OxoBiodegradable
Plastics Institute

Biodegradable Plastic Bags – Hope or Hoax?

Today's press is replete with stories about the environment and specifically about the ways that modern society mistreats the world in which we live. One only need turn on the television, open a newspaper or surf the web to find stories about depletion of the ozone layer, misuse of non-renewable natural resources, extinction of species, stockpiling of garbage, poisoning of groundwater, littering, marine pollution, etc, etc. The good news is that we are talking about these problems and in the past few decades have taken massive steps to reduce the impacts of human habitation on the planet. Much of this has happened through the development and implementation of new technologies.

At the same time, however, technological developments have created their own "collateral environmental damage". New technologies permit the feeding of an ever growing, polluting global population. New, more affordable products enhance the quality of life for growing numbers of people but cause problems at the end of their useful life. Even antibiotics, the wonder drugs of he 1950's, have led to more virulent strains as micro-organisms have adapted to and are immune to them. Our response to these changes is to continue to update and develop new technologies to deal with these issues and this is a perpetual process.

Plastic packaging, and specifically plastic bags, is the subject of an increasing amount of public debate. Plastics became generally available in the 1950's and have changed the way we live, generally for the better. With reference to plastic packaging, these materials provided major health benefits by, for example, inexpensively protecting foods from spoilage. They provided convenience and economic benefits by providing the means for people to inexpensively contain products for transport. And they provided environmental benefit by replacing much larger quantities of mainly cellulose based (trees) packaging that were used.

Their excellent properties also, however, caused problems for the environment. Because they were strong, light, resistant to attack by the elements, inexpensive and easy to form into products, they were ideal for single use packaging applications. Unfortunately, as is often the case, the attributes that made them useful, also made them problematic – they persisted for a long time when they were discarded. The following is a discussion of one of the technologies, oxo-biodegradation, that has been developed to manage this property and specifically to bring some perspective to some of the claims and criticisms made regarding products which use this technology and whose makers are represented by OPI, their industry organization.

What are oxo-biodegradable plastics? These are conventional plastics such as polyethylene, which are long chains of carbon and hydrogen atoms, that are treated with an additive that accelerates the reaction of the plastic with atmospheric oxygen leading to the insertion of oxygen atoms into the structure and the breakdown of the large polymer molecule. This is called degradation and its physical

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manifestation is the disintegration of the plastic. The smaller pieces are not the original plastic but rather are totally different species that are digestible by micro-organisms. The use of these as an energy source by micro-organisms is called biodegradation – the same process by which naturally produced products such as leaves and grass, themselves made of polymeric materials containing carbon, hydrogen and oxygen, are returned to the ecosystem. The additives that accelerate this process are called prodegradants. These are catalysts that contain small amounts of the same metal ions as are required by plants and animals, including humans, as micronutrients.

The proprietary technology that utilizes this well understood chemistry lies in the ability to control the rate and timing of the degradation process in order that products using it retain their useful properties until they are discarded. At this time, heat and/or unfiltered sunlight initiate the degradation. This behaviour is well documented in peer reviewed scientific journals and is **FACT**.

Are there alternative biodegradable technologies? Yes, there is an analogous mechanism for degradation and biodegradation called hydro-biodegradation where a different type of plastic molecule is degraded by reaction with water and the degradation products are then biodegraded by micro-organisms. Products using this technology are often made from naturally occurring materials such as starches but may also incorporate products made from petroleum. Products made from these polymers typically degrade and biodegrade slightly faster than those made using oxo-biodegradable technology but generally do not have the same processability and strength that the oxo-biodegradable products share with conventional plastics, particularly film products and this is **FACT**.

Why is there confusion in the marketplace? Most of the marketplace confusion derives from competitive jockeying for market position, some of it irresponsible. Claims are made for one technology and contested by proponents of the other. Validation of claims is properly sought through the development of and certification to recognized performance standards; however, these are sometimes used inappropriately. Indeed, the requirements of these standards may be based more on the capabilities of a particular technology than on the needs of the user.

From OPI's viewpoint, a particularly irresponsible attack on oxo-biodegradable technology was launched by a group called the "International Biodegradable Polymers Association and Working Groups" or IBAW.

