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EPI's Oxo-Biodegradable Plastics Guidebook

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Aims and Objectives

The purpose of this Guidebook is to ensure that customers and potential customers of EPI, licensees, end users, retailers and food companies are all familiar with the most recent developments in packaging plastics: controlled-lifetime polyolefins (PE, PP) and polystyrene (PS).

The objectives of each section are designed to explain a particular facet of how EPI's products enhance the packaging business.

1. The Plastics Age
2. TDPA® Technology from EPI
3. Definitions: Degradability, Biodegradability (aerobic), Oxo-biodegradation
4. Applications of plastics incorporating TDPA®, Landfill Cover Applications, Agricultural Applications
5. TDPA® Product Safety: No heavy metals in TDPA; Manufacturing Safety; Food Contact Compliance
6. Testing and performance evaluation
7. Disposal environments: Landfill Disposal, Reduction in Litter Accumulation, Composting, Aqueous Media
8. Recyclability
9. Cost
10. Myths versus facts
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1. The Plastics Age

From the second half of the 20th century, plastics have replaced more traditional materials (glass, metals, paper, etc.) in a wide variety of applications, owing largely to having superior properties. Some years ago, the total volume of plastics exceeded the total volume of steel used and now more plastics are used than metals. Of the several dozen generically different kinds of plastics, let us focus on the most widely used types: polyolefins.

The polyolefins are used in an amazing array of products from antiballistic fabrics to peanut butter jars to ropes, from stadium seats to protective food wraps to carrier bags. For example, as packaging materials for food, polyolefin plastic films are inexpensive, light, easily fabricated, inert, non-toxic, odourless, resistant to microorganisms, disposable or recyclable by conventional disposal technology, degradable by some natural mechanism(s) if littered. The polyolefins meet all these criteria; no other class of materials does.

As the uses for polyolefin bags and other film products proliferated, it was noted that limited-use plastics lasted much longer than they needed to, i.e., they persisted too long in the environment after being used and then discarded. Owing to their inherent durability, many plastics continue to accumulate in the municipal solid waste stream, continue to be a source of persistent litter, and continue to impact our environment. It was necessary to add one final property to these ubiquitous materials. The time had come for the introduction of ***Controlled Lifetime Plastics.*** This has been accomplished.

2. TDPA® Technology from EPI

Nearly 20 years ago the experts at EPI Environmental Products Inc. developed materials [Totally Degradable Plastic Additives: TDPA®] and processes for controlling the lifetime of conventional polyethylene, polypropylene and polystyrene resins. The plastic products made using conventional resins to which EPI's TDPA® has been added retain all the advantages of the conventional products but display the required additional characteristic of degrading rapidly after use and disposal, by natural mechanisms and with no unwanted environmental consequences. There is a simple explanation as to how this works.

It has been known for some time that hydrocarbons such as polyolefins degrade slowly by a process called oxidative degradation (ref. 1 & 2) – a sequence of free-radical reactions whereby atmospheric oxygen combines with the carbon and hydrogen in the plastic molecules, with a number of inevitable consequences:

- the size of the polymer molecules is reduced, and oxygen is attached to the molecular fragments;

- there is a loss of mechanical properties including strength, stretchiness and flexibility;
- the plastic changes from water repellant (hydrophobic) to water wettable (hydrophilic);
- the brittle plastic disintegrates.

Although polyolefins do not biodegrade because their molecules are too large and are hydrophobic, their much smaller hydrophilic oxidation products do (ref. 3, 4 & 5). Over a period of many years, ordinary polyolefins can undergo this two-stage process – oxidation followed by the biodegradation of the oxidation products. This is analogous to the slow bioassimilation of naturally-occurring materials, for example polymers such as leaves, straw and natural rubber.

