OXO-BIODEGRADABLE PLASTICS ASSOCIATION
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Recycling of Biodegradable Plastics

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The science and mechanisms of biodegradation

Commercial biodegradable plastics fall into two distinct classes distinguishable by their biodegradation mechanisms.

1. Oxo-biodegradable Plastics

Oxo-biodegradable plastics have been in commercial use since the 1970s, and are based on commodity polyolefins, particularly polyethylene and polypropylene. Their technological performance during manufacture and use is indistinguishable from that of regular polyolefins, and their biodegradation is caused by an additive which promotes transition metal ion oxidation in the presence of atmospheric oxygen.

The length of the useful life of the plastic products is determined by antioxidants (processing stabilisers and UV stabilisers) contained within the additive, and the additive can be formulated so that the plastic product degrades according to whatever timescale is required.

Oxo-biodegradable plastics can be collected in the main polyolefin waste stream for recycling and are fully compatible with regular polyolefins.

If the new product to be made from recyclate is intended to be degradable, the process is quite straightforward, as a pro-degradant effect is actually desired. This applies particularly to closed-loop recycling in plastic factories, or where used oxo-biodegradable "back-of-shop" plastics (e.g. shrink-wrap

and pallet-wrap) are sent back for recycling into more oxo-biodegradable products.

However, as polyolefins will always suffer a loss of properties during recycling, whether the recycling feedstock contains oxo-biodegradable plastic or not, the manufacturer using the recyclate to make a new product may need to add stabilisers, and/or further pro-degradant additive, to achieve the desired result, depending upon the use for which the new product is intended.

Similarly, if the new product to be made from recyclate containing oxo-biodegradable plastic has a very thick cross-section, (such as road cones, garden furniture etc), the process is straightforward. Again, whether the recyclate contains oxo-biodegradable plastic or not the manufacturer of the new product will need to add stabilisers to maintain the mechanical strength that would otherwise be diminished during the process. If suitably formulated, these stabilisers will neutralise any residual pro-degradant additive.

If the new product to be made from recyclate is a film intended for long-term use, such as a damp-proof membrane, the manufacturer of the new product should always add stabilisers to ensure strength and longevity, whether the recyclate contains oxo-biodegradable plastic or not. As already indicated, these stabilisers will neutralise any residual pro-degradant additive

2. Hydro-biodegradable Plastics

The second class of biodegradable plastics is the hydro-biodegradables, which are generally based on intermediates of biological origin derived from crops. Crop-based plastics were developed some 20 years after their oxo-biodegradable counterparts, and there are two sub-classes of different origins.

The earliest was poly (3-hydroxy butyrate), PHB, produced biologically from sucrose. This is an expensive product with a relatively low thermal decomposition temperature, which was partially overcome by varying the structure of the alkanoate structure (PHA). The second sub-group of hydro-biodegradable polyesters are the synthetic aliphatic polyesters, which are in some cases based on biological intermediates (e.g. poly(lactic acid), PLA),

Both sub-groups are physically incompatible with main stream plastic wastes and even with commercial polyesters, due to their thermal instability.

Plasticised starch is a different type of bio-based plastic used in packaging. This material has acceptable initial properties but has poor durability due to hydrolysis in the presence of oxygen during use, and cannot normally be re-processed for use in the same application. Starch-based plastics hydro-biodegrade rapidly, but only in microbial environments, and they emit methane under anaerobic conditions. Like other bio-based plastics, they are

not compatible with mainstream plastics used in packaging and cannot be recycled into useful secondary products.

Conclusions

Oxo-biodegradable plastics can be recycled and can be made from recyclate, but hydro-biodegradable plastics cannot.

The degradation of oxo-biodegradable plastics is controlled by stabilisers which inhibit abiotic oxidation. The same stabilisers control the performance of plastics during reprocessing and second use.

No equivalent stabilisation procedure is possible in the case of hydro-biodegradable polymers, and such bio-based polymers are not normally physically compatible with main- stream polymers.