Oxobiodegradable Polyolefins: Their Biodegradation and Recycling

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Plastic is a familiar component of modern living used in all sorts of packaging, household and commercial applications. The manufacture of thermoplastics converts light oil fractions that would otherwise be flared, into lightweight plastics. In essentially every life cycle analysis of plastics, in comparison with other materials e.g. packaging, the use of plastic demonstrably leads to major savings in energy, weight and pollution. Whilst the benefits of lightweightness, strength, imperviousness to gas and water, transparency, sealability, printability and low cost are highly regarded, the very strength and durability which makes plastic such a useful and economic material can be a major problem when disposal is required. One of the most useful and economic of the new technologies, it produces plastics which degrade by a process of oxo-degradation.

Biodegradation and Recycling – The oxo-degradation technology is based on a very small amount (1 or 2%) of prodegradant (pro-oxidant) additive being introduced into the conventional manufacturing process, thereby changing the behavior of the plastic. The degradation of the plastic begins when the programmed service life is over (as controlled by the additive composition) and the product is no longer required. Polyolefins (PE, PP, PS), as commercial products, are resistant to oxidation due to the presence of antioxidant and stabilizers. They can be made oxobiodegradable by the use of pro-oxidant additives. The most active pro-oxidants are those which are based on transition metal salts capable of yielding two metal ions of similar stability and with oxidation number differing by one unit only, e.g. Mn^{2+}/Mn^{3+}. Thus, the material degrades by a free radical chain reaction involving oxygen from the atmosphere. The primary products are hydroperoxides, which can be thermolysed or photolysed under the catalytic action of the pro-oxidant leading to chain scission and production of low molecular mass oxidation products such as carboxylic acids, alcohols, ketones and low molecular mass hydrocarbon waxes. Peroxidation leads to hydrophilic surface modification, which is favorable to micro-organisms, which can bio-assimilate the low molecular mass oxidation products. The various pro-oxidants and their effects on polyolefins and in various environments will be discussed.

Recycling – The lifetime of any oxo-biodegradable product before the onset of rapid oxidation to embrittlement is controlled by the ratio of the pro-oxidant and antioxidant concentrations. Up to the point where the antioxidant is completely depleted and oxidation of the polymer starts, there is no change to the polymer structure. If the plastic is included in a recyclate stream before degradation starts, it will take with it its pro-oxidant. However, the bulk of the plastic will contain antioxidants but not pro-oxidant. The result is that the pro-oxidant effect is completely swamped by the massive excess of antioxidant.

This effect was demonstrated in the third-party study commissioned by the Government of the Province of Quebec, where it was shown that carrier bags made from oxobiodegradable PE with pro-oxidant from EPI (Environmental Products Inc.) are entirely compatible with conventional plastics recycling, at mixtures up to 50%. The recycling of OBP in comparison with BP will be presented.

CONCLUSIONS

Oxo-biodegradable plastics degrade by a combination of oxidation and biodegradation in times which are long compared to many bioplastics but acceptable for many applications:

- Oxo-biodegradable plastics are compatible with existing recovery/recycle processes.

- Oxo-biodegradable technologies have the potential to reduce the environmental impact of polyolefins and to create new markets in agriculture and packaging.