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Mr. Mark Blainey,
European Chemicals Agency,
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Mark.BLAINEY@echa.europa.eu
May 3rd, 2018

Dear Mr Blainey,

Re: Response to the EU report on oxo-plastics, January 2018

I am writing to you as I am deeply concerned with the conclusions of the EU Commission's report[1] (16/01/18) and the subsequent proposal to ban oxo-plastics in the EU. I request that the proposal to ban oxo-plastic be retracted due to conclusions drawn from my own research outlined below.

Scientific Research at QMUL

I am a research scientist at Queen Mary, University of London, a member of the Russell Group of Universities and I have over 20 years' experience in the fields of biochemistry and microbiology. Over the last three years, together with a team of chemists and geobiologists, we have conducted a range of microbiological and biochemical tests to investigate the molecular mechanisms of plastic and polymer biodegradation.

Firstly, we have discovered that many of the testing methods used to date are insufficient to fully assess biodegradation and bio-toxicity[2,3]. Consequently, any previous conclusions reached on the bioavailability of any form of plastic do not give the full picture regarding the efficacy, environmental and biological impact of any part of the degradation process.

Importantly, we have applied our methods and compared the biodegradation of LDPE and oxo-LDPE in a fully defined and sealed environment by a bacterial species typical of a marine or a soil environment. Under these conditions we have observed significantly higher rates of carbon assimilation as a result of microbial activity once oxo-LDPE has undergone some degree of ageing[2]. Abiotic degradation of plastic causes a significant drop in the molecular weight of the oxo-polymer that is not observed for conventional LDPE. The oxidation of the polymer also makes the molecule more readily accessible for microbial mediated enzyme activity. Once biodegradation of a long carbon-hydrogen chain has begun there is no reason to believe that assimilation would not continue to occur until all the material has been consumed by the micro-organisms. In the laboratory, biodegradation is not expected to proceed as quickly or as fully as it would in the open environment[4]

[1] EU: *The impact of the use of oxo-degradable plastic, including oxo-degradable plastic carrier bags, on the environment* (2018).
[2] This work is currently undergoing peer review prior to publication in a scientific journal.
[3] Castro-Aguirre, E. *et al*. 2017. Insights on the aerobic biodegradation of polymers by analysis of evolved carbon dioxide in simulated composting conditions. *Polym. Degrad. Stab.* **137**, 251-71
[4] We have just begun testing plastic with environmental cultures and expect this work to be completed by the end of the year.

since the plastic is the only source of carbon and other nutrients cannot be replenished. Additionally, plastic in the environment has been shown to be colonised by many microorganisms[5], and not, as we have tested, a single species. Nonetheless, we clearly observed higher rates of oxo-plastic consumption compared to LDPE.

Further to my own research, I herewith include my direct response to several major features raised in the EU report that I urge be re-evaluated.

Addressing EU report

1. Research and science

The EU report states that experiments on oxo-LDPE are carried out "over too short a time span" and "give no conclusive evidence". This data will be forthcoming, as I have presented here, but rigorous, responsible, cross-disciplinary research of <u>any</u> type of plastic be it bio-based, biopolymer, oxo- or LDPE is costly and slow. To date, tests on oxo-plastic only compare against LDPE, where oxo-LDPE fares better. There are very few independent studies that subject all forms of plastic to the same conditions simultaneously. Until this has been carried out, there is no conclusive evidence to present any type of plastic as having a greater environmental impact.

I am troubled by the apparent desire of the EU Commission to discredit a single type of modified plastic; it does not send the positive innovative message that is needed. Further, the EU report heavily cites a single author that is dismissive of primary scientific sources[6]. Academic publications are subjected to severe scrutiny during the peer review process; provision of plastic from a company must be stated but does not force the scientist to present only data supporting a particular industry.

2. Fragmentation of plastic

Micro and nanoparticles exist in the open environment. They are a product of the breakdown process of LDPE released over the last 50 years. There is no technology available to remove it, though there is evidence of certain bacteria that have evolved to consume it[7]. These tiny pieces of plastic are part of a transitory phase during the disintegration of the polymer prior to inclusion in the carbon cycle. The EU report clearly acknowledges that oxo-plastic undergoes an accelerated rate of fragmentation, which could reduce entanglement and catastrophic ingestion by higher organisms. However, what has been omitted is that the oxo-plastic additive catalyses the depolymerisation of the primary carbon chain that makes a plastic bag. Not only is the physical plastic bag breaking down, but the long polymer hydrocarbon chain is oxidised and reduced in size, termed abiotic degradation. The lower molecular weight organic compounds are more readily assimilated by microorganisms as the molecules start to resemble naturally occurring compounds such as fatty acids[8]. I explained this directly to Commission officials in Brussels on 30th November 2017 as I wanted them to understand this fundamental point. I am concerned by the omission of this evidence from the Commission's report.