The IBAW attack is based on the premise that plastics are not biodegradable unless they meet the EU standard for compostability. There is a large body of published peer reviewed science (see e.g. www.oxobio.org/cologn%20paper.pdf and references therein) that demonstrates that oxo-biodegradable plastics, while they do not meet this standard for compostability, and cannot be certified to do so, do indeed biodegrade. It must be recognized that this standard and its ASTM counterpart were developed for hydro-biodegradable products. Indeed there are studies, including an independent one done for an agency of the Quebec, Canada Government (see www.oxobio.org/criq_fr.pdf or www.oxobio.org/criq_en.pdf for the French and English versions respectively) that found that

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composts made using oxo-biodegradable plastic bags were of high quality and that these bags composted well.

European and US standards associations have both developed compostable plastics requirements and both require very rapid rates of mineralization (conversion of carbon in the plastic structure to carbon dioxide) which are not currently met by oxo-biodegradable products. Interestingly, the rates specified by the two standards are different. This is presumably because the choice of a rate of biodegradation is quite subjective, related more to the ability of the plastic to achieve it than to the real need in compost. Indeed, a strong argument can be made that very rapid biodegradation precludes the ability of the plastic material to contribute to the organic content of the receiving soil.

The ASTM standard also limits the allowable metal content of compostable plastics to the levels that are required of soil amendments. This might be appropriate if it was contemplated that plastic bags would be composted without any other organic materials. In fact, these bags are used to contain organic materials that weigh tens or hundreds of times the weight of the bag. The Quebec compost study, mentioned above, found that the composts made using oxo-biodegradable bags as the container for organic waste exhibited metals concentrations only slightly higher than those made using alternative technologies and well within legislated Canadian guidelines. These guidelines, incidentally, were developed using the principle of "no net degradation" of receiving soils (that is that when added to the soil, such composts will not reduce the quality of the soil).

The IBAW paper seems to imply that the inability to certify oxo-biodegradable products to the EU compost standard that was developed for hydro-biodegradable products somehow renders claims made for the former products irresponsible. Purveyors of oxo-biodegradable products are careful to ensure that the claims that they make for their products meet the requirements of ISO 14021:1999 ("Environmental labels and declarations – self declared environmental claims (Type II environmental labelling)") as well as regulations in the jurisdictions in which they market their products.

The concerns of safety and eco-toxicity referenced by IBAW have been addressed in several studies. Both the totally independent Quebec study and other published work referenced for example in "Biodegradable Polymers for Industrial Applications", Ray Smith(ed), CRC Publishing (2005) found that composts made using oxo-biodegradable bags were not eco-toxic.

Salts of cobalt are commonly used as the prodegradant catalyst in oxo-biodegradable products. The Canadian Council of Ministers of the Environment has established a level of 34 ppm as the maximum allowable cobalt level in class A composts – composts unrestricted in their use. (http://www.compost.org/standard.html). The document "Guidelines for Compost Quality" (available for purchase at www.ccme.ca) includes the following quotation: "Trace elements, for example, mercury, cadmium, lead, may be present in raw materials from which compost products are produced. Excessive accumulation in soils over the long term may result in toxicity to plants, animals and humans. However, copper, cobalt, molybdenum and zinc (and possibly nickel and selenium) are plant micronutrients, and their presence may be useful in compost. Also arsenic, cobalt, chromium, copper,

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molybdenum, nickel, selenium and zinc are micronutrients required by animals and humans (Webber and Singh, 1995)." Of the metals listed above, cobalt is the only one that may be used in prodegradant formulations by our members.

Other than in Canada, where the federal Fertilizers Act limits cobalt concentration in sludges, composts and similar materials represented as fertilizers or supplements to 150 ppm, there is little other legislation respecting cobalt levels in soils. Cobalt in soil is not regulated in the US. In Switzerland a VBBO Value (target value) for cobalt in soils has been established at 25 ppm.

The 34 ppm maximum level of cobalt allowable in Canadian composts was determined based on a concept called no net degradation (as noted above this means it will not reduce the quality of the soil). This concept requires that the use of compost not change the regional levels of trace elements in the receiving soils. In the Quebec study, the researchers measured only 7.2-7.6 ppm of cobalt in the compost made using oxo-biodegradable bags. This compares with 4.4-4.9 ppm for composts made from degradable bags using a hydro-biodegradable technology not utilizing an additive versus 51.19 ppm (http://www.thecdi.com/cobaltfacts/index.html) as the average background level in European soils. This would seem to obviate the allegation of potential persistency and bio-accumulation.