While the slow oxidation/biodegradation of the polyolefins is understood to be useful in the long term, it is necessary to speed up this two-stage process drastically in order to make it practically useful in managing the accumulation of discarded plastic products. It is essential, however, to retain all the useful properties of polyolefins while adding the characteristic of rapid oxidation followed by biodegradation – but not until the useful life of the plastic is over. For example, polyolefins are hydrophobic and therefore not biodegradable. This is important in keeping food from spoiling in plastic bags or food wrap while transporting and displaying perishable food items. Furthermore, while it is relatively easy to make the polyolefins degrade more rapidly than normal, this is not what is required. Processability, shelf life and use life must be maintained. Rapid degradation must not begin until the material has been used, possibly several times, then finally discarded. The shelf life and service life could be as short as a few months (e.g., food wrap) or as long as several years (e.g., agricultural mulch film).

The controlled lifetime technology developed by EPI for polyolefins works in the following way: Proprietary TDPA® formulations contain fatty acid compounds of specific transition metals (iron is an example of a transition metal) as their primary active ingredient. They act as catalysts* in speeding up the normal reactions of oxidative degradation with the overall process increased by up to several orders of magnitude (factors of 10). (*It should be noted that catalysts of many kinds are widespread in Nature; others are used very commonly by industry. By definition, it takes only a small amount of catalyst to do what is required and the catalyst is not consumed in the reaction.) The products of the catalyzed oxidative degradation of the polyolefins are precisely the same as for conventional polyolefins because, other than a small amount of TDPA® present, the plastics <u>are</u> conventional polyolefins. Many commercially useful hydrocarbons (e.g., cooking oils, polyolefins, many other plastics) contain small amounts of additives called antioxidants that prevent oxidative degradation during storage and use. Antioxidants function by 'deactivating' the free radicals that cause degradation. Lifetime (shelf life + use life) is controlled by antioxidant level and the rate of degradation after disposal is controlled by the amount and nature of the TDPA® catalyst.

The latter is the EPI product in the form of a fine dispersion in a polymeric matrix to be added by the converter to conventional polyolefin resin at a level recommended by EPI (generally in the range of 2 – 10%) depending on the specific application and the performance required.

3. Definitions

Degradability

This term is used here to denote the susceptibility of polyolefins to the loss of physico-chemical properties as a result of molecular weight reduction owing to oxidation. It's very slow in the environment for conventional polyolefins but very much more rapid when TDPA® additives are incorporated in the resins. Heat, UV light, mechanical stress or some combination of these causes the oxidation of plastics in various environments. Testing of specific resin – additive formulations is done by EPI using the accelerated tests and procedures that have been designed by ASTM to simulate exposures in common disposal environments. EPI recommends specific formulations and addition levels to its licensees that are based on the requirements of the application and the results of this testing.

Biodegradability (aerobic)

This term refers to degradation resulting from susceptibility to the actions of microorganisms. In other words, in the presence of air, microorganisms such as bacteria and fungi consume the material, converting the carbon in part to cell biomass and in part to carbon dioxide, and the hydrogen to water. This set of processes proceeds in the natural environment under many conditions and converts organic materials into soil-improving compost.

Oxo-biodegradation

Oxo-biodegradation may be defined as biodegradation in which polymer chain cleavage is primarily due to oxidation which may be mediated by abiotic chemistry, microorganisms or a combination of both. This is a fancy way of saying that oxo-biodegradable plastics undergo oxidative degradation and their oxidation products biodegrade.

Polyolefins containing TDPA® additives are oxo-biodegradable plastics.

4. Applications of plastics incorporating TDPA®

The appearance, processability and performance of polyolefins containing TDPA® additives are virtually the same as those produced with the same resins but without prodegradant additives. Not surprisingly then, the TDPA® containing polyolefins may be used in all the applications for which conventional polyolefins are suitable. The use of polyolefin plastics in packaging applications is commonplace because these materials are inexpensive, easy to fabricate, have good barrier properties, are hydrophobic and are available with a wide range of physical and mechanical properties. The various polyethylenes, polypropylene blends and copolymers of them plus polystyrene account for more production than all the other packaging plastics combined because of this versatility and on the basis of cost/benefit analysis. Carrier bags made of HDPE, trash bags made of LDPE, clear films of LDPE for food wrapping and clear clothing bags made of oriented polypropylene are a few examples of many that could be cited as examples of packaging versatility. In all these applications, the plastic packaging can be and is being made of TDPA®-containing resin.