There is no evidence that standard LDPE undergoes any oxidation. Indeed only macroscopic and not molecular degeneration is observed. It is noteworthy that bio-based LDPE differs from LDPE only in the source of the carbon that comprises the backbone (coming from sugar cane rather than oil).

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[5] Dussud, C. *et al.* 2018. Evidence of niche partitioning among bacteria living on plastics, organic particles and surrounding seawaters. *Environmental Pollution.* **236,** 807-816

[6] Ellen MacArthur Foundation. 2017. Oxo-degradable plastic packaging is not a solution to plastic pollution and does not fit in a circular economy. Endnote 6. Less than 10% of references are peer reviewed scientific studies.

[7] Yang, J. *et al.* 2014. Evidence of Polyethylene Biodegradation by Bacterial Strains from the guts of Plastic-Eating Waxworms. *Environmental Science and Technology.* **48** (23). 13776-13784

[8] Kawai, F. *et al.* 2004. Comparative study on biodegradability of polyethylene wax by bacteria and fungi. *Polym. Degrad. Stab.* **86,** 105–114

Consequently, bio-based LDPE degrades in the exact same manner as LDPE *i.e.* slowly. Thus bio-based LDPE is not a better alternative than LDPE or oxo-LDPE. However, it is not included in the reference to ECHA.

3. Biodegradation in the marine environment

Previous reports[9] have attested to the lack of evidence for biodegradation of oxo-LDPE in the marine environment. There are no standards for <u>any</u> type of plastic under these conditions. We are working hard to address the lack of rigorous and non-polluting testing methods and have demonstrated, in the laboratory, that oxo-LDPE can be assimilated by bacteria commonly found in the oceans. I would find it irresponsible to impose powerful legislation with the little scientific data currently available.

4. Plastic in the food chain

The report rightly raises concern regarding incorporation of plastic into the food chain. However, there is no evidence to suggest that this is unique to oxo-plastic and rather that such assimilation will occur for all forms of plastic, be it bio-based, a true biopolymer, oxo- or LDPE. This is not a reason to ban a single form of plastic. Further, no toxic effects of the degradation of the specific oxo-LDPE additive have been shown either in our experiments or when subjected to standard testing methods.

Conclusions

There is no doubt that the current rate of plastic accumulation is unacceptable and new policies to restrict our reliance on plastic are needed. However, we still have very little understanding of the biological and chemical mechanisms of plastic breakdown. Importantly, we have no evidence at this point that <u>any</u> current commercially available form of plastic has greater toxicity during the degradation process. Indeed, oxo-plastic has been shown to have a higher rate of degradation compared to conventional LDPE, which is the main cause of accumulated plastic waste and microplastics.

To this end, I am surprised that the EU are proposing to ban a product that is certainly no worse than the unmodified LDPE that is not subject to the same action. Legislating against a single form of plastic is not the way to resolve the accumulation of many forms of poly-hydrocarbon but actively goes against EU policies that call for redesign and innovation.

I implore ECHA not to propose a restriction and allow more independent, scientific research to be carried out.

Yours sincerely,

Dr Ruth Rose

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[9] EU commission, Eunomia. (2016).The impact of the use of oxo-degradable plastic on the environment.

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Finland

Pisa, 9th May 2018

Mark.BLAINEY@echa.europe.eu

Respectful Mr. Blainey,

I had recently discovered that the European Commission has made reference to European Chemicals Agency (ECHA) under Article 69 (1) of REACH, alleging that Oxo - Biodegradable Plastics constitute a risk to human health and environment.

By looking at that question from my more than half century involvement in R&D activities in Polymer Science & Technology at Academic & Industrial level, let me say that I think it would be a serious mistake if Oxo-biodegradable Polymeric Materials & Relevant Plastic Items(OBPs) would be banned or restricted in the EU. It is not correct to say that OBP technology produces just fragments of plastic, and I cannot agree with the January 2018 Report of the Commission that there is any case for banning or restricting them.

