Biodegradable Plastics Association

A not-for-profit Association

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BPA RESPONSE TO

DEFRA's Hazardous Substances Advisory Committee (HSAC)

review (July 2019) of "oxo-degradable" plastics -

We agree with HSAC that "Many of the advantages, conveniences and indeed environmental benefits of modern life brought to us over the past 70 years have been thanks to the employment of plastics. …. Plastic films and packaging have provided health and safety benefits, reduced food waste and lowered the costs of transportation."

"Such applications typically employ plastics from the polyolefin family (long chain polymers formed from alkanes) and include polyethylene and polypropylene. … The benefits of these plastics come from their properties of durability, flexibility, water repellence and light weight."

HASC say that about 4% of our fossil fuels go towards plastics manufacture and they cite Hopewell et al., 2009, who in turn cite the British Plastics Federation, but the BPF themselves offer no data to support their assertion. Oil is not primarily extracted to make plastics - it is extracted to make fuels for vehicles, ships, and aircraft, and would continue to be extracted if plastics did not exist. Plastic is made from a by-product of the refining process. Some electricity is of course used to drive the machinery, and this may come from hydro, fossil-based, or renewable sources, but is less than the energy used for recycling plastics, and in the production of paper.

The BPF go on to say, and we agree, that:

• The production of plastic products uses far less energy compared to those made from alternative materials. Substituting plastics with alternatives would increase the lifecycle energy consumption of these products by approximately 57% and the greenhouse gas emissions would rise by 61%.

• Plastics reduce the consumption of oil elsewhere. They reduce the weight of vehicles, aircraft, ships, packaging and products, meaning that less fuel is burned and CO_2 emissions are lower.

• Used plastics can be recycled numerous times. If it doesn't make economic or environmental sense to recycle, then the energy can be recovered through incineration, as used plastics have a higher calorific value than coal.

The HSAC say that "There is a now a worldwide realisation that plastics, particularly those associated with single use applications, are accumulating in the environment due to their poor degradative characteristics. This is particularly notable in the marine environment, where the problem appears to be getting rapidly worse." "Based on existing studies, it might be predicted that it would take 300 to 500 years for the complete breakdown of an LDPE or HDPE product." **This is why oxo-biodegradable plastic was invented.**

The HSAC Review is notable for its failure to distinguish between oxo-degradable and oxo-biodegradable plastics. While the Review is said to be about oxo-degradable plastics, it is really about oxo-biodegradable plastics, and we will respond to the Review on that basis. HSAC say “it is not clear if such terms have been standardized” but they ought to know that they have in fact been standardized.

“Oxo-degradation” is defined by CEN (the European Standards authority) in TR15351 as follows:

“degradation identified as resulting from oxidative cleavage of macromolecules.” This describes ordinary plastics, which abiotically degrade by oxidation in the open environment and create microplastics, which do not become biodegradable except over a very long period of time. No Standard has been written for measuring the degradation of these plastics.

By contrast, “oxo-biodegradation is defined by CEN as “degradation resulting from oxidative and cell-mediated phenomena, either simultaneously or successively”. This means that the plastic degrades by oxidation (which is accelerated by a catalyst) until its molecular weight is low enough to be accessible to bacteria and fungi, who then recycle it back into nature. These plastics are tested according to ASTM D6954, BS 8472, and comparable standards.

HSAC say that “Current commercial oxo [bio]degradable plastics appear to be largely related to single-use polyethylene and polypropylene packaging, and agricultural films. This is correct. As to agricultural films, see below.

HSAC continue “Within the parent material are embedded what are known as prodegradants which appear to be chiefly metal-organic complexes which help catalyse light and heat stimulated fragmentation of the polymer sheets” – Why did HSAC not ask us, instead of trying to guess? The prodegradants are usually salts of manganese or iron which catalyse the natural process of oxidation, which in turn reduces the molecular-weight. They are put into a masterbatch which also contains stabilisers, and the skill in formulating the masterbatch is to achieve the right balance between the two ingredients so as to give the finished product a suitable shelf-life and service-life.

HSAC say “It would seem that temperatures above 40 °C are necessary for the heat activated reaction to be effective (Bonhomme et al., 2003). This is not correct, and the cited work does not make that claim. If this were true we would never see degradation outside the laboratory and this is clearly not the case. Bonhomme et al use several temperatures to evaluate degradation in order to determine degradation rate at ambient conditions (this is the Arrhenius approach - by measuring the rate at different temperature you can determine how temperature effects the rate of reaction). They observed degradation even in the samples stored at 5 and 20C.