Landfill Cover Applications

One novel application of EPI's technology is the oxo-biodegradable daily landfill cover. It is mandatory in many countries to apply a cover each day to the active face of a landfill for both aesthetic and sanitary reasons. This has commonly been 15 cm of soil, which is effective but expensive and wasteful of both landfill space and arable earth. Enviro® Cover, an EPI product made from PE containing TDPA® is used in a number of countries to replace soil as a cover for open faces of landfills. It is important that these covers maintain their structural integrity and their barrier properties until work resumes in that area of the landfill. It is equally important that they then degrade and disintegrate so that there can be no reduction of the flow of gasses and liquids through the bulk of the waste (ref. 2 & 6). Discussion of the environmental advantages of using EPI's oxo-biodegradable landfill cover is to be found elsewhere (ref. 6, 7 & 8).

A particularly impressive illustration of the features of Enviro® Cover is found in the results of a study conducted at one of the world's largest landfills, Puente Hills at Whittier, California. This landfill receives an average of 12,000 tonnes of non-hazardous municipal solid waste a day from the city of Los Angeles. Enviro® Cover has been used as an alternative cover since 1999 because it has been determined to be the most cost effective alternative cover material that meets regulatory requirements and provides prolonged coverage of waste for more than 6 weeks on the waste slope. The ability of Enviro® Cover to remain intact as a complete cover over the waste and soil for almost 7 weeks in severe summer conditions and to degrade after this period has enabled Puente Hills Landfill to save more than 30,000 ft^3 of soil a day in covering waste.

Agricultural Applications

Ciba Specialty Chemicals are developing and marketing products for agricultural applications (ref. 10) based on EPI's TDPA® technology, using the trade name Envirocare™. Extensive laboratory testing and field trials have demonstrated the effectiveness of these products. Several internationally-recognized standard tests have been used to demonstrate that both un-degraded and degraded Envirocare-based agricultural products are non-ecotoxic.

5. TDPA® Product Safety

No heavy metals in TDPA®

The term “heavy metals” has no scientific meaning and should not be used. Since it is frequently used by those who are not scientists it will be used here to mean lead, arsenic, mercury, cadmium, selenium, barium, chromium, nickel and antimony. None of these elements is found in any of EPI’s TDPA® additives. These are analyzed on a regular basis by certified independent laboratories in Europe and North America whose reports consistently confirm the absence of “heavy metals” in TDPA®.

The UK Food Standards Agency’s Expert Group on Vitamins and Minerals has carried out a risk assessment on trace elements and has shown that all the transition metal salts used in TDPA®- plastics are in fact trace elements necessary for healthy plant and human growth (ref. 9)

None of the active ingredients or the additives in EPI’s TDPA® is classified as a carcinogen by the International Agency for Research on Cancer (IARC). California has some of the most aggressive environmental and public health legislation in the world. TDPA® additives do not contain materials presently known by the State of California to cause cancer or reproductive toxicity at a level of exposure subject to the requirements of the California Safe Drinking Water and Toxic Enforcement Act of 1996 (California Proposition 95) nor do they contain any substance that would require a warning notice under the Proposition 65 regulations.

Manufacturing Safety

To assess any potential workplace hazards associated with the manufacture of products utilizing TDPA® additives, EPI commissioned an independent laboratory (Levelton Consultants Ltd.) to determine worker exposure to TDPA® additive during the manufacture of both the additives and products containing them. Results from this study showed that neither the air nor process water were contaminated with the components of TDPA® and that factory exposure levels were several orders of magnitude below the allowable exposure limits. Furthermore, the concentration of airborne metal ions was extremely low, well below the NIOSH (National Institute for Occupational Safety and Health) and WCB (Worker’s Compensation Board) legislated levels.