In OBP, very small amounts of pro-oxidant/pro-degradant additives (1-2% by weight) are added to conventional formulations of PE and PP during their processing to make relatively short service-life packaging items or mulching films. This causes oxidative degradation much more quickly than in conventional plastics, and converts the plastic into oxygen-containing which are known to be biodegraded by microorganisms present in the terrestrial and aquatic environmental compartments. All this happens under normal conditions, and no special conditions are necessary. Light and heat will accelerate the oxidation process of OBP but they are not essential, and nor is moisture essential for this process.

The biodegradation produces H_2O, CO_2 and Cell Biomass, but under anaerobiosis, instead of CO_2 there is production of methane so it is not desirable for anything to biodegrade deep in Landfill.

Recently in the scientific literature it has been reported that the PE oxidized material can be converted by specific microorganisms like *Ralstonia Eutropha* to poly(hydroxy alkanoate)s as reserve materials.

The use of pro-oxidant/pro-degradant additives based on fatty acid salts of transition metals like Fe, Co, Mn, Ni is safe and the very small amount used in OBPs is justified by their tandem role in the regeneration of the “redox” action.

The OBPs, once they have experienced oxidative degradation by spontaneous or induced environmental ageing, are not going to accumulate in the various environmental compartments, thus ruling out any addition to the environmental burden of “microplastics”.

Also, I want to stress that contrary to the allegation that OBPs can cause problems in the recycling of PE & PP plastic items at the end of their service life, I have never heard any reports of any such problems. There are in addition scientific publications including two authoritative Reports (see attachments of the first pages of the Reports available on request) stating their compatibility with mechanical recycling.

As a conclusion let me say that OBPs must continue to be available in the European Union because they are much better for the environment than conventional plastic and do not present any risks to human health or the environment. Their position in commodity packaging is placing no demands on resources from feed & food chains, and they can be made by existing plastic factories without any problems.

The above considerations are validated by the research activities performed over many years by the Research Group I was directing (see attachment) as well as from the contributions given by international research groups from all over the world. (see attachment)

I am attaching quite a few docs including my CV that I hope might be useful to you for understanding my position in favour of OBPs. If you need some other inputs and clarifying elements on the points that I have raised in the present letter and relevant attached files I would be more than pleased to satisfy your requests.

As you most likely are aware, OBPs are being accepted in Developed as well as in Developing Countries and Countries in transition, and in some countries there is legislation which makes them mandatory. They are not dependent on land and freshwater resources needed for the ever growing demand for food and feed applications as the World population is expected to reach from the present 7Bn something like 10 Bn in year 2050.

Yours-Sincerely.

Emo-Chiellini.

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Datum 2018-04-18 Beteckning

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Comments on the request to the European Chemical Agency to prepare a restriction to oxo-biodegradable plastics

We have taken note of the request from the European Commission on the restriction proposal on oxo-biodegradable plastics (OBP). As motivation, three main reasons are given by the commission:

1. OBP may not degrade under all relevant environmental conditions
2. OBP could negatively impact on the quality of plastic recyclates
3. OBP constitutes a potential risk to the environment because of their potential to generate microplastics

In our opinion, as it stands, this request provides no scientific based reasons for the proposed restriction on used of oxo-biodegradable plastics.

Plastics derive their mechanical properties from their long chains. Thus, biodegradation of all types of polymers (both synthetic and natural) requires an abiotic chemical process to cleave the chains to molecules small enough to penetrate the cell membrane to be metabolized. Consequently, the rate of degradation of polymers depends on the type of polymer and environment (temperature, oxygen, moisture, etc.). OBP are identical to conventional plastics but containing small amounts of prodegradant additives.

Comment to reason 1 – The term "biodegradable" is only meaningful if the environment and the period is specified. For this reason there are various standard test methods to verify biodegradability under specific conditions e.g. ISO 14855 - ultimate biodegradability under controlled composting conditions, ISO 17556 - ultimate biodegradability in soil, EN 14987 - disposability in waste water treatment plants, ISO 14853 - ultimate anaerobic biodegradation in an aqueous system, etc. Consequently, the first argument applies to all biodegradable materials not only to OBP.

