OXO-BIODEGRADABLE PLASTICS ASSOCIATION

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PLASTICS IN THE MARINE ENVIRONMENT

Introduction

"If all the plastic had been made with oxo-biodegradable technology there would be no ocean plastic garbage patches.[1] "

In the 2012 study published in the Marine Pollution Bulletin[2] "Occurrence of micro-plastics in gastrointestinal tracts of pelagic and demersal fish from the English Channel" it was shown that the majority of plastic particles consumed by the fish were rayon (57.8%) and polyester fibres. These are derived from clothes, hygiene products and nappies.

Recent research in the Great Lakes has found pollution by microbeads used in cosmetics.

Micro-plastics are not therefore necessarily derived from plastic bags nor even from packaging of all types- which normally use polyethylene and polypropylene. Nor have they been shown to absorb toxins to any greater extent than other particles in the sea.

Oxo-biodegradable plastics do not contribute to pollution - on the contrary, they are bioassimilated into the bio-background. This is because the material descends to low molecular-weight materials much more quickly than normal plastic. At that stage they are no longer plastics and have become biodegradable in the same way as a leaf or seaweed. They do not therefore float around in the sea for decades absorbing other materials.

Oxo-biodegradable plastics are not intended to deal with litter in homes and offices. They are designed to biodegrade in the open environment when exposed to natural phenomena such as wind, rain, sunlight, etc and to do so in a synergistic relationship to micro-organisms naturally occurring in the open environment.

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[1] Professor Gerald Scott, DSc, FRSC, C.Chem, FIMMM , Professor Emeritus in Chemistry and Polymer Science of Aston University, UK; Chairman of the Scientific Advisory Board of the Oxo-biodegradable Plastics Association; Chairman of the British Standards Institute Panel on Biodegradability of Plastics.

[2] Lusher, A.L., et al. Occurrence of microplastics in the gastrointestinal tract of pelagic and demersal fish from the English Channel. Mar. Pollut. Bull. (2012), http://dx.doi.org/10.1016/j.marpolbul.2012.11.028

The theory of absorption of toxins by micro-plastics is still a theory. At the University of Washington Tacoma seminar (Autumn 2008)[3] Prof. Thompson was reported as using the language of opinion rather than fact;-

"Thompson's research and various studies have *suggested* that plastic specks in the water column and sediment *appear* to absorb highly toxic and pervasive pollutants, such as PCBs (polychlorinated biphenyls) and pesticides such as DDT (once commonly used to eradicate agricultural and forest pests, and now banned in the United States and other countries). As one *theory* goes, if the oceans' smallest organisms are dining on plastics dosed up with toxins, then highly concentrated chemicals *could possibly* accumulate up the food chain."

Discussion

1. Polychlorinated biphenyls (PCB) had been widely used globally up until the early 1970's as additives in many product groups such as plastics, lubricating oils, greases and electrical installations. Their properties of low conductivity, high heat resistance and chemical stability has meant that they had been known to persist in the environment, but they have now been banned in many countries. One reason for the ban was the persistence of such toxins in the sea surface micro layer of the marine environment.

2. The following summary review demonstrates that it is highly improbable for oxo-biodegradable plastic materials to adsorb and accumulate these toxins in the marine environment.

Review

3. Several studies have been done, including those by Pascall *et al,* Takada *et al*, Mato *et al* and Teuten *et al*, which demonstrate that *conventional* polymers such as polyethylene and polypropylene will readily adsorb PCB and other toxins. This is because the polymers are inherently non-polar and hydrophobic in nature, and with a low Tg (glass transition temperature), their rubbery nature allows for greater segmental mobility, pore-size, free volume, diffusion and partition coefficients. This means that hydrophobic organic toxins such as PCB can in theory adsorb to the polymers (through Van Der Waals attractive forces) from the aqueous environment.