HSAC say that “a demonstration of degradation, or biodegradation being underway can be reported as an increase in carbonyl groups, a reduction in tensile strength, a reduction in molecular weight, additional CO_2 being generated or by the presence of microorganisms within the plastic structure itself (Table 2). These signals of partial degradation are different to the demonstration of the complete loss of the parent material."

Yes, this is obvious. Just showing a carbonyl peak in FT-IR, or that a material has reduced tensile-strength, is useful, but not determinative. However, since sufficiently low mw oligomers are known to be biodegradable, biodegradability can be shown by demonstrating conversion of the material to molecular weights less than 5,000 g/mol.

HSAC say that “Although this fragmentation into smaller and smaller plastic particles should be a helpful precursor to biodegradation, this has rarely been observed in a convincing manner outside laboratory conditions.” HSAC will know that the EN13432 standard for “compostable” plastic requires biodegradation to be tested in a laboratory (not in a compost heap) but they seem to expect oxo-biodegradable plastic to be tested in outdoor conditions. This has been done in the

Oxomar project, sponsored by the French Government at their marine facility in the South of France. https://www.biodeg.org/wp-content/uploads/2021/07/Final-report-OXOMAR-10032021.pdf

This was a three-year interdisciplinary study, and the scientists said in their report that "The goal of this task (C3Task2) was to evaluate the biodegradation of OXO-bio in marine waters. This task has been divided in two parts by (i) following several months of OXO-biocolonization by marine microorganisms under natural conditions and (ii) by evaluating the biodegradability of OXO under natural conditions as compared toa cultivated microorganism with known PE-biodegradation abilities."

In conclusion they reported that "We have obtained congruent results from our multidisciplinary approach that clearly show that oxo-biodegradable plastics biodegrade in seawater and do so with a significantly higher efficiency than conventional plastics. The oxidation level obtained due to the d2w prodegradant catalyst was found to be of crucial importance in the degradation process." See also the report from Queen Mary University 11th February 2020. https://www.biodeg.org/wp-content/uploads/2022/10/QM-published-report-11.2.20-1.pdf Para 2.6 says "prior to testing, samples of LDPE and oxo-LDPE were surface-weathered in sea water for 82 days, undergoing natural variations in sunlight and UV intensity

"As to the correlation between laboratory tests and the real world, the evidence of Dr. Graham Swift, (Vice-chairman of the relevant Technical Committee at ASTM) is as follows: "It has been my experience that results from laboratory testing are very likely to be reproduced in the real world. I can see no cause for concern that they would not, and have seen no evidence that they have not." https://www.biodeg.org/wp-content/uploads/2021/02/Swift-evidence-to-BEIS.pdf

HSAC is incorrect in saying that "fragmentation into smaller and smaller plastic particles" is the precursor to biodegradation – the precursor is the reduction in molecular weight, which converts the plastic into monomers and oligomers with little or no tensile strength, so they fall apart.

If oxo-biodegradable technology merely caused fragmentation it would be much less useful, and the relevant Standards – ASTM D6954; BS8472; AFNOR T81-505; UAE 5009/2009; SASO 2879 etc would not include tests for biodegradation.

The process is described by Professor Ignacy Jakubowicz as follows: "The degradation process is not only a fragmentation, but is an entire change of the material from a high molecular weight polymer, to monomeric and oligomeric fragments, and from hydrocarbon molecules to oxygen-containing molecules which can be bioassimilated." https://www.biodeg.org/wp-content/uploads/2020/05/Reply-to-Ellen-MacArthur-Foundation-from-Prof-Ignacy-Jakubowicz-21-8-17.pdf

It is possible to test for degradation in the natural environment, and it has been "observed in a convincing manner outside laboratory conditions" for example in seawater in the south of France as noted above. It is then a simple matter to measure the molecular-weight of the degraded residue. It follows that if the molecular weight is c5,000 or less the material is biodegradable.

