OXO-BIODEGRADABLE PLASTICS ASSOCIATION

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TIMESCALES FOR DEGRADATION

It is important to remember that there are four phases to the life of an oxo-biodegradable plastic product.

1. Shelf-life
2. Service-life
3. Oxidation and Disintegration
4. Biodegradation

1. Shelf-life

When oxo-biodegradable plastic products are made, they will usually be packed in a cardboard, plastic or other opaque packaging and therefore shielded from ultra-violet light and with very little or no access to oxygen. Whilst they remain in this packaging at normal room temperatures or below, no significant degradation will occur.

2. Service-life

After removal from their packaging, the oxo-biodegradable products need to have a service-life during which they are in all respects fit for purpose. The length of the service-life is decided by the commercial end-user. Service-life is determined by the formulation within the additive (not the amount of the additive), for the particular resin package, and the additive-supplier adjusts the formulation accordingly.

Typically, supermarkets expect a combined shelf-life and service-life for a carrier-bag of about 18 months, because they have to keep stocks, and wish to encourage customers to re-use many times for shopping and other purposes before final disposal. Carrier bags are not “single-use” bags. For a bread-wrapper a shorter combined shelf-life and service-life of about 6 months, could be specified, though some may request a longer period.

If collected during phase 1 or 2 the product may be safely recycled with ordinary plastic
http://www.biodeg.org/position-papers/recycling/?domain=biodeg.org

3. Oxidation and Disintegration

At the end of the service-life of the product the pro-degradant additive causes the molecular chains within the polymer to break down. This is done by a process of oxidation and will therefore occur only if oxygen is present. It can occur in the

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open environment or in the upper layers of a landfill, but deeper down in a landfill, if conditions are anaerobic, the process stops and the undegraded material will not emit methane. This is important because methane is a greenhouse gas 23 times more powerful than CO2. By contrast hydro-biodegradable plastics (usually bio-based and marketed as compostable) do emit methane in anaerobic conditions.

The oxidation phase is purely abiotic and does not depend on bacteria or other micro-organisms, nor is moisture necessary. As oxidation proceeds the molecular-weight of the polymer decreases rapidly from 250,000 Daltons or thereabouts to an average of 40,000 when it no longer has the physical properties of a commercial polymer. The average molecular-weight continues to descend to 5,000 or less.

The molecular structure is then completely different and it has even at 40,000 already been converted to inherently biodegradable low molecular-weight materials such as aldehydes, alkenes, ketones, alcohols, ethers, esters, and peroxides, which are similar or in most cases identical to those formed during bio-degradation of natural materials. The fragments resulting from the oxidation process will stick to soil particles and will not be easily wind-borne, as they are hydrophilic compared to the original polymer which is hydro-phobic.

The process requires only oxygen. It does not need sunlight or elevated temperatures, but these will synergistically accelerate the process. The time taken to reduce to an average value of 5,000 Daltons depends on the amount and intensity of heat and/or light, but would normally be less than 6 months from commencement of oxidation in the open environment in temperate climates. In warmer climates it would be faster and in arctic conditions slower.

This is the timescale on which legislators need to focus, because the material will then be no longer a plastic; it will have lost its strength and will be no longer capable of entangling wildlife or blocking drains. It will not by that time be visually intrusive, and it is not toxic. Testing of oxo-biodegradable plastics includes a standard OECD test to demonstrate non eco-toxicity.

4. Biodegradation

At the end of the oxidation phase the biodegradation phase begins, and it may be partly concurrent with the oxidation phase. It is not necessary for the material to be composted, and biodegradation will continue in normal environmental conditions until about 90% biodegradation has been achieved. The remaining 10% is transformed into harmless biomass through microbial activity.

Accordingly, the time taken for the biodegradation phase to be completed is not important. A leaf could take many years, and ASTM D6954 allows a combined oxidation/biodegradation period of two years for 60% of a single oxo-biodegradable polymer to convert to CO_2. BS8472 does not impose a time limit at all.

It is not in fact necessary to repeatedly perform expensive and very time-consuming carbon-evolution tests to demonstrate biodegradation if it has been established by GPC tests according to ASTM D6474-99 that the material has descended to 5,000 Daltons or less, as described above. The fragments then include oxygen as organic functional-groups.

The Standards for compostable plastic such as ASTM D6400, EN13432, Australian 4736, ISO 17088 etc. require the material to convert itself substantially into CO_2 gas within 6 months. This is the timescale required by industrial composters, for whom time is money, but such a short timescale is not necessary for oxo-biodegradable plastic, which is designed to biodegrade in the open environment. Nor is a high rate of conversion desirable, because conversion to CO_2 gas contributes to climate-change and depletes the carbon available for the soil.