Comment to reason 2 – OBP have the same properties as the corresponding conventional plastics. They are also designed to have a certain service life using stabilizers before they start to degrade. It has been proven in several studies that OBP can be recycled together with corresponding conventional materials without negative impact on quality of recyclates. Furthermore, consumption of the OBP materials is negligible compared to the total demand for plastics. In this context, the presence of small amounts of OBP will not have any significance for the quality and long term properties of the recylates. This has been proven in an experimental work, reported in the scientific paper (*Polymer Degradation and Stability 97 (2012) p. 316-321*).

Comment to reason 3 – As mentioned above, polymer based materials derive their mechanical properties from their long chains. However, hydrocarbon polymers contain structural elements that are susceptible to oxidative degradation reactions. Therefore, they always contain stabilizers that are used to protect the polymer during melt processing and to protect the finished article upon exposure to light and air. During use, the stabilizers are continuously consumed and when they are gone the degradation process begins. It can be emphasized that the mechanism of oxidation is essentially the same with or without prodegradants but the prodegradants significantly accelerate the oxidation. Microplastics are always formed as intermediate in the degradation process regardless of whether it is regular plastic or OBP but the period between the beginning of degradation and bioassimilation is much shorter for OBP. Consequently, OBP should constitute less risk if any to the environment regarding microplastics formation.

Finally

OBD materials are not a general solution to the environmental problems but they provide benefits for the environment in some specific applications in the same way as other biodegradable materials do.

RISE Research Institutes of Sweden AB
Energy and circular economy

Ignacy Jakubowicz
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<u>Comments on Oxo-Biodegradable Plastics</u>

Graham Swift, Ph.D., Polymer Consultants, 10378 Eastchurch, Chapel Hill, NC 27517, USA.

Before commenting on the novel and unique chemistry of oxo-biodegradable plastics I would like to introduce myself to the reader by outlining and summarizing my substantial experience in plastics so that it is clearly understood that what I am writing has a sound and unbiased foundation.

- I am a graduate of the University of London with B.Sc. (1961) and Ph.D. (1964) degrees.

- I worked in the polymer and plastics industry in the USA for over 30 years and hold more than 100 US Patent in those fields and I have published widely and lectured internationally as an invited speaker.

- I have developed biodegradable water-soluble polymers and also plastics for a variety of applications.

- On retiring from Industry, I was invited to consult with many international corporations and formed by own consulting company as indicated above. In this capacity, I have helped to develop or advised on progress in all aspects of the biodegradable plastics industry, including the one under consideration: OXO-BIODEGRADABLE PLASTICS.

- I have been a member of the ASTM D20.96, the committee charged with developing standards for testing biodegradable plastics, since its inception and I currently serve as <u>vice chairman</u>. During this time, I have written and or commented on every standard developed and now in existence and used worldwide.

- I am <u>totally committed</u> to a maintaining a sustainable and healthy environment on this planet.

My comments, in response to the Report of the European Commission, should be considered seriously before action by the European Parliament and the Council.

<u>Comments:</u>

You have correctly outlined the major issues facing <u>ALL</u> biodegradable plastics:

- biodegradability in various environments,
- environmental impacts in regards to litter,
- the potential for recycle.

What I do find, though, is your hypotheses and assumptions on oxo-biodegradable plastics are somewhat shortsighted or hyperinflated based on an obvious biased and limited appreciation for their role in the key areas which we agree are very important for all of us.

Biodegradation is a common process in nature for the recycle of all organic materials through enzymatic degradation, assimilation and utilization by living organisms. The products of this process which can occur in the presence or absence of oxygen, aerobic or anaerobic respectively, are gases, water, and biomass. In nature, many mechanisms are operative and different time scales are apparent for materials with different composition and different applications or roles they function in; for example, hydrophilic materials such as celluloses are “fast biodegraders” and hydrophobic materials such as lignin are extremely “slow biodegraders”. Slow biodegraders, like lignin, may take years to biodegrade in two stages, the first is abiotic degradation promoted by enzymes such as laccases and peroxidases to produce low molecular weight organic compounds that are then biodegraded and assimilated by appropriate micro-organisms. Such oxo-biodegradation processes may take many years.