Table 2 in the HSAC Report shows a very simplified version of test results. Each study uses different materials and different methods, and has different objectives. A lot of time and money has been spent to tell us that oxo-biodegradable plastic doesn't meet the composting standards, which it is not designed to do. In fact, there are many reasons why even the industrial composters themselves consider that plastics marketed as compostable are not useful. https://www.biodeg.org/subjects-of-interest/composting/

There is in this HSAC Report an over reliance on simply putting samples outside, which is intuitively more pleasing but is no substitute for scientific evidence obtained in a laboratory. The cited studies are taken at face value - for example we know that O'Brine and Thompson did see advanced degradation (if you look at the data and not their conclusions) - and only trivial chemical analysis of the samples was done - only a qualitative FT-IR scan.

Yashchuk (2012) was a test on composting of film exposed for only a short time (96 hours UV). We would not expect enough degradation to see any significant results.

HSAC say “There is no guarantee that oxo (bio)degradable plastics would receive the necessary pre-treatment of light and heat to start the fragmentation process.” In fact, UV light and heat will accelerate the process but elevated temperatures are not necessary, and only a short exposure to uv light is required to inactivate the stabilisers in the masterbatch. As oxo-biodegradable technology is intended for plastics which escape into the open environment as litter, it is most unlikely that they will not receive the requisite exposure to sunlight. In the hypothetical event that they did not, the performance of the plastic would be no better and no worse than ordinary plastic.

Thereafter, the performance of oxo-biodegradable plastic is quite different from photo-degradable plastic. Photo-degradable plastic requires continuous exposure to sunlight, but oxo-biodegradation will continue even in the dark.

HSAC say “There is no guarantee that discarded oxo-degradable plastics will receive sufficient light and or thermal pre-treatment before they enter waste disposal systems to facilitate degradation.” However, oxo-biodegradable plastics are not intended for waste-disposal systems – they are intended to biodegrade if they get into the open environment from which they cannot realistically be collected.

A report was published in 2017 by the Ellen MacArthur Foundation and endorsed by some of the world’s largest producers of the very plastic packaging which is polluting the oceans. It was also financially supported by companies who market plastic as “compostable” who see oxo-biodegradable plastics as a threat to their market-share. The Report claimed that “oxo-degradable” plastics [sic] simply fragmented into tiny pieces of plastic - but having engaged with our scientists they no longer say that.

They now admit in their May 2019 report that oxo-biodegradable (which they still incorrectly describe as “oxo-degradable”) plastics are manufactured so that they can degrade faster than conventional plastics and that **they do become biodegradable**, but they say that “it is not yet possible accurately to predict the duration of the biodegradation for such plastics.”

Any such prediction depends on factors which are variable in the open environment, and for that reason a broad indication only can be given as to timescale. It is however possible to say with certainty that at any given time and place in the open environment an oxo-biodegradable plastic item will become biodegradable significantly more quickly than an ordinary plastic item (Queen Mary University say 90 times faster- https://www.biodeg.org/wp-content/uploads/2022/10/QM-published-report-11.2.20-1.pdf)

That is the point. - Do we want ordinary plastic which can lie or float around for decades (HSAC say 300-500 years) or oxo-biodegradable plastic which will be recycled back into nature much more quickly? Of course, we don’t want plastic in the environment at all, but that is not the present reality.

Will it fully biodegrade? It is well known that plastic whose molecular weight has been reduced is much more capable of biodegradation than ordinary plastic, and we have heard no reason from any scientist why, once degradation has commenced, it should not continue until the material has become biodegradable and biodegradation is complete. Even if it did not fully biodegrade it would be better than ordinary plastic, which would not have biodegraded at all.

It is not important how long a particular piece of plastic in a particular place will take to biodegrade – the importance of oxo-biodegradable technology is that it will reduce the overall burden of plastic in the environment.

HSAC say “There is very little helpful literature available either on long-term field trials of biodegradation or ecotoxicity tests on a range of organisms for these plastics.” With regard to eco-toxicity tests, oxo-biodegradable plastics are tested according to the OECD Standards, and are non-toxic. The industry Standards for oxo-biodegradable plastic such as ASTM D6954 or BS 8472 require that the standard ecotoxicity tests be performed, and the results will be found in the reports of the independent test houses who have tested according to those standards. These are not usually published, because they are very expensive and are commercially confidential. They could however have been made available to HSAC if they had asked. The ecotoxicity tests are essentially the same as those performed on bio-based plastics according to ASTM D6400 or EN 13432.

