage of conversion of carbon in the sample to carbon in the gaseous form. Microbial assimilation/utilization of the carbon substrate is evidenced by the evolved gaseous carbon and is a measure of biodegradability.

This test method reproduces those types of landfills in which the gas generated is recovered or even actively promoted, or both.

TEST RESULTS

Results of the ASTM D5511 test method are presented in Figure 2 for standard and additive-supplemented PE bags. Degradation levels of about 10% are achieved in 120 days compared to 1.3% for the non-treated bags. At 120 days, biodegradation follows a linear slope and has not reached a plateau. The percent degradation measured for the treated PE bags exceeds the amount of additive put in the plastic, demonstrating biodegradation of the carrier plastic and not just the additive. The results indicate that PE bags supplemented with additive have a potential for biodegradation.

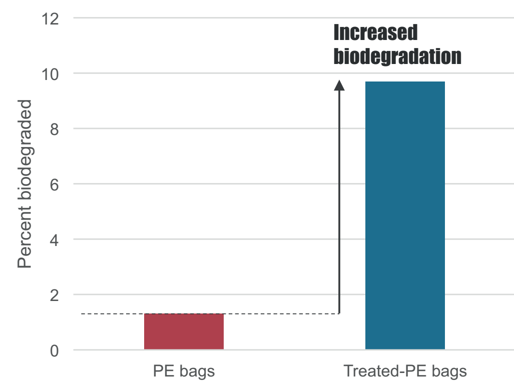

Figure 2. Degree of degradation of standard vs. additive-treated PE bags after 120 days in anaerobic high solids setting. Biodegradation was determined from gaseous carbon emission.

Results of the ASTM D5526 test method are presented in Figure 3 for LDPE bags with additive[i]. Degradation levels ranging from 30 to almost 50% are achieved in 391 days in simulated landfill conditions with varying total solids content. Biodegradation calculations are based on CO_2 and CH_4 production and not on indirect parameters such as visual disappearance or weight loss, sustaining the biodegradation claim. The percent degradation largely exceeds the amount of additive put in the plastic, demonstrating that the LDPE carrier plastic is biodegrading and not just the additive.

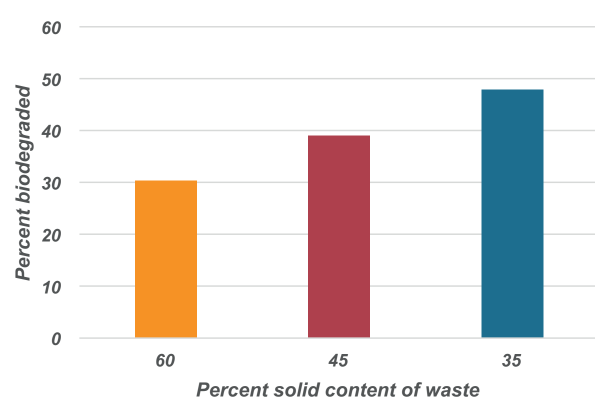

Figure 3 . Degree of degradation of LDPE bags after 391 days in different landfill settings. Biodegradation was determined from gaseous carbon emission.

[i] Tests were conducted by a third party facility and the results were provided by the additive supplier to serve as reference for our product.

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POTENTIAL BENEFITS OF LANDFILL BIODEGRADATION

Biodegradation is a strategy aimed at improving end-of-life product management. Rapid degradation of the plastic has the ability to:

1. Reduce volume of waste due to biodegradation during the active life of the landfill. By extrapolating biodegradation data from Figure 3, one can expect 30-50% reduction in the waste volume of additive-treated LDPE bags after 391 days compared to a conventional bag;
2. Increase the economic feasibility of landfill-gas recovery. Landfill-gas recovery is the process by which methane gas generated from solid waste deposited in a landfill is collected, converted, and used as an energy source;
3. Minimize the duration of after-care of the landfill.

Validating that a landfill site with gas recovery is available locally is advised to take full advantage of the **Twirl'em Ecolo bag**s and wisely manage the methane emission that will result from biodegradation.

CONCLUSION

Incorporating biodegradability into plastics in concert with a targeted disposal system like landfill with gas recovery offers an interesting end-of-life value proposition for applications where other more favorable end-of-life options in the waste hierarchy (e.g. recycling) are not accessible.

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