The organic material under consideration, oxo-biodegradable plastics, are based on polyolefins which are recognized as slow to biodegrade due to several well-known similar factors as exhibited by lignins, including their hydrophobicity, as established by many researchers, notably Professors Ann-Christine Albertsson and Gerald Scott. In an effort to make these hydrophobic staples of the plastics industry, inexpensive and convenient properties for many applications, much research has been conducted to enhance their biodegradation rate. Oxo-biodegradable plastics are a result of this continuing research based on mimicking natural enzymatic oxidation processes which breakdown natural hydrophobic materials, such as lignin. Small amounts of transition metal catalyst termed pro-degradants enhance the oxidative degradation of high molecular weight and hydrophobic polyolefins to lower molecular weight oxygenated, common organic compounds, materials which are readily biodegraded by micro-organisms. The rate and degree of the oxidation phase leading to low molecular weight biodegradable organic compounds has certainly not been optimized at this stage of development, even though there are viable and useful commercial products. Hence, it is a highly irregular intervention in science to even consider restricting the use of oxo-biodegradable plastics, rather than indicating their short comings to be addressed (which producers are aware of) and to focus their future development in applications and disposal sites where they offer value to everyone, producer, consumer and the government.

Application Opportunities and Disposal Options for Oxo-Biodegradable Plastics

As the name implies, oxo-biodegradable plastics were developed primarily for their use in areas and applications where their disposal will be in the presence of air such that on disposal abiotic oxidation is followed by aerobic biodegradation.

Hydrophobic Plastic + O_2 >> Oxidized Organic Chemicals + Microbial Activity >> CO_2 +Biomass

Little is known of their behavior in anaerobic environments, though research is beginning to shed light on the potential for biodegradation under such conditions, as will be discussed briefly.

Compost(Aerobic):

At present, it is not possible to compost oxo-biodegradable plastics to achieve the degree of biodegradation that is mandated for plastics designed for that disposal medium. The time constraints are just not possible to meet given the stage of their development of this technology.

Soil(Aerobic):

Mulch film is a great application for oxo-biodegradable plastics where it has indeed found wide acceptance. It offers film properties with controlled short-term degradation and biodegradation after the task is complete obviating the need for tedious and expensive clean-up. Interestingly there is evidence in this longtime application that refutes some of the criticism levelled at oxo-biodegradable plastics. Notably, the oft claimed long-term accumulation of plastic because of slow biodegradation and long-term toxicity of the soil environment because of metals accumulation. Neither has been substantiated with no evidence of soil deterioration or crop quality.

Landfill(anaerobic):

As the Report from the Commissioners indicates, landfills are complex disposal sites that have changing environments, initially aerobic and later anaerobic. I have written several reviews of this disposal medium and also done field and laboratory experiments with oxo-biodegradable plastics introduced into such environments. Contrary, to some opinions, landfills are generally not tombs for organic material. They are active microbial environments that can result in the degradation and biodegradation of organic materials under either of the environmental conditions mentioned. I have published work from research on oxo-biodegradable plastic in a UK landfill where molecular weight (Mw) of the plastic decreased from well over 100,000 to <5000, clearly in a range where biodegradation could occur. More recently (yet to be published), a similar plastic evaluated under anaerobic landfill conditions in an ASTM test method (D5511) biodegraded over 50 % in about 700 days indicating a life time of <<100's of years.

Given that off-gases from landfill biodegradation can be and are being captured for energy generation, this is an obvious opportunity for the recycle of oxo-biodegradable plastics which can be optimized and accelerated by utilizing anaerobic bioreactors.

Litter(aerobic):

This phenomenon is not controlled and certainly a societal and environmental problem as the Report spells out for both land and sea pollution. However, it is hardly fair to lay the blame on any one plastic, let alone oxo-biodegradable plastics. Of all plastics in common use, oxo-biodegradable plastics are but a minor fraction and contribute very little to the eye-sores on land and the floating debris at sea. Additionally, the breakdown mechanism of oxo-biodegradable plastics to hydrophilic organic intermediates, hardly is consistent with the formation of hydrophobic nanoparticles that threaten the environment. Rather, the intermediates are likely water soluble or swellable.

Indeed, in the wide spread problem of litter, humans are the issue as in all (plastic) littering, that is where the problem should be attacked NOT by limiting valuable plastics which have contributed mightily to human comfort. Is this not avoiding the solution?

