TECHNOLOGY AND TESTING OVERVIEW OF GREEN GENIUS BIODEGRADABLE TRASH BAGS WITH ECOPURE

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Overview

Green Genius biodegradable trash bags use a patented ingredient called EcoPure to enable polyethylene plastic trash bags to biodegrade – even in anaerobic landfill environments. The following paper explains how biodegradation works, how this additive enables the biodegradation of plastic and how these bags are tested for biodegradation.

What is biodegradation?

Biodegradation is nature's way of recycling wastes, i.e., breaking down organic matter into nutrients that can be used by other organisms. "Degradation" means decay, and the "bio-" prefix means that the decay is carried out by an assortment of microorganisms, commonly known as microbes.

The microbes that are important to biodegradation are heterotrophic, which means they feed on carbon for growth, and consist mainly of bacteria and fungi. They live and feed in almost every condition on the planet -- be it aerobic/anaerobic, wet/dry, hot/cold or light/dark. Some microorganisms also have the naturally occurring ability to degrade, transform or accumulate a huge range of compounds including hydrocarbons (e.g. oil), polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), pharmaceutical substances, radionuclides and metals.

Biodegradation shouldn't be confused with degradation or photo-degradation. These processes break down matter due to ultraviolet light, a chemical action or a mechanical action. However, they don't lead to actual biodegradation into organic matter. With normal plastic, these processes can fragment large pieces of plastic into smaller pieces that can still be harmful to the environment. In particular, degraded plastic can cause tremendous harm where toxic plastic “nurfs” are swallowed by marine life.

How is normal polyethylene made and why doesn't it biodegrade?

Polyethylene, the most common material for plastic films and bags, is derived from a natural gas called ethane, which is actually a by-product of petroleum refining. Ethane, a carbon-based organic matter, goes through two sequential processes to make polyethylene: (1) “cracking” to make ethylene and (2) “polymerization” to make polyethylene. These processes create a very strong and malleable product that can be further modified into low-density polyethylene (LDPE) and linear low-density polyethylene (LLDPE) for food storage and trash bags.

During this process, an organic matter, ethane, becomes “synthetic” and, most importantly, very difficult for microbes to break down. Specifically, polymerization creates long carbon-based chains that aren't “edible” by microbes. The only way to make them “edible” is to reintroduce new organic matter for the microbes to feed on.

How do we make plastic biodegradable?

Green Genius introduces an organic additive, EcoPure, to plastic that makes it biodegradable. EcoPure is a patented material developed by Bio-Tec Environmental in Albuquerque, New Mexico. Based on years of research, the additive is a revolutionary approach to biodegradation for all types of plastics – polyethylene, PET, polypropylene, polystyrene and PVC. It is being used in a multitude of products including food storage bags, trash bags, plastic binder sleeves, water bottles and even shoe soles.

EcoPure is essentially a complex mixture of organic nutrients that act as chemo-attractants for microbes. By binding to the molecular structure of plastic, EcoPure attracts microbes to colonize on plastic, a normally repellent material for microbes. The microbes start feeding on the plastic and their enzymatic actions actually promote the biodegradation of the plastic. This starts a long process of biodegradation that results in simple organic matter: bio-mass and bio-gas.

Given EcoPure works with microbial activity and, as explained above, microbes live in almost any environment, Green Genius bags with EcoPure will biodegrade in varying conditions of light, heat, moisture and oxygen. This is in contrast to other technologies that require very specific conditions, especially of oxygen, heat and moisture.

To better explain this whole process, we will take you step-by step from production to biodegradation.

1. Blending

The EcoPure additive is blended in with polyethylene resin during the manufacturing process. During the high heat blending process, EcoPure embeds into the plastic by expanding the molecular structure of the plastic and scissoring the polymer chain. It is evenly dispersed throughout the entire batch and all materials (including the drawstring) to ensure that microbial activity happens on the entire bag.