Food Contact Compliance

Keller and Heckman LLP, an international law firm with expertise in regulatory law, provided an opinion that the TDPA® additives they reviewed comply with food packaging safety requirements as regulated by the United States Food and Drug Administration (FDA) and the European Union's Safety Committee for Food (EFSA).

TDPA® additives are either listed in the FDA's food additive regulations as GRAS (Generally Recognized as Safe) or have been tested to ensure that they are within acceptable limits for rate of migration from plastic packaging into foods with which they are in contact. These additives have been deemed to comply with the US Federal Food Drug and Cosmetic Act and all applicable food additive regulations.

TDPA® additives comply with the relevant European Union (EFSA) and Member State legislation applicable to food contact materials and may be used in plastic food packaging in Europe. Most of the components of TDPA® additives may be used in contact with food without restrictions. Some are subjected to specific migration limits, and tests have shown that these comply with the requirements of the Frame Work Directive (89/109/EEC) and the Plastics Directive (2002/72/EC).

Individual products sold in Canada for direct food contact applications have to be approved by the Canadian Food Inspection Agency (CFIA). For example, for each application incorporating TDPA®, end-product manufacturers are required to obtain approval from CFIA before the product can be used for food contact. A number of applications to date have been approved for products containing TDPA® including polystyrene food trays for meat packaging and polypropylene cutlery.

6. Testing and Performance Evaluation

The use of ASTM test methods for evaluating the susceptibility of polyolefin film products to the effects of heat and sunlight is a well-established practice. For many years, EPI has been testing commercial films and bags containing TDPA® additives using both accelerated laboratory methods as well as outdoor exposures. Typical data are presented in ref. 2. For example, carrier bags, made from HDPE and containing TDPA® were exposed in a QUV machine (laboratory equipment that simulates accelerated real-life conditions of elevated temperature plus UV light) as well as outdoors. The bags were totally embrittled after 144 hours in the laboratory equipment and heavily oxidized (degraded) after 2 months exposure outdoors. Unexposed bags or those containing no TDPA® but exposed were unaffected, i.e., no degradation. Another example is a packaging bag made from polypropylene. These bags containing no TDPA® or with the proprietary additive but without accelerated exposure to heat or UV light showed no changes in properties. The bags containing TDPA® showed complete embrittlement after 96 hours in the QUV apparatus, drastic degradation after 90 days outdoors, and complete fragmentation after 36 days in a lab oven at 71°C.

7. Disposal Environments

Landfill disposal

Many plastic film products end up in landfills after use as a result of municipal waste collection. This is probably the fate of most carrier bags and food wraps although recycling programs of post-consumer plastics are fortunately available in a number of communities. It is of interest then to compare the behavior of conventional carrier bags with those containing TDPA® pro-degradant additives. It is mandated in a number of countries, e.g., Australia, USA, that sanitary landfills are to be operated under conditions as dry as possible, presumably so as to minimize the amount of leachate formed. Since dry conditions do not favour microbial activity, it is assumed by many that biodegradation is not a factor in the conversion of organic waste to gaseous products in landfills. Nevertheless it is a fact that the temperatures in landfills are well above ambient and this is due to microbial activity. Detailed discussion of this situation is found in refs 6 & 7. It is clearly an advantage to have discarded carrier bags and the like degrade in landfills, and repeated testing has proven that polyethylene film products containing TDPA® degrade relatively rapidly in landfills. For example, films made from LLDPE/LDPE blends were shown to undergo significant oxidation with resulting embrittlement as a result of being buried 2 meters below the surface of landfills in China and in Canada for several winter months – only if those films contained TDPA® (ref. 8). Further, the effects of landfill burial (a UK site) for 10 months on LDPE film with and without TDPA® pro-degradant are even more spectacular (ref. 3,10). There were no changes in the buried or unburied control or in the unburied TDPA–PE films. The M_w of the recovered TDPA-PE films had decreased from a starting value of 115,000 to 4,250. At that lower value the oxidized plastic fragments are readily biodegradable.