Recycle:

There are always concerns in any materials handling industry when new materials are introduced. Oxo-biodegradable plastics are no different. They do require identification and recognition that they contain prodegradant additives, but in many studies, there have been positive results with successful blending and re-use with other materials. This is an issue for the recyclers to address and implement changes given that oxo-biodegradable plastics are useful and have a place and need in their respective markets.

Testing Protocols:

Testing Protocols, including guides, methods, specifications for biodegradable plastics are widely accepted for evaluating plastics for disposal areas such as compost, water treatment plants, anaerobic digestors, and landfills. Most of these are focused on materials that biodegrade over a short time period and are useful for plastics specifically designed for such disposal. This has clearly encouraged the development of biodegradable plastics that have short lives and measurement is amenable to laboratory testing. There is an obvious omission of testing protocols for longer term biodegradation, such as is needed for oxo-biodegradable plastics. This is a critical omission in the testing arsenal and one that needs addressing, since plastics such as oxo biodegradables are not being fairly evaluated and false or premature conclusions are being drawn.

Conclusions:

I conclude from my experience that:

- There are real needs and opportunities at this moment for oxo-biodegradable plastics, including mulch films, gas production from anaerobic digestors and landfills where applicable, and recycle. In the future, as the technology advances and degradation control are more easily exerted, they will challenge other biodegradable plastics in short term applications.

- No government restrictions are needed on oxo-biodegradable plastics which are still in the infancy stage, based on natural processes, and likely to be of much broader utility than we now witness.

- New biodegradation tests need to be developed or current ones extended to include better environmental fate protocols for longer term biodegradable plastics such as oxo-biodegradable

- There is need for limitations on advertising of all biodegradable plastics, especially regarding claims beyond what is proven.

- Litter issues should also be address where the problem resides, with people irresponsible people.

Graham Swift

May 10, 2018

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Please allow me to introduce myself in a quick way. I am a professor of Environmental Sciences at the Federal Institute of Education, Science and Technology of Porto Alegre, RS, Brazil. I have a doctorate in materials science (conventional plastics) concluded in 1996 and another doctorate in soil science (biodegradable plastics) concluded in 2008. I ended up focusing more on oxobio materials, because they showed greater potential in the Brazilian plastics market and also in many other countries. Since then, I have been following articles on these materials, published in high-profile journals, and I have participated in many events to discuss materials with a lower environmental impact in many countries of the world. I worked for many years with several conventional plastic materials in a Brazilian petrochemical industry.

I have read the report of the European Commission on oxo-biodegradable plastic materials and clearly noticed some antipathy and a great lack of familiarity with these materials. I am very much in agreement with the urgent need for action to contain the growing plastic pollution throughout the Earth environment. However, in order to be fair and help to show the other side of the subject, I would like to share my experience with these oxo-biodegradable materials.

When I started my doctorate in biodegradable plastics, I was also very skeptical of these materials at their three test levels: oxidative degradation, biodegradation, and toxicity. I ended up changing my opinion, as the results showed that the materials were actually biodegradable and showed no signs of toxicity (I did also plant-ecotoxicity tests after the thesis). I have got very significant information from a book by Professor Gerald Scott (1927-2013): “Polymers and the Environment” (RSC Paperbacks, 1999), where Scott describes natural and artificial polymers, and explains that oxobiodegradability is a natural phenomenon , that creates a very important component of soils: humus.

To date, I have not read an article published in a journal reporting any kind of toxicity of oxobio residues in the environment, and there is a growing number of papers describing measured biodegradability in different environments. I know some works that failed to measure biodegradability because, in my view, they were conducted in an inadequate manner or because they used an inadequate technique to evaluate the low rates of biodegradation (comparable to the biodegradation rates of humus). In my doctoral work, I used a very sensitive biodegradation detection technique developed by Chiellini in Italy, and modified according to the technique used in the Faculty of Agronomy of the Federal University of Rio Grande do Sul - Porto Alegre.

I would like to comment that I have carefully studied the structure and characteristics of the fragments formed with the oxidative degradation of oxobio plastics, because some people said that those fragments were nothing else than plastics of a reduced size and would only aggravate environmental pollution, because they could not be collected for recycling. This is a fundamental error which the Commission has made. In reality, I found that those fragments could not even be considered as plastics, because their structure and properties had become completely different. They are oligomers containing high concentrations of oxygen (especially as carbonyls), hydrophilic - useless as plastics, but useful as carbon and energy sources by environmental microorganisms.

