BPA RESPONSE TO DEFRA's Hazardous Substances Advisory Committee (HSAC) review of "oxo-degradable" plastics July 2019

1 The first point to note in the HSAC Review is the 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 it on that basis. HSAC say "it is not clear if such terms have been standardized" but they have in fact been standardized as follows:

1.1 "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 degradation of these plastics.

1.2 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 and comparable standards.

2 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."

3 "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."

4 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[1] but the BPF themselves offer no data to support their assertion. Some electricity is of course used to drive the machinery, and this may come from hydro, fossil-based, or renewable sources, but 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, and does not therefore contribute to fossil-depletion.

The BPF go on to say that:

4.1 "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.

4.2 "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%.

4.3 "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: used plastics have a higher calorific value than coal."

5 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.

6 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 true. As to agricultural films, see below.

7 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" – This is nearly correct. The prodegradants are usually organic salts (also called soaps) of manganese or iron which catalyse the natural process of oxidation, which in turn reduces the molecular-weight.

8 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. The metal typically makes up less than 10% of the catalyst and is added at trace levels only to the plastics. An oxo-biodegradable additive will typically contribute much less than 0.01% metal.

[1] https://www.bpf.co.uk/press/oil_consumption.aspx

9 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 ageing equipment used in 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 20°C.

10 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."

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

12 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.” This is not correct. It is not “fragmentation into smaller and smaller plastic particles” which is the precursor to biodegradation – it is the reduction in molecular weight of the polymer itself, which in turn results in loss of cohesion.

13 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.

14 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.” http://www.biodeg.org/Reply%20to%20Ellen%20MacArthur%20Foundation%20from%20Prof%20Ignacy%20Jakubowicz%20-%2021-8-17.pdf

15 It is not difficult to test for degradation in the natural environment, and it has been “observed in a convincing manner outside laboratory conditions” for example in seawater at Bandol in the south of France. It is then a simple matter to measure the molecular-weight of the degraded residue.

16 However, it is futile to attempt testing for *bio*degradation in the open environment – because it would be impossible to measure CO_2 evolution (which is the standard measure of biodegradation) under those conditions. Scientists have therefore devised laboratory protocols over many years which

simulate the natural process of biodegradation, and similar laboratory protocols are used for testing "compostable" plastic according to EN13432 or ASTM D6400. The degraded residue of an oxo-biodegradable product, taken from natural outdoor and laboratory degradation has been observed at Queen Mary University London to be consumed by bacteria commonly found on land and in the sea.

17 The most recent report from QMU was published in February 2020 and can be seen at https://www.biodeg.org/wp-content/uploads/2020/02/published-report-11.2.20.pdf In that report the researchers say that the study "demonstrated a clear correlation between the molecular weight of the sample and CO_2 released, taken as a measure of biodegradability" and that "the biodegradation of oxo‐LDPE (+450 h UV) was 90‐fold greater than that of LDPE (+450 h UV), and 45‐fold greater than that of unaged oxo LDPE after 35 days."

18 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 composters themselves consider that compostable plastics are not useful.[2]

19 There is in the HSAC paper an over reliance on simply putting samples outside, which is aesthetically and intuitively more pleasing but is no substitute for laboratory evidence. 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.

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

21 HSAC say "There is no guarantee that oxo-degradable plastics would receive the necessary pre-treatment of light and heat to start the fragmentation process." In fact it is necessary only for the plastic to be exposed to air. UV light and heat will accelerate the process but are not essential. It is in any event most unlikely that the plastic would not be exposed to both. Oxo-biodegradable plastic technology is designed to deal with plastic which escapes into the open environment as litter where it will almost certainly be exposed to UV light, and to ambient heat. Elevated temperatures are not necessary. It could possibly be deprived later of light or heat or both, but the process of oxidation once started, will continue. In the hypothetical event that it did not, the performance of the plastic would be no better and no worse than ordinary plastic.

22 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 the producers of crop-based plastics, who see oxo-biodegradable plastics as

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[2] https://www.biodeg.org/oregon-composters-dont-want-compostable-packaging/

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.

23 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.”