There is significant microbial activity in landfills owing to the high carbon content of the material in municipal solid waste (MSW), and the ubiquity of microorganisms and moisture. You cannot expect to operate landfills as 'dry tombs' when you are adding food waste and lots of cellulosic materials at the active face. At the surface and for several meters below there will be enough oxygen and water that aerobic biodegradation of the organic matter will occur. A vast array of fungal species and aerobic bacteria will convert carbon to carbon dioxide. A limit to this activity will be the impervious plastic bags, sheets and films that prevent the free movement of gasses and liquids through the mass of organic waste that is contained in or 'protected' by this ordinary plastic. After a time, (months, years) the MSW that is well below the surface or active face will no longer have an adequate supply of oxygen and water to support the aerobes. Then whatever anaerobic bacteria are present will convert (much more slowly) the carbon in the remaining organic material largely to methane, which is 24.5 times more potent as a greenhouse gas than is carbon dioxide. It follows that there are advantages, both environmental and commercial to encouraging rapid aerobic biodegradation while there is enough oxygen and water in the upper levels of the MSW in the landfill. A simple and inexpensive way to do this is to use TDPA® - based oxo-biodegradable polyolefins in packaging since most packaging is deposited in landfills.

Under normal conditions, degradation of EPI's TDPA® - based polyethylene film will begin approximately thirty days after disposal in a landfill (ref. 6). This time to the onset of degradation could be as short as two weeks under ideal conditions or it could be as long as several months under cold, wet conditions. Fragmentation of the films, bags and other containers will follow after abiotic oxidation, aided by the inevitable mechanical stresses (e.g., from compacting equipment) in the landfill environment. This will allow the free circulation of air and water through the upper levels of the waste mass for some time: months at least, perhaps a year or more and the readily biodegradable organic materials in the MSW will be bioassimilated by aerobic microorganisms. This relatively rapid conversion will reduce the volume of waste and this will prolong the useful life of the landfill. Obviously, with so much more material bioassimilated during the aerobic phase, there will be much less to undergo slower anaerobic degradation to produce more damaging methane. Furthermore the site, after filling and capping, will be available that much sooner for other purposes such as recreational fields.

Reduction in Litter Accumulation

Littering of any material is a social problem that cannot be avoided by development of novel plastics technologies. It seems that, in spite of laws, fines and social pressures, a small percent of the population continues to litter owing to ignorance and/or indifference. It has been demonstrated mathematically (ref. 11) that the best if not the only way to prevent the accumulation of litter outdoors is to reduce the lifetime of the littered material. Furthermore, it has been observed over a number of years that the requirement in much of the United States that the polyolefin six-pack ring holders for beverage cans be photodegradable has resulted in a major reduction in the litter and wildlife problems caused when these devices are discarded outdoors. This is the first major application of oxo-biodegradable plastics. It should be remembered that the products of oxidative degradation of polyolefins are biodegradable so there has been no build-up of plastic fragments over the years. The continued use of oxo-biodegradable plastics is not encouragement of littering but simply an effective way to cope with an existing, seemingly perpetual problem.

Composting

Most polyolefin short use-life and other film products will not enter composting units and so compostability of such materials is not an issue. Plastic bags for collecting and transporting compostable material are the exception of course (please see below).

However, there is the mistaken impression that biodegradability and compostability are the same: they are not. Biodegradability refers to the consumption of material by microorganisms. Compostability refers to material that undergoes degradation by biological processes during the composting process to yield carbon dioxide, water, inorganic materials and biomass at a rate consistent with other known compostable materials, leaving no distinguishable or toxic residue. Since managed composting is the only disposal route for plastics for which a standard performance specification has been developed, this standard has often been inappropriately used as the determinant of environmental acceptability. There are numerous situations, soil contact conditions for example, in which biodegradation is an important mechanism for the recovery of value from used/discarded plastics. Compostability is not involved.