[3] http://www.tacoma.uw.edu/news/microplastics-threatens-oceans-marine-life

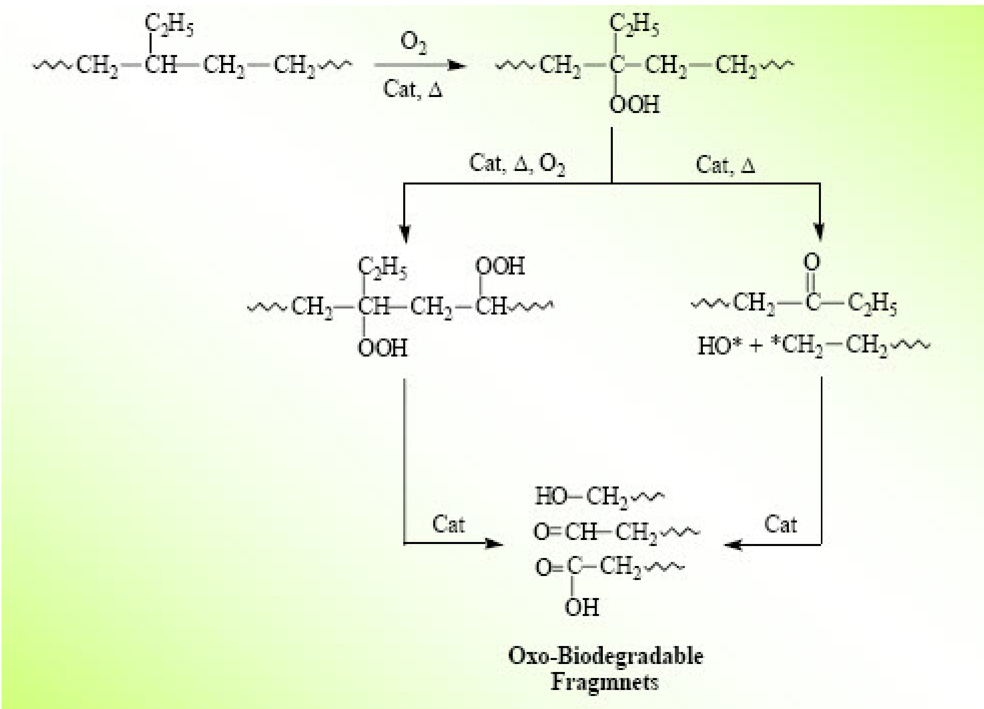
4. The increased pore-size and free volume also means that if the toxin is adsorbed to the polymer, it will not readily desorb, and thus over long periods of time the polymer will break down by shear, friction and weathering, and the potential for the plastic material to adsorb toxins is present. Takada *et al* demonstrated that in a field experiment in Tokyo Bay conventional plastic fragments collected from the bay had adsorbed up to 892 ng/g. This suggested that the plastic had persisted in that area for at least twenty-seven years (assuming a linear uptake profile).

5. Pascall et al included polyvinyl chloride and polystyrene in their study. The results from their field experiments demonstrated a significantly lower adsorption uptake of

6. PCB toxin. The difference in chemical structure resulting in differing polarity of the polymer, more rigid packing (demonstrated by higher Tg) resulting in restricted segmental mobility, and restricted pore size explains the reduced adsorption observed.

7. This information helps to build a picture of what would be expected for oxo-biodegradable polymer materials. Under the action of oxygen, UV light, and moderate heat, polyethylene and polypropylene containing oxo-biodegradable additives will change their molecular structure and break down by a mechanism analogous to that shown in Figure 1.

Figure 1, Chiellini, CEEES



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Workshop (2005) Confederation of European Environmental Engineering Societies

8. Figure 1 demonstrates how hydroperoxy intermediates are readily formed in the initial phase of degradation, and immediately there is a change in chemical structure and increase in polarity. The formation of these oxygenated species already makes the polymer less attractive to adsorption of PCB and related hydrophobic toxins. Lower diffusion and partition coefficients result from increased cohesive forces, reducing segmental mobility and pore-size. The highly polar functional groups that are formed will not interact with the non-polar toxins either through chemical reaction or intermolecular interaction.

9. The second stage of degradation is the molecular-weight reduction of the hydroperoxy intermediates (with the vicinal form proceeding more rapidly) to intermediate and short-chain aldehydes, ketones, esters, and hydroxyl and hydrocarbon radicals. These will proceed further to carboxylic acids which will be readily bioassimilated by micro-organisms.

10. In summary the constantly progressing chemical breakdown of the polymer results in species with increased hydrophilic character that will readily solubilise and emulsify in the ocean environment. It would, therefore, not be possible for hydrophobic toxins such as PCB to accumulate on oxo-degradable plastic materials

Conclusion

11. It is sometimes suggested that plastic materials, in particular polyethylene and polypropylene, will adsorb and accumulate hydrophobic toxins that can be found in the sea surface micro layer. However in this review it has been shown that such plastics when treated with additives such as d_2w will change their chemical and physical properties during degradation and that hydrophobic toxins will not be readily adsorbed.

12. There is, therefore, no reason why oxo-biodegradable plastic materials would provide a route for hydrophobic toxin accumulation and the potential to harm marine life-forms, or provide an entry route for these chemicals into the human food chain. No experimental evidence has been published that links oxo-biodegradable plastic materials with the accumulation of persistent hydrophobic toxins in the oceans.

13. Oxo-biodegradable plastics can therefore play a useful role in reducing plastic pollution of the oceans. Indeed if all the plastic had been made with oxo-biodegradable technology there would be no ocean garbage patches.

Work referenced in the Discussion

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