2. Storage and Use

EcoPure does not impact the performance or shelf life of the Green Genius Bags. In fact, EcoPure has been found to strengthen bags, especially for puncture resistance. Given EcoPure is only activated by microbe-rich environments, Green Genius bags will not start biodegrading on the shelf or in the home. This is a distinct advantage over other technologies, such as oxo-biodegradable, that can start the degradation process when exposed to heat, light or oxygen. This results in brittleness or bag failure before or during use by a consumer.

3. Disposal and Biodegradation

Once a Green Genius bag biodegradable trash bag is disposed of in a microbe-rich environment, like a landfill, the biodegradation process begins. Below is a detailed description of the key phases in the landfill decomposition cycle and how Green Genius bags with EcoPure biodegrade:

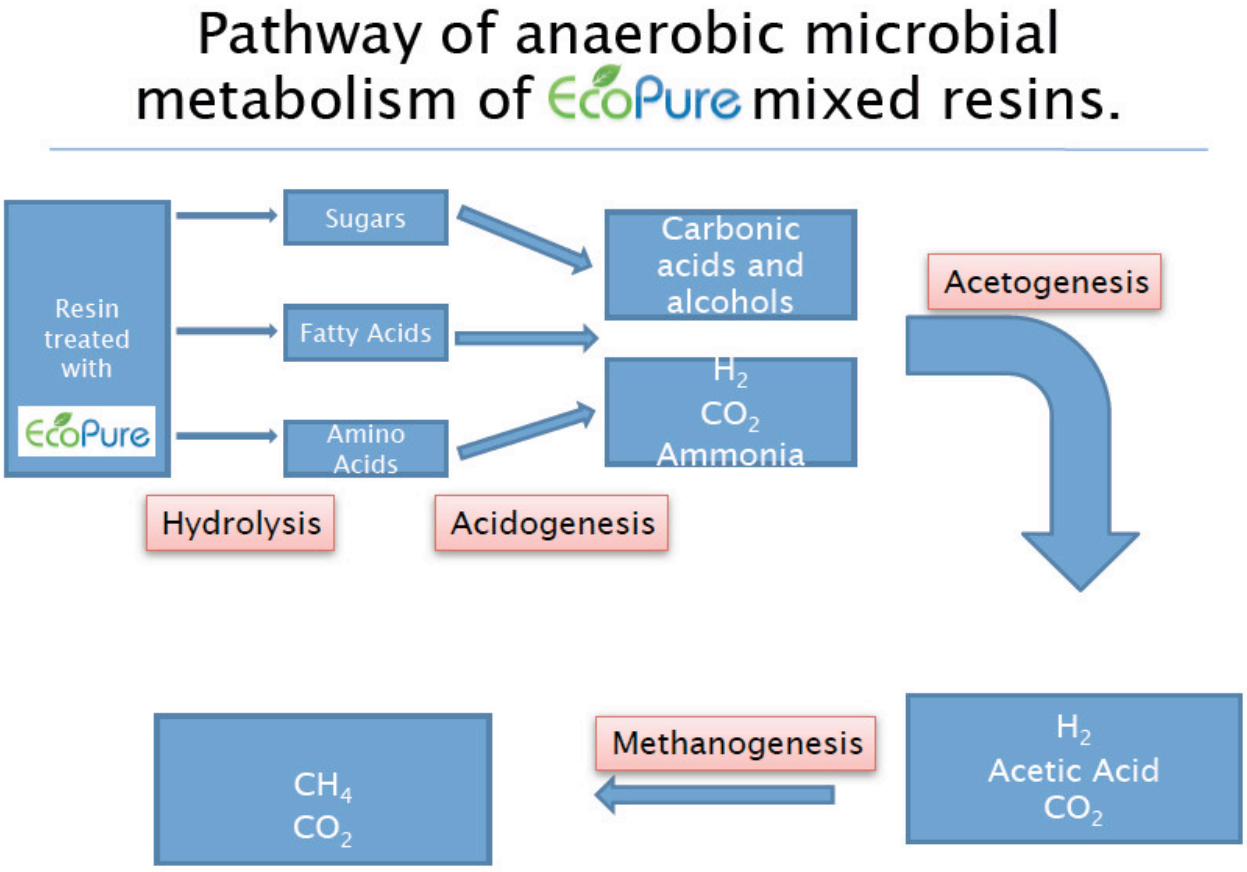
I. Aerobic Phase (first few days in landfill) – This is the period when aerobic microbes are becoming established and moisture is building up in the refuse. While standard plastic absorption capability is relatively small, the EcoPure additive causes further swelling, weakening the polymer bonds and creating molecular spaces where moisture and microbial growth can rapidly begin the aerobic degradation process.