Another problem with the mistaken idea that compostability is invariably an asset is that the term can have several different meanings: home composting [not considered here], composting which involves a closed-container maturation period, and outdoor windrow composting. An additional problem is that neither of the composting standards (see below) provides a reasonable facsimile to full-scale composting conditions. Nevertheless, EPI's TDPA® - based polyolefins can provide products that compost nicely in commercial composting facilities.

Plastics that are permitted to enter commercial composting plants must have no deleterious effects on the composting operation, must undergo biodegradation themselves, and must not leave a harmful or toxic residue at the end of the composting procedure. EPI commissioned two composting studies, one in Austria and one in the UK for TDPA® - PE and for TDPA® PP respectively. The results may be summarized as follows:

- An extensive commercial-scale composting trial was carried out by Professor B. Raninger (Leoben University) using the municipal composting plant at Vienna Neustadt in Austria. This plant serves a population of about 100,000 people and typically treats about 10,000 tonnes of mixed household and garden waste annually. Composting occurs in two stages: an in-vessel, forced aeration 'tunnel' process for 2 weeks followed by an outdoor, open pile composting stage. PE bags modified by TDPA® were included in the composting stream at a realistic level (1.1 wt%) for bags in a commercial composter. After 6 months of composting, the final compost produced was of excellent quality and met all the requirements of the Austrian Compost Quality Seal. Test results at the BVA labs (Linz, Austria) showed that the compost with EPI compostable sacks showed minimum or no trace of heavy metals and passed the plant tolerance and seeds and propagules tests (Austrian Standard On 2023). Eco-toxicity tests carried out by Organic Waste Systems (OWS Belgium) according to DIN V 54900-3, ON S 2200 & ON S 2023 indicated absolutely no toxic or harmful by-products. There were no negative effects in the crest test, the summer barley plant growth test, the daphnia test and the earthworm test.

- Another composting study was carried for EPI (Europe) by CalRecovery (Europe) Ltd. In this case the shredded municipal green waste input to an open windrow composting plant located in Leeds, UK contained 1 wt% of a TDPA® PP film produced for short term packaging in garden centers and intended to be composted after use. After 13.5 weeks composting, with occasional turning, the plastic was completely disintegrated to the point where only under well-lit conditions could extremely small film fragments be distinguished. The resulting compost was found to satisfy the disintegration criterion of EN 13432. The plastic film did not interfere with the composting process, did not give rise to any eco-toxicity effects in the final compost, and did not have any negative impacts on the quality of the final compost.

  The results of other composting trials in Canada, USA and Germany are summarized in ref. 8, page 459. It has been shown repeatedly that EPI's oxo-biodegradable plastics compost well and produce good quality composts although they do not mineralize quickly enough to meet the arbitrary time limits in the standards ASTM D 6400 and EN 13432. Of course, neither do oak leaves nor paper. This is because the test methods in those standards derive from the BOD test that had originally been developed to evaluate the environmental persistence of synthetic detergents in inland waterways during the 1950s. Indeed, EN 13432 and EN 14046 require that as-produced plastics must mineralize to 90% within 6 months at $58^{o}C$. This is a ridiculously high rate of biodegradation that fails to meet the requirement of the European Waste Framework Directive which requires that organic waste be reclaimed. There should be as much 'unconverted' biomass and humic material as possible in the compost because this is what imparts the nutritive value in horticultural and agricultural applications of compost. If all the carbon in the compost bags has been converted to carbon dioxide during composting, then there is no recovery and a resource will have been wasted. There is no method of measuring biomass formation in either EN 13432 or in ASTM D 6400, although ASTM has long recognized that organic material in composting operations need not mineralize fully until long after the compost has been utilized as soil conditioner/fertilizer.