It should be emphasized that cobalt is essential to life as a key component of vitamin B12 (http://www.championtrees.org/topsoil/b12coblt.htm). Cobalt is fed to cattle and cobalt is sometimes applied as a fertilizer supplement to fields that are deficient in the element.

Like many things, one can get too much of a good thing; however, there is remarkably little literature describing human toxic effects, particularly via ingestion by means other than through respiration. Evidence of toxic effects of cobalt taken orally primarily derive from cases where individuals consumed large amounts of beer containing cobalt foam stabilizers over extended periods and even these effects were exacerbated by alcohol and poor diet. The amount of cobalt that they ingested would be equivalent to an individual eating 5-10 oxo-biodegradable shopping bags a day on an ongoing basis. There is more evidence of human health issues that derive from inhalation of cobalt containing dusts; however, as yet unpublished studies by EPI, an OPI member company, have demonstrated that the levels of airborne cobalt in processing its oxo-biodegradable products are far below occupational health guidelines. Further, in the environment, the cobalt from these products is in an oxidized form that will bind to soils and is present in very low concentrations so that it will not become airborne in any significant quantity.

OPI members do not claim that their products are a solution to littering. Littering is a behavioural issue and the solution to it is to educate people to refrain from doing it. Biodegradable technology, either hydro-biodegradable or oxo-biodegradable can, however, form part of a management strategy. It has been shown mathematically (J.E. Guillet, "Plastics and the Environment" in G. Scott and D. Gilead, "Degradable Polymers: Principles and Applications", London, Chapman & Hall. 216-246 (1995)) and is intuitive that controlling the lifetime of discarded plastics controls their accumulation as litter.

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As regards recyclability, the polymer backbone of oxo-biodegradable products is identical to that of conventional polyolefins so these products are inherently compatible. The prodegradants that are added to effect the breakdown of the polymer structure are catalysts – that is, they accelerate the speed at which processes that happen, even in the untreated polymer, occur. These prodegradants do not initiate anything and have absolutely no effect so long as antioxidants are present. Anti-oxidants are added by the resin manufacturers in order to allow processing of conventional plastic resins and may be added by users of recycled materials making products destined to have a long lifetime. In addition, the impact of prodegradants is further reduced through dilution in the existing recycle stream. This science is well understood and is supported by practical experience. Processors currently recycle scrap into both degradable and non-degradable products. Grocery chains collect used bags for recycling. Hydro-biodegradable products, because their chemical structure is completely different from that of conventional polyolefin plastics, are inherently incompatible with the conventional recycling stream. It is for this reason that one of the leading suppliers of these products has recently launched an independent recycling program that requires the segregation of his products from the mixed recycle stream.

Much is made of the sustainability of hydro-biodegradable products versus oxo-biodegradable ones because the former are often made from various plant sources whereas the oxo-biodegradables are based on the application of additives to petroleum based polymers. While the use of "natural" feedstocks sounds nice, it should be recognized that the starches and other inputs derive from cultivated crops that must be sowed, fertilized, harvested, transported and converted to polymers in specially designed chemical plants. Petroleum based energy sources are used in all of these steps. It is also true that some of the hydro-biodegradable products use petroleum based polymers as part of their formulation. So the comparison of sustainability is not black and white but rather one of degree.

The intention of this paper is not to denigrate hydro-biodegradable technologies or products but rather to respond with established scientific facts to the concerns that IBAW has raised regarding oxo-biodegradable products and to provide interested parties with information on some of the benefits of products using this technology, the more important ones of which are:

- Oxo-biodegradable products (OBP's) utilize conventional resins and retain their excellent physical properties for their primary intended use. This also allows them to retain the benefits of reduction through down gauging.
- OBP bags can be reused like conventional plastic bags.
- OBP's are and can be shown to be recyclable in existing recycle streams, unlike competing products that are not compatible with conventional plastics.
- OBP's have been shown to compost effectively and to yield high quality composts.
- OBP products are processed in existing plastic processing facilities with existing equipment and near identical processing parameters to conventional plastics

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- OBP's are much less expensive to the consumer than alternative products thus making them much more likely to be adopted by consumers, thereby supporting organics recycling programs.

For further information regarding this exciting technology, please visit our website at www.oxobio.org or email us at info@oxobio.org.

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