HSAC say "It should be noted that in a review of the relative risk of 71 different chemicals found in Britain's rivers, Cu came 1st (highest danger), Mn came 7th, Fe came 8th and Ni 12th in terms of risk (Johnson et al., 2017). Consequently, the dispersion of more of these metals into the environment, particularly if they were to enter water courses would be unwelcome.” Oxo-biodegradable masterbatches are usually based on Fe or Mn, and do not contain any substances in excess of the limits permitted by Art 11 of the EU Packaging Waste Directive 94/62/E or Annex A.1.2 of EN 13432.

The ecotoxicity tests are done with a much higher concentration of oxo-bio plastic than would be present in the environment.

With regard to “field trials of biodegradation” see the Oxomar report above.

The relevance of oxo-bio technology to agricultural films is that if farmers use ordinary film it will not degrade when they want it to degrade, and when they harvest their crop they will have to remove acres of contaminated plastic from their fields, which is time-consuming and therefore costly work. It cannot be burned or sent to landfill, but in some areas it may be collected for recycling.

Recycling is not however a good option, because if the film has been exposed to sunlight in the fields it will have degraded to the point where it is no longer fit for recycling, and it will also be contaminated with soil and/or organic matter. Also, collection for recycling attracts very large vehicles to country lanes, causing congestion, pollution, damage to the roads, and possibly danger of accidents. Also, the recycling process is expensive and complicated, and the resulting product is of lower quality than what you put in. There are no carbon-reduction benefits. You transport it around, then you have to wash it, then you have to chop it up, then you have to re-melt it, so the collection and recycling itself has its own environmental impact.

A better option for farmers and growers is to use oxo-biodegradable plastic, so that the plastic will degrade at the appropriate time, and can be ploughed into the soil where it will be consumed by naturally-occurring bacteria and fungi. This should be a reasoned exception to the circular economy idea. Symphony Environmental Technologies Plc has conducted successful field trials , and is able to supply a suitable product. https://www.biodeg.org/wp-content/uploads/2020/09/Pembroke-Mulch-Film-Trial-Report-30.09.13V1.pdf

The type of plastic marketed as “compostable” is not suitable for agricultural mulch films because the degradation time cannot be programmed, the material is not strong enough, it is too expensive, it does not properly biodegrade outside the special conditions found in an industrial composting unit, and it does not convert into compost.

HSAC say “Although there is worldwide concern over microplastic pollution of the environment, it remains the case that lethality to wildlife is more closely associated with large and intact plastic material.” This is correct, so it is highly desirable that the dwell-time in the environment of plastics as macro-plastic should be as short as possible.

HSAC then say “a plastic which disintegrates more readily, may be at odds with the current strategy of controlling losses to the environment.” Yes, all plastics, whether biodegradable or not should be collected and properly disposed of, but if an item of oxo-biodegradable plastic has not been collected during its useful life it probably never will be. It is not realistic to expect that all the plastic will be collected, and there is currently **no policy for the plastic which is not collected**. The policy should be to use oxo-biodegradable technology, which is available now, at a very low cost.

RECYCLING

HSAC then say that oxo-biodegradable plastic might compromise the quality of recycled plastics.

As to recycling, see https://www.biodeg.org/subjects-of-interest/recycling-2/

It is well known that plastics marketed as “compostable” will compromise the quality of recycled plastics, but they are not rejected by policymakers for that reason.

Plastic cannot of course be recycled unless it is collected, and oxo-biodegradable technology is intended for plastic which does not get collected. Even if the plastic can be collected, Greenpeace reported in October 2022 https://www.greenpeace.org/usa/reports/circular-claims-fall-flat-again/ that “mechanical and chemical recycling of plastic waste fails because plastic waste is extremely difficult to collect, virtually impossible to sort for recycling, environmentally harmful to reprocess, often made of and contaminated by toxic materials, and not economical to recycle.”

Any objection to oxo-biodegradable plastic, on the basis that it might contaminate a post-consumer waste stream, is clearly inapplicable if the relevant waste plastic is not going to be mechanically recycled. See the video at https://youtu.be/NLkfpjJoNkA which explains why recycling of most types of plastic makes no sense in economic or environmental terms.

Also, the presence of pro-oxidants is not important if the recyclate is to be used for short-life products such as carrier bags, garbage sacks, or general packaging, where biodegradability is desirable.

Whilst almost all pre-consumer waste (eg factory offcuts whose composition is known) is recycled, almost all post-consumer waste plastic is not. There are reasons for this, one of which is that a great deal of water is needed to wash post-consumer waste to make it useable, so the amount of waste-water generated is enormous. Moreover, this process leaves prodigious quantities of dirty solid waste, including biological waste that is hazardous and highly undesirable.