Aqueous Media

Discarded plastics are a serious problem in freshwater as well as marine environments. The difficulties in addressing this situation include the complexities of identifying the origins of this pollution and the variety of plastics involved. Alleviation of these problems can occur for those items that are or could be made from polyolefins. If these products are made from TDPA® -based oxo-biodegradable polyolefins, then the combination of heat, sunlight and mechanical stress in the environment will result in the oxidation of the material and bioconversion of the oxidation products. Since PE and PP have specific gravities lower than water, these materials will float and be exposed to UV radiation (sunlight) and heat; degradation and disintegration with drastic molar mass reduction will occur.

Chiellini et al. prepared thermally oxidized LDPE containing TDPA® with acetone-extracted fractions that were even more highly oxidized. These were exposed to microflora present in river water. Biodegradation was assessed by monitoring carbon dioxide generated in a respirometer. Levels of biodegradation up to 12% and 48% for the oxidized fragments and the corresponding acetone-soluble fractions were measured over a 100-day time frame.

8. Recyclability

EPI's TDPA® technology supports sound environmental practices such as reduce, reuse and recycle, but also encourages responsible consumption through the use of plastic materials that do not persist or accumulate in the environment. The post-consumer collection and recycling of used plastics is a good way to conserve resources and to minimize the impact of plastics on the environment. Unlike hydro-biodegradable plastics (those that are claimed to be made entirely or in part from renewable sources) oxo-biodegradable plastics, and in particular those incorporating EPI's TDPA® are compatible with the conventional recycle stream.

Recently, a research study was commissioned by RECYC-QUEBEC (Canada) to evaluate the recyclability of several types of carrier bags available in the province of Quebec. The study was done by an independent research institute (Centre de recherché industrielle du Quebec – CRIQ) that prepared blends of four different types of degradable bags with conventional HDPE bags at degradable bag concentrations ranging from 5 to 50%. The blends were then converted into thin films and into ¼" thick discs. The physical properties of each of these samples were then measured and compared with the HDPE control. Finally, each of the samples was subjected to accelerated aging under conditions of elevated temperatures and humidity with concurrent exposure to UV light, as specified in standard ASTM test methods. The physical properties were measured versus exposure time and compared with the equivalently aged HDPE control.

One of the four types of bags tested in this way was one used by the Quebec Liquor Board (SAQ) that was made by Omniplast Inc. using EPI's TDPA® additive. Only the SAQ bag was found to perform at least as well as the HDPE control in all respects and therefore was deemed to be fully compatible with the conventional polyethylene recycle stream. The other 3 types of bag failed to perform satisfactorily.

9. Cost

The cost to manufacture oxo-biodegradable plastic products, using EPI technology, is only a few percent higher than if the products were made without the TDPA® component. Hydro-biodegradable plastics (those such as linear polyesters that hydrolyze to produce biodegradable products) on the other hand, are generally complicated to produce, lack the economies of large scale production enjoyed by the polyolefins, are characterized by difficulties in recycling in-process scrap, but are subject to the same inflationary feedstock pressures as conventional plastics. Since many of the hydro-biodegradable products use plant-based inputs whose alternative uses are as foods and as inputs for biofuels (e.g., bioethanol) for all or part of their composition, their cost structure is increasingly driven by rising energy costs. They are already considerably more expensive (2-5 times) to manufacture and this is expected to persist or even increase as energy costs increase.

