

Testing of Degradable Plastics

ASTM Standards and Methods Employed by EPI to Test Degradable Plastics

EPI has developed a wide range of additives to incorporate into polyethylene (PE), polypropylene (PP) and polystyrene (PS) to control the use life, as well as the degradation rate in various disposal environments.

Brief Description of the Oxo-Biodegradable Plastics Degradation Mechanism

Step 1: Oxo-degradation – is an abiotic/chemical stage which begins with the cleavage of carbon chain backbone in PE, PP or PS into shorter chain molecules and the incorporation of oxygen into these molecules as organic functional groups (i.e.: carboxylic or hydro-carboxylic acids, esters as well as aldehydes and alcohols). The hydrocarbon polymers change their behaviour from hydrophobic to hydrophilic thereby allowing the fragmented polymer to absorb water.

Step 2: Bio-degradation – is a microbiological stage in which biodegradation of the fragmented polymer takes place. The molecular weight of the polymer is reduced during the first step to levels that will allow bacteria, fungi and algae to consume the carbon backbone fragments into their trophic process. The end chemical products of the biodegradation step are CO₂, H₂O, a small quantity of minerals and biomass with no toxic or harmful residues to soil, plants or macro-organisms.

The American Society for Testing and Materials (ASTM International) acknowledges the oxo-biodegradable technology in ASTM D 6954–04. This is a standard guide specifically developed for plastics that degrade initially by an oxidative process and subsequently biodegrade. D 6954 prescribes the tests to be done in order to rate these materials in terms of their ability to degrade, biodegrade and to assess their ecotoxicity impact to the environment of the disposal site.

The degradation of plastics incorporating EPI's TDPA® additives is monitored and assessed from the physical, mechanical and chemical point of view in the following manner:

To monitor the physical transformation of degraded plastics, the change in melt index is monitored during accelerated aging and weathering exposure. The melt index is indirectly related to the molecular weight of polymers; so, the lower the molecular weight of the degraded plastic, the higher is the melt index. This is tested in accordance with **ASTM D 1238**.

To assess mechanical transformation, the Elongation at Break is measured. The method used to monitor the change in tensile elongation during the degradation process is **ASTM D 882**. The plastic is considered to have reached its degradation end-point when 75% of the specimens tested have an elongation at break of 5% or less, as per **ASTM D 3826**.

To assess chemical changes in the polymeric structure, FTIR (Fourier Transform Infra-Red) absorption spectra analysis is used. For example, when PE or PP degrades, chemical products with carbonyl groups in their molecules are generated; these may be: alcohols, aldehydes, carboxylic acids, etc. Control samples of plastic film with no TDPA® additives and samples of plastic film incorporating TDPA® additives are tested in the FTIR before the onset of degradation and periodically during the degradation process until the sample is totally degraded. During the testing, the film samples incorporating TDPA® additives will show the continuous accumulation of chemical products with carbonyl groups when compared to regular control samples; indicating the chemical changes associated with the polymer degradation process.

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1. ASTM D 1238

This method covers the measurement of the rate of extrusion of molten resins through a die of specified length and diameter under prescribed conditions of temperature, load and piston position in the barrel. The melt viscosity for PE, PP or PS is expressed by the melt index, a property tested under standard conditions. The melt index is indirectly related to the molecular weight of polymers. So, where a TDPA® incorporated plastic sample has a higher melt index than a control sample without TDPA® additives, the melt index indicates that the molecular weight of the TDPA® incorporated sample has decreased and is therefore degrading.

2. ASTM D 882

This method covers the determination of tensile properties of plastics in the form of thin sheeting, including film (less than 1.0 mm in thickness). This test is used to monitor the change in tensile elongation during the degradation process. The tensile modulus of elasticity is an index of the stiffness of thin plastic sheeting which has a direct relationship with degradation of the polymeric material. Samples with additive and control samples are tested using this method at zero time exposure and at various time intervals until the degradation end point is reached. The Degradation End Point is defined in ASTM D 3826.

3. ASTM D 3826

This method covers the determination of the degradation end point (a brittle point) for degradable PE/ PP films and sheeting less than 1.0 mm in thickness. The degradation end point is that point in the history of a material when 75% of the specimens tested has a tensile elongation at break of 5% or less.

4. ASTM G 53 + ASTM D 5208

These test methods cover the principles and operating procedures for using the fluorescent ultraviolet (UV) and condensation apparatus to simulate the deterioration caused by sunlight and water as rain or dew. Samples to be tested are "aged" according to the conditions/ procedures in these methods. The weathering data obtained represent comparative data measuring the difference in degradability before and after UV exposure.

5. ASTM D 5576

Using an FTIR spectrometer, the accumulation of chemical products with carbonyl groups in polyolefins is monitored.

6. ASTM D 5510

This method defines the exposure conditions of plastics at various temperatures when exposed solely to heat conditions. After exposure, samples will be tested based on this method which replicates the conditions in end-disposal environments (landfill and composting).



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