In fact, I observed the formation of biofilm (of epiphytic organisms) on the surface of polyethylene films exposed to outdoor weathering for one year under 100% relative humidity. These fragments are formed even under adverse conditions. Often, I watch samples of oxobio film samples break up in my office in the dark. These fragments are biodegradable and certainly will not form a layer of plastic on the surface of the oceans because they will be used by organisms present in the soil, air and in the aquatic bodies as a source of nutrients.

The biodegradation of oxobio plastic materials in aquatic environments was tested by Chielllini, among other researchers, and also by me. We noticed that it occurs quite clearly. The aquatic environment is particularly favorable to the degradation of these materials, because the types of plastic in which oxo technology is commonly used will float on the surface, where there is an abundance of oxygen and ultraviolet radiation, where the temperature is relatively high and where there is the continuous movement of the waves, introducing mechanical effort, which also helps to break the plastic molecules. Biodegradation is also accelerated by the presence of the organisms that make up the plankton.

I can understand the idea of circular economy, much advocated by the Ellen MacArthur Foundation, where end-of-life products are reused as raw materials for other products. However, in my way of thinking, this concept is unsuitable for plastics, since they are composed of organic matter, and as such are easily degraded by the action of the environment (heat, oxygen, UV radiation, etc.), but mainly of mechanical stresses and temperature during reprocessing. This makes the idea of 100% recyclability of plastics (maintaining the original properties) become utopian.

Furthermore, it is extremely difficult and costly to collect small pieces of plastic scattered in the environment and then clean, classify and reprocess them. Nevertheless, oxobio products are recyclable, because their service life can be adjusted through the antioxidant/pro-oxidant balance.

I would like to comment that natural polymers (inherently biodegradable) and hydrobiodegradable plastics are fantastic materials and deserve their place in the market. Some are made with very creative and admirable technologies. In order to evaluate which materials are most recommended - from the environmental point of view, the most current tool is the life cycle assessment, considering all the environmental impacts, from obtaining the raw materials and energy, to the disposal or recycling at the end of their useful life. In this regard, in addition to the economic and processing difficulties, many hydrobio materials do not perform as satisfactorily as one would expect. In particular, the production of plastics from plants seems to me a reprehensible practice, since it presents among its consequences: deforestation and loss of biodiversity, soil degradation (nutrient export, erosion and compaction), water consumption, eutrophication, acidification, global warming, depletion of fossil fuels and minerals, etc.

We can not ignore the fact that biodegradable plastics made from plants, although they can be readily biodegradable under composting conditions, may be more impactful to the environment than conventional plastics made from petroleum.

In conclusion, I do not believe that oxobio products are a risk to humans or the environment. I do not think it is a good solution to ban them from the plastics market. But I believe that something must be done urgently to avoid the immense environmental pollution of conventional plastics, whose manufacturers insist on the utopia of recycling 100%. Oxobio may not be the ideal solution for the planet, but they are an excellent solution for the present and real world. In summary, I am in favour of the oxobio materials for our current world. Please do not let any type of biodegradable plastic be banned.

I will also upload this letter to section IV of: https://comments.echa.europa.eu/comments_cms/CallForEvidence.aspx?RObjectId=0b0236e18244dc70.

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Jiutepec, Morelos; May 4th 2018

Dear Mr Mark Blainey – ECHA-Heisinki

PRESENT

Whoever hereby subscribes, in my capacity as Technical Research and Development Manager and, moreover, as a member of the National System of Researchers, in the most attentive manner, I am writing to you, to express the following: The global accumulation of non-degradable products is one of the most important environmental concerns today. The use of degradable materials is an option to mitigate the environment or impact generated by the consumption of plastics. One of the technologies used for the manufacture and use of degradable plastics is the use of pro-degrading additives that are incorporated in conventional plastics to promote its degradation under certain conditions.

Based on scientific studies carried out by the Research Center in Applied Chemistry in 2011 under the direction of Dr. Mario H. Gutiérrez, it was demonstrated that polymers additivated with prodegradantes agents are susceptible to a molecular weight reduction close to 5000 Daltons, same reduction that occurred as a result of a thermal degradation followed by the protocol that marks ASTM D 5510-94 (2001). This result reaffirms that the generation of waste from thermal degradation is biologically ready to be consumed by microorganisms and non-microplastics that have high molecular weight.