10. Myths vs. Facts

I. Isn't it wasteful to use PE carrier bags?

No it isn't, for the following reasons:

a) It requires much less energy to make PE bags than to make paper bags.

b) More air pollution and water pollution is caused by making paper bags.

c) Transportation costs are much higher for paper bags.

d) Paper bags do not have good wet strength.

e) If plastic packaging were eliminated and replaced with more conventional materials, it has been estimated that that the volume of packaging waste would increase by over 250%, the weight would increase by more than 400%, the energy consumption by over 200%, and costs by more than 200%

II. Wouldn't it be preferable to use plastics that are made from renewable resources, e.g., corn, rather than PE?

No, it would not, for the following reasons:

a) All plastics require energy inputs from fossil fuels for production, fabrication, transportation and the like. Some hydro-biodegradable plastics (so-called renewable plastics) are blends or mixtures with polymers that derive from petroleum sources. Some hydro-biodegradable plastics are made entirely from petroleum products. Those plastics that are made from crop derivatives require the use of synthetic fertilizers, pesticides and the like as well as energy for fermentation, separation and polymerization.

b) Those so-called bio-plastics, made from renewable resources such as food crops, are in competition for food of which there is already a shortage in the world, and for which prices are already too high for tens of millions of people.

c) Those so-called bio-plastics that derive from food such as corn are now in competition also with input for the manufacture of bio-fuels such as ethanol. Long term pricing and supply problems are inevitable. Projections to the time when non-edible green plants can be used for bio-plastics and bio-fuels are not helpful since already vast additional forested areas are being cleared to grow edible crops because lands currently used for agriculture are utilized for growing more corn and palms for bio-fuel.

d) The use of more nitrogen-based fertilizer to grow more corn will increase the amount of N_2O, a greenhouse gas, in the atmosphere.

e) Post-consumer plastics other than the polyolefins (PE, PP) cannot be recycled with the existing plastics recycling stream. Any contamination of that stream by a so-called renewable bio-polymer, including especially the ones containing starch would render the stream useless. This would be a significant waste of resources.

f) In order to obtain different shelf-life/service-life performances for bio-plastics, a different resin would need to be synthesized for each product.
With EPI's technology, the same resins are used for a range of performance criteria, only the additive package needs to be adjusted.

III. Isn't it true that plastic shopping bags have been taxed or even banned in some places?

Yes, that is the case, but these short-sighted political maneuvers have produced no recorded benefits but some detrimental effects.

a) In Ireland, a tax on plastic shopping bags was imposed, apparently to reduce waste and address a litter problem. It was announced after the first year that the use of plastic carrier bags was reduced by about 90%. It was not widely publicized but noted anyway that the consumption of bin liners (plastic bags not subject to the tax) had increased by about 90%. People need something in which to bring home their purchases, and something in which to put their kitchen waste.

b) Proposed legislation in California aims to allow the use only of those plastic bags that are compostable according to ASTM Standard D 6400. The lobby pushing for the acceptance of hydro-biodegradable bags that meet this Standard appears to have succeeded in convincing the authorities that only these bags should be allowed even though they cost more than oxo-biodegradable bags, they cannot be recycled in the existing recycle stream and they, for the most part, will not be collected for composting after use.

IV. Isn't the re-useable grocery bag the obvious environmentally preferred replacement for the PE shopping bag?

No, it isn't for a number of reasons.

a) The multiple-use bags that are commonly available now are considerably more expensive to make than are PE bags, and much heavier to distribute from the manufacturer. They need to be cleaned regularly for health reasons because they will become contaminated with food. They represent a formidable litter problem if discarded carelessly, and they're too expensive to use as receptacles for garbage.

b) Those who ban or restrict the use of polyolefin shopping bags need to be reminded that consumers require something in which to bring home their purchases plus something to put their kitchen waste in. For the reasons described already the shopping bags of choice are those made using EPI's TDPA® technology

c) A typical use pattern for PE shopping bags bringing home the purchases (several times from those stores that deduct a bit from the bill for each used bag), then other uses around the house such as carrying shoes, books etc. and finally in the kitchen for holding food waste before "binning" and transport to the landfill. Any used bags surplus to the waste collection function can be returned to the store for recycling.

It has been explained above that the polyolefin bags made using EPI's TDPA® technology are just as versatile and useful as ordinary PE bags. They can be used, re-used and recycled just like ordinary PE bags, but they do not accumulate in the environment after being discarded. They are, after all, oxo-biodegradable.

11. References

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