Overview:

Companies that currently use and promote Oxo-degradable technologies are unaware of the degradation mechanism of the technology and how the material interacts with a plastic bottle, cup, or other consumer product. This white paper is written to inform the general public and business owners of how oxo-degradable and oxo-biodegradable technologies compare to truly biodegradable technologies in the market.

Background Information:

The human race continues to advance the use of plastic material, as it is a robust component of our everyday lives. The search for a biodegradable plastic has gone on for decades in an attempt to meet this growing demand and solve the consequential environmental issues. This search for biodegradable plastic has been a long confusing road from the technology standpoint, beginning with degradable plastic.

Degradable plastic is designed to be broken down by light and heat, originally named photodegradable and remarketed as oxo-degradable and now oxo-biodegradable.

Photodegradable plastic was originally designed to be used in 6-pack ring holders for large organizations like ITW. They were one of the first to utilize photodegradable iron stearate interacting with the sun to reduce the harm of sea turtles getting their necks caught in the rings. This technology is still used to this day as it is mandated by the EPA that all 6-pack ring holders must contain this Photodegradable technology reducing the potential littering harm to our beaches and sea life. ITW holds the patent on this 6-pack ring holder as well as the photodegradable 6-pack ring holder technology.

Photodegradable products have taken on a new name and have been re-marketed as oxo-degradable products and even more recently as oxo-biodegradable products. These technologies are no different than the photodegradable technologies in the final outcome of the product. The plastic pieces are left behind for microorganisms to consume over a long period of time.

The name change from oxo-degradable to oxo-biodegradable comes as no surprise as a biodegradable product is the consumers ultimate desire. Plastic biodegrades naturally and when photodegradable/oxo-degradable/oxo-biodegradable technologies are exposed to UV light the polymer is fractured into pieces, leaving (as they claim) a potentially increased ability for microorganisms to consume the broken down polymer. This product only works when it is littered, as it must be in the presence of UV light to trigger the fragmentation. There is no scientific evidence to show that these plastic fragments are then consumed at an increased rate due to the technology. What we do know is that UV light breaks the plastic down into smaller pieces.

BioSphere Plastic LLC has a proprietary additive which when added to normal resins can encourage the biodegradation of the plastic material by a reaction with enzymes created by microorganisms. Current culture is lead to believe that plastic is not biodegradable. This is incorrect. All plastic is organic in nature and has been proven to biodegrade by microorganisms by several different groups, some of them being high school students in Canada and Ben Gurion University scientists in Israel. This information has paved the way for BioSphere to bring to market the following technology and become a rapidly growing worldwide used technology.

The BioSphere technology allows microorganisms to produce CO_2 and CH_4, both of these are the result of the consumption of the plastic. When microorganisms consume anything aerobically or anaerobically these two gases are produced. Anaerobic biodegradation produces CH_4 and Aerobic biodegradation produces CO_2. The BioSphere technology allows the microbes to consume the plastic product in all active microbial environments.

The Science:

BioSphere Plastic LLC technology is built on the fundamental properties of building polymers and depolymerization.

In the molecular world, the small subunits that ultimately link together to form larger molecules are called **monomers**, which literally means "single unit" (*mono* = one). When a bunch of monomers join together into a much larger molecule, they form a **polymer**, meaning "many units" (*poly* = many).

How does this "linking together" happen? There is a process by which this joining usually occurs, called **dehydration synthesis**. Two monomers line up next to each other, a hydrogen (H) from one monomer binds with a **hydroxyl group** (OH) from another monomer, and voilà! A water molecule is born: $H^+ + OH^- = H_2O$.

During dehydration synthesis, two subunits, or **monomers**, bind to each other where they were once bound to their respective hydrogen (–H) or hydroxyl (–OH) groups. This blissful union is presided over by an **enzyme** that is mainly there to help speed things along. The name of the process is dehydration synthesis because monomers are literally coming together and synthesizing a polymer by dehydrating, or removing a water molecule.

This is how a polymer is formed. How a polymer is **hydrolyzed** is the basis of our **technology.**

This is done by the addition of water between the bonds. Now the question that people wonder is how we do just that.

Anytime you allow water to attack the bonds between polymers this allows for hydrolyzing of the bonds which in turn lowers the molecular weight of the product. The addition of BioSphere additive introduces key elements into the polymer structure which allow hydrolyzation of the polymer.

Microbes produce **enzymes**, these enzymes are part of the **organic cycle** which produce reactions. Reactions by enzymes which are produced only by microorganisms create catalysts which are formed by gram-negative and gram-positive bacteria. The catalysts accelerate metabolic reactions. The metabolic reaction we use (even though there are multiple metabolic pathways in this reaction) is the carbohydrate metabolism.

We boost the ATP to carry more energy back to the **pyruvic acid** (Anaerobic) or the **Acetyl CoA(**Aerobic) cycles. This in turn creates proteins or lipids from the Pyruvic Acid cycle (Anaerobic) and acetyl CoA cycle(Aerobic).

This process created by microorganisms does not occur on the shelf, nor does it occur when water is in contact with the plastic. This reaction of microorganisms only occurs when the product is placed in an active microbial environment. BioSphere additive attracts over 600 different types of microbes to consume the polymer. The enzymes that the microbes produce react with the BioSphere additive creating a catalyst that breaks down the molecular weight of the polymer making it easier for microorganisms to consume the plastic. This is called biodegradation.

Oxo-degradable/PhotoDegradable/Oxo-Biodegradable Technologies

Science of Oxo's and Photodegradable Products:

Oxo-degradable plastics such as Perf Go Green and Planet Green Technologies use iron stearates and small amounts of cassava starch with UV Inhibitors to reduce the polymer/plastic into smaller chains. These chains are reduced by UV light once the UV Inhibitor has worn off. Regular plastic such as PET water bottles, when placed into direct sunlight, begin to degrade without the use of oxo-biodegradable technologies. The PET water bottles working with oxo-biodegradable technologies work faster to degrade under direct UV light. These technologies do not work when placed into landfills, compost piles or anywhere on earth without light. These technologies were created for the purpose of reducing the potential harm of littering on beaches. The problem that comes with placing UV Inhibitors into the plastic is working against the goal of oxo-degradable plastic. The UV inhibitors actually do not allow for the product to break down when exposed to UV light. This in turn creates a long lasting plastic product without a change in physical properties in the short term and over three years later when still exposed to UV light it will begin to break down.

The Key scientific issues of Oxo-degradable plastic are found below.

1. http://www.nature.com/news/2011/110421/full/news.2011.255.html

2. http://grist.org/article/degradable-plastic-bag-manufacturer-makes-false-claims-about-product/

3.http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=16263

4. http://www.newtimes.co.rw/news/index.php?i=15091&a=57310

The photodegradation, thermal degradation of the plastic polymer will not occur without UV light.

UV Light is not found inside landfills, compost piles or any other disposal methods other than litter. Furthermore, to sustain the shelf life of the product as seen above in link 4, you will notice that an Oxo-biodegradable plastic does not break down as intended in the real environment outside of internal testing.

Adding in Oxo-degradable additives adds no benefit for the first 3 years due to the UV inhibitors that are used. Without these UV inhibitors the products would fall apart on the shelf if exposed to UV light.