24 Any such prediction depends on variable factors, and for that reason a broad indication only can be given as to timescale. It is known that conventional plastic fragments do not become biodegradable for many decades, but it is 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.

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.

25 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 reasons from any scientist why, once degradation has commenced, it should not continue until the material has become biodegradable and biodegradation is complete. In any event even 60% conversion to biodegradable materials means 60% fewer microplastics in the environment.

26 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.

27 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, the Standards for oxo-biodegradable plastic such as ASTM D6954 require that standard 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.

28 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 ecotoxicity tests are done with many times higher concentration than would be observed in the environment. They show no toxic effects.

29 With regard to "field trials of biodegradation" it is, as mentioned above, futile to attempt testing for *bio*degradation in the open environment because it would be impossible to measure CO_2 evolution under those conditions. This has to be done in a laboratory, and the scientific literature is available.

30 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.

31 This is not however a good environmental option, because it 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. The carbon-reduction benefits are also unclear. 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.

32 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. These mulching films have to be bespoke products for the particular crop which the farmer wishes to grow, under the particular climatic conditions on his farm, Symphony Environmental Technologies PLC has conducted successful field trials[3], and is able to supply a bespoke product.

33 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 macro-plastic should be as short as possible.

34 HSAC then say "a plastic which disintegrates more readily, may be at odds with the current strategy of controlling losses to the environment." They give no reasons why this should be the case, and all plastics, whether biodegradable or not should be collected and properly disposed of where possible. However, 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. The policy should be to use oxo-biodegradable technology, which is available now, at a very low cost.

RECYCLING

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

[3] https://www.symphonyenvironmental.com/resource/successful-farm-trial-for-oxo-film/

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

37 Compostable plastics convert into CO_2, not compost, and turning plastic into CO_2 cannot of course be described as recycling.

38 Mechanical recycling is not relevant to oxo-biodegradable agricultural film, because the intention is that it should biodegrade on the farm.

39 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.

40 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.

41 By contrast, PET bottles are worth collecting for recycling, and oxo-bio technology is not suitable for use in their manufacture.

42 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.

43 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.

44 Moreover, conventional plastics may contain pro-oxidant additives that were added for different intended functionalities. For example, colourants 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. Users of recyclate cannot therefore assume that the recyclate does not contain pro-oxidants.

45 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." These anti-oxidants would neutralize any pro-oxidant residue in any oxo-biodegradable plastic in the feedstock.

46 Obviously 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

47 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."

48 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.

49 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.

EUROPEAN UNION

50 "A report was prepared in 2017 which reviewed the topic of oxo-degradable plastics and the environment (Hann et al., 2017) to help inform The Commission." It did not recommend a ban.

51 The OPA response to this report may be found at https://www.biodeg.org/wp-content/uploads/2019/12/opa-comment-on-the-eunomia-report-2016.pdf

52 Eunomia noted that "the industry had no specific standard to meet, which left the ground open to claims that may be confusing to consumers." In fact the industry tests its oxo-biodegradable products according to ASTM D6954, and the OPA has issued its own standard for determining whether a product is oxo-biodegradable.[4] We would have no objection to this being made mandatory.

CONCLUSION

[4] http://www.biodeg.org/wp-content/uploads/2018/09/opa-standard-specification-oxo-biodegradable-pe-pp-film-finished-products-aug-2018.pdf

53 In 2019 an independent review of the scientific evidence[5] was conducted by Peter Susman QC at the request of Symphony Environmental and concluded that:

53.1 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

53.2 the benefit is obvious of reducing future contributions to the scourge of plastic pollution of land and sea"

55 See also the paper published subsequently by Queen Mary University London[6] and mentioned above.

55 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.

56 HSAC also say:

56.1 "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. That is an entirely different technology which should not be confused with oxo-biodegradable technology.

56.2 "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

56.3 "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." Oxo-biodegradable plastics are not intended for degradation in waste-disposal systems – they are intended to biodegrade if they get into the open environment from which they cannot realistically be collected.

[5] https://www.biodeg.org/uk-judge-find-the-case-for-oxo-biodegradable-plastic-proven/

[6] https://www.biodeg.org/wp-content/uploads/2020/02/published-report-11.2.20.pdf