OXO-BIODEGRADABLE PLASTICS ASSOCIATION

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OPA CHALLENGES ENZYMATIC AND MICROBIODEGRADABLE ADDITIVES

1. There is a recently-developed class of plastics consisting of conventional petroleum-derived resins containing additives sometimes described as enzymatic and sometimes as microbiodegradable, additives. These are not oxo-biodegradable plastics. It seems reasonable to believe that the additives themselves will biodegrade, but will they make the plastic biodegrade?
2. Aggressive marketing indicates that these additives can promote the biodegradation of a host of polymers including, polyethylene, polypropylene, polyester, polystyrene, PVC, etc. in a time frame from a few months to several years, and even when buried deep in landfill.

PERFORMANCE CHARACTERISTICS

3. It is difficult to believe on the published scientific evidence that incorporation of these additives into a polymeric matrix will render the resultant plastic article biodegradable at all, and on the basis of known scientific principle it is hard to see how they can. In addition, degradation of PVC may produce toxic residues that are highly dangerous.
4. It seems that the product consists of a starch or polycaprolactone (PCL) matrix often extended with mineral filler, with no pro-degradant catalyst salts in the composition.
5. The basic idea seems to be to add a functional hydrophobic (eg PCL) to the polyolefin, which assists in the *disintegration* of the plastic product by the penetration of water and microorganisms into the chains, and as a consequence in biofilm formation. However, unlike an oxo-biodegradable additive it does not change the plastic into a biodegradable material.
6. The presence of biodegradable ester groups probably promotes an increase in the microbial population around the plastic wastes, because the oxygenated organic residues are a source of carbon and energy for the microbes. However, this could give a false reading in a CO2-evolution laboratory test, suggesting that the plastic itself is biodegrading.
7. The difficulty is to make large and apolar molecules such as polyethylene and polypropylene biodegrade by enzymatic action. This seems improbable, for it is precisely because PE and PP do not present a metabolic pathway for enzymes that their barrier properties are useful for food-packaging.
8. The inherent durability of polyolefin materials is provided by their hydrophobicity and high molecular-weight, and the hydrophobic nature of polymers prevents bacterial colonisation. How does the additive overcome these properties to allow degradation of the polymer by microbes?
9. It appears that the additives could act on a polymer in the second or biotic stage of degradation but it is difficult to accept in the absence of a prior period of abiotic degradation, that any biodegradation of the polymer - as distinct from the additive - can occur.
10. Previous chemical degradation, whether hydrolytic or oxidative, would be essential to reduce the size of the polymer molecules and introduce polar

oxygenated groups and unsaturates into the chain. This step could occur through the use of oxo-biodegradable additives incorporating transition metal salts, but it seems that the "enzymatic" or "microbiodegradable" additives being marketed do not contain such salts, and there is no mention of any other chemical substitute which could induce free-radical reactions to promote the degradation of the plastics.

11. It is not therefore possible to think of chemical degradation, leading to biodegradation, of an oil-based polymer without the transition-metal salts or without extensive exposure to environmental factors (UV, heat, mechanical stress) which can induce oxidation/degradation over a long period of time.
12. One of the "microbiodegradable" additives was analysed and found to be based on a high melt-index LDPE incorporating some CaCO3, TiO2 and a small concentration of primary antioxidant (heat stabilizer). No other chemical compounds were found. A film made with this additive was analysed and found to contain inorganic filler derived from CaCO3 and some primary antioxidant and approx. 400 ppm of a secondary stabilizer. Based on this analysis, these films cannot biodegrade.
13. Likewise, one of the "enzymatic" additives was analysed, and was found to consist of a spongy mass of polycaprolactone containing granular starch. It did not contain transition-metal cations. A bag apparently made with the additive was also analysed. It was found to consist mainly of polyethylene , with granular starch and a very high level of calcium carbonate crystals. It is likely that the bag would disintegrate, but unlikely that the polyethylene would biodegrade.
14. The companies promoting these products will produce test reports, but there seems to be ambiguity in the testing. It is for example often unclear whether the data refers to the additive or the final product, e.g. the packaging article in which the additive is included. Also, is the CO2-evolution recorded in the test, coming from degradation of the plastic or of the additive?
15. Also, some of the testing seems to be on blends of material using much higher addition-rates of additive than that which is recommended in the marketing documents and on the websites. Adding a high proportion of a starch cellulose or PCL to a conventional plastic will obviously alter its properties, processing-characteristics, and recyclability, but the strength and fitness-for-purpose of products extended in such a manner must be doubtful.
16. Some of the laboratory reports refer to biodegradation tests according to ASTM D5538 performed on samples that contain 50% of the additive in a polymer matrix. Other tests look at microbial colonisation of film containing 5% additive and pure (100%) additive pellets. These tests are not helpful, and are more appropriate for bacterial and fungal resistance testing. Similarly anaerobic degradation (ASTM D5511) tests appear to have been performed on a sample of the additive itself as opposed to a plastic article with the additive included.
17. Other biodegradation tests have been conducted on a powder instead of a degraded film, but the disintegration test in EN13432, para. 7 requires that ..."Unless technically impossible the packaging, packaging material or packaging component shall be tested for disintegration in the form in which it will ultimately be used"
18. Another brand of these types of additive was reviewed by an experienced polymer consultant in 2010 who reported as follows: "There is no viable evidence that the technology is capable of delivering on the claims that the additives can convert commodity plastics of all types to completely biodegradable analogs. The claims are as misleading as those made by many others, which use a similar approach of organic additives to promote biodegradation in commodity plastics. Both approaches have been tried several times before by a number of groups using starch and fatty acids

which were found to be unsuccessful and never implemented commercially. The technology is inadequate and claims based on it are unfounded.”

19. Further, if biodegradation is by an enzymatic process, how can the enzymes survive the processing conditions within the melt-processing equipment?
20. In short it is unlikely that these additives will work as claimed.

LANDFILLING OF “ENZYMATIC” and “MICROBIODEGRADABLE” PLASTICS

21. With regard to claims that these additives will promote degradation in landfill, Para. 260.7 (c) (2) of the Green Guide issued by the Federal Trade Commission of the United States provides “that marketers should clearly and prominently qualify [compostable] claims to the extent necessary to avoid deception if the claim misleads reasonable consumers about the environmental benefit provided when the item is disposed of in a landfill.” Consumers may be deceived if the marketer does not draw attention to the fact that some plastics can generate methane deep in landfill and that methane is a dangerous greenhouse gas.
22. Some landfills are designed to collect the gas, but a company cannot know when marketing a product whether the product will be disposed of in one of them.
23. The EU Landfill Directive 1999/31/EC has required a substantial reduction in the amount of biodegradable material going to landfill, and plastics which biodegrade in landfill (which oxo-biodegradable plastics do not) are therefore unacceptable in Europe.
24. It is likely that sending plastics to landfill will be banned altogether in Europe. In its Green Paper published on 7th March 2013 (COM(2013) 123 final) the European Commission says "From a resource efficiency perspective, it is particularly important to prevent landfilling of plastic waste. Any landfilling of plastic is an obvious waste of resources which should be avoided in favour of recycling, or of energy recovery as the next best option."