II. Anaerobic, Non-methanogenic Phase (roughly 2 weeks to 6 months) - After O2 concentrations have declined sufficiently, the anaerobic processes begin. During the initial stage (hydrolysis), the microbe colonies eat the EcoPure particulates, and through an enzymatic process, solubilize large polymers down into simpler monomers. The secreted monomers mix with the EcoPure organic additive, causing additional swelling and opening of the polymer chain and increased quorum sensing. This further excites the microbes to increase their colonization and consumption of the polymer chain. As time progresses, acidogenesis occurs where the simple monomers are converted into fatty acids. CO2 production occurs rapidly at this stage.

III. Anaerobic, Methanogenic Unsteady Phase (6 to 18 months) - The microbe colonies continue to grow, eating away at the polymer chain and creating increasingly larger molecular spaces. During this phase, acetogenesis occurs where fatty acids are converted into acetic acid, carbon dioxide and hydrogen. As this process continues, C2O rates decline and H2 production eventually ceases.

IV. Anaerobic, Methanogenic Steady Phase (1 year to 5 years) - The final stage of decomposition involves methanogenosis. As colonies of microbes continue to eat away at the remaining surface of the polymer, acetates are converted into methane and carbon dioxide, while hydrogen is consumed. The process continues until the only remaining element is humus. This highly nutritional soil creates an improved environment for the microbes and enhances the final stage of decomposition.

Below is an illustration of the entire process.



What is left at the end of this process?

Once biodegradation is complete, there will only be bio-mass in the form of humus, a degraded soil made of nutrients and inert substances. This material is considered harmless and may, in certain cases, be used as compost.

Green Genius bags are designed to ensure that there are no toxic or harmful residues within this humus. The virgin polyethylene, the additives and the colorants in the bags are certified by our suppliers to be non-toxic per EPA regulations. The recycled plastic, especially the 12% post-consumer recycled content, may contain trace amounts of heavy metals. However, given it only makes up a small portion of each bag, the recycled content should still allow Green Genius to qualify for heavy metal limits under the ASTM D6400 standard for compostability. Lastly, Green Genius bags also contain a certain amount of calcium carbonate, similar to seashells, which is a completely inert substance when biodegraded.

How are Green Genius Bags tested for biodegradation?

Green Genius bags have been tested by an independent, EPA-certified lab using ASTM D5511, the industry standard test for determining anaerobic biodegradation of plastic materials under high-solids anaerobic-digestion conditions. What does all that mean? Let's break it down:

- **Anaerobic** – It literally means "without air" and is the condition most people associate with landfills.
- **High Solids** – This is scientific lingo for a dry disposal environment, another "average" condition.
- **Digestion Condition** – This means there is microbial activity. Microbes thrive in all landfills – even in their dark, anaerobic depths.

So while there is no test for an "average landfill", ASTM D-5511 simulates conditions found in most landfills and is the most common test for simulating this environment.

This test was conducted by Northeast Labs in Berlin, Connecticut (www.nelabsct.com). Northeast Labs holds licenses and certifications from the EPA, FDA and USDA as well as numerous state agencies. In Northeast Labs' ASTM D5511 testing report, it states “Green Genius trash bags when tested by ASTM D5511, which determines anaerobic biodegradation of plastic materials under high solid anaerobic conditions, were found to be biodegradable. This procedure simulates the conditions of a properly operated landfill treating pre-treated household waste as a sole substrate.” A copy of this letter can be obtained upon request.