The recycling charity RECOUP says (“Recyclability by Design”) that “where plastic products are particularly lightweight and contaminated with other materials, the energy and resources used in a recycling process may be more than those required for producing new plastics. In such cases recycling may not be the most environmentally sound option.” It is too costly in financial and environmental terms to collect it, transport it, sort it, bail it, store it, and then reprocess it, and that is why it was being dumped in the forests in Asia. These are exactly the kind of products for which oxo-biodegradable technology is used.

By contrast, PET bottles are worth collecting for recycling, but oxo-bio technology is not compatible with PET and will not be found in PET bottles.

Mechanical recycling is not relevant to oxo-biodegradable agricultural film, because the intention is that it should biodegrade on the farm, where it will be organically recycled back into nature.

Users of recyclate cannot in any event assume that the recyclate does not contain pro-oxidants even if oxo-biodegradable plastic is not present. Conventional plastics may contain pro-oxidant additives that were added for different intended functionalities. For example, colorants in general can act as pro-oxidants. If they partake in the creation of radicals or reactive oxygen species, such as singlet oxygen (1Δg), they can trigger photo-degradation of the polymer matrix." Conventional plastic products have been found to regularly contain Fe, Ba, Ti, Zn, Cu and V. Some individual conventional plastic bag samples also contain Cr and Pb.

HSAC themselves say "This abiotic degradation mechanism is well known by the manufacturers and, ironically, it is common for plastics to contain additives to reduce propensity for this form of degradation. To this end, antioxidants are added to slow down abiotic degradation."

Long-life products such as damp-proof membranes are normally made from virgin polymer, but if recycled material is used for lower-grade products it would have to be stabilised anyway, as advised by the Austrian specialist laboratory TCKT in para. 1 of its March 2016 report. http://www.biodeg.org/TCKT%20Report%2017.3.16(1).pdf The experts say "long-life films should be made with virgin polymer, or be stabilized to deal with loss of properties caused by the recycling process, whether or not any pro-degradant additive is present. Such stabilization would effectively neutralize the effect of any pro-degradant additive."

Although oxo-biodegradable plastic is used for low-value items which are not worth recycling, the experts in Austria (TCKT Report para. 4) and South Africa (Roediger Report May 2012 page 3 http://www.biodeg.org/ROEDIGER%20REPORT%2021%20May%202012.pdf) have confirmed that plastic products made with oxo-biodegradable technology may be recycled without any significant detriment to the newly formed recycled product.

This accords with the experience of OPA members who have recycled many thousands of tons of oxo-biodegradable plastic over the past 20 years without any adverse effects.

The best way to deal with contaminated post-consumer plastic film is to send it to modern, non-polluting, thermal recycling facilities and to use the energy released from the plastic to generate electricity, instead of wasting it by sending to landfill.

EUROPEAN UNION

See https://www.symphonyenvironmental.com/eu-court-case-update/

CONCLUSION

In 2019 an independent review of the scientific evidence was conducted by Peter Susman QC at the request of Symphony Environmental and concluded that:

- oxo-biodegradable technology does facilitate the ultimate biodegradation of plastics in air or seawater by bacteria, fungi or algae, within a reasonable time, so as to cause the plastic to cease to exist as such, far sooner than ordinary plastics, without causing any toxicity; and
- the benefit is obvious of reducing future contributions to the scourge of plastic pollution of land and sea"

See also the paper published subsequently by Queen Mary University London noted above.

The OPA is satisfied on the scientific evidence that under normal conditions in the open environment oxo-biodegradable plastic will degrade and then biodegrade significantly more quickly than ordinary plastic, and the dwell-time of plastic in the environment will be significantly reduced. For that reason ordinary plastic should be replaced with oxo-biodegradable plastic as soon as possible.

HSAC also say:

- "we only appear to have evidence on the fate of oxo-degradable [sic] plastics containing metal-based complexes and not for those with organic prodegradants. It is not clear if organic prodegradants are present in commercial products." OPA members use metal salts, usually of manganese or iron, and we are not convinced of the efficacy of organic prodegradants.

- "It would be useful to know if the incorporation of biodegradation promoters such as cellulose or starch offer benefits to the biodegradation of polyolefins." The OPA does not think it does. They may cause the plastic item to fragment, but we are not convinced that they cause the plastic itself to biodegrade.