On the other hand, experiments carried out with the Autonomous Metropolitan University, were carried out with the purpose of evaluating the oxidation, biodegradation and potential ecotoxicity process of the polyethylene films with the inclusion of an oxo-degradable additive, in accordance with ASTM D -6954. After 180 days of laboratory controlled composting, the samples reached the following percentages of biodegradation: polylactic acid, 41%; printed oxo-degradable polyethylene, 32.24%; oxo-degradable polyethylene, 25.84%; printed polyethylene, 18.23% and polyethylene, 13.48%. The cellulose used as a control sample was mineralized in 58.45%. The ecotoxicity evaluation showed that the biodegradation products of the analyzed samples did not generate a negative effect on the germination or development of the plant species studied.

Under the proper management of waste conditions, these plastics can be used as an option to reduce the environmental impact of plastic films and / or packaging for food or various products. Since the inclusion of this technology suggests with scientific support based on ASTM 6954 the plastics analyzed show that there is fragmentation in the molecular chains of the polymer, in addition to the degradation products; under the conditions of analysis, they showed that none of the samples released toxic byproducts to the substrate at levels higher than those contained in the soil. In addition, the biodegradation of these plastics in a controlled system of compost did not generate toxic metabolites that affect the germination rate of the plants of the different species studied. These results indicate that oxodegradable plastics can be used safely, provided that the conditions for their correct biodegradation are met since they do not exhibit toxic effects for plant species and, according to the definition, no microplastics are produced.

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PhD Adriana Reyes-Mayer
Technical Manager
Member of the National System of Researchers,

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To Mr. Mark Blainey,

ECHA,

Helsinki

Mark.BLAINEY@echa.europa.eu

9th May 2018

Dear Sir,

OXO-BIODEGRADABLE PLASTIC

I understand that ECHA has been requested by the EU Commission to advise whether OBP poses a risk to human health or the environment. I am quite sure that it does not, and I wish to make a contribution to your study of oxo-biodegradable plastic.

My basic education is chemical engineering in plastics processing and application. My scientific activity is in the field of photodegradation, gamma irradiation in plastic modification and stability. I was working for more than 30 years in petrochemical industry dealing with development of polyolefins in agricultural application as well as packaging. I have been working with oxo-biodegradable technology for the past seven years in Serbia, Croatia, Slovenia, Kosovo and Macedonia. It is very easy to use, and manufacturers and end-users are satisfied with it. I have heard of no problems with recycling.

I was very surprised that the EU Commission had made this reference to ECHA, and having read their report dated 16th January 2018 I think they are fundamentally mistaken. The purpose of incorporating a prodegradant masterbatch in a plastic product is not just to cause fragmentation, but to catalyse oxidation so that the molecular weight of the polymer reduces rapidly at the end of the useful life of the product and converts it into biodegradable materials.

A conventional plastic will perform in much the same way but it will persist in the environment for a much longer period. It will fragment under the influence of uv light but the fragments will have a molecular weight for several decades which is too high to enable biodegradation.

The time that the abiotic process takes is the rate-determining step, for once the material becomes biodegradable it will be assimilated by the micro-organisms in much the same timescale as they would assimilate any other biodegradable material.

It is well understood that the abiotic process will be accelerated by light and heat, but they are not essential in the case of OBP, which will degrade much more quickly than conventional plastic under any given conditions in the environment so long as oxygen is present. Moisture is not necessary for the abiotic process.

Landfill is not relevant to OBP because it will not degrade (and will not therefore become biodegradable) in anaerobic conditions. This is an advantage, not a disadvantage, because biodegradation in anaerobic conditions generates methane, which is a dangerous greenhouse gas. Composting is not relevant either, as OBP is not designed to comply with the standards currently used for compostable plastic in the EU and is not marketed for that purpose.

Oxo-biodegradable technology is the only way we can deal with plastic which has escaped into the environment, and the governments of Slovenia, Serbia, Kosovo, Montenegro, Macedonia, and Albania have passed legislation in favour of it. Future generations in the Balkan countries will not thank ECHA if you try to deprive us of this technology.

Marica Mlinac Misak

Zagreb, May 9th 2018

INAINE

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Mexico-City, May 20th 2018

To: European Chemicals Agency

Concerning the "Report from the Commission to the European Parliament and the Council" of 16th January 2018 on "the impact of the use of oxo–degradable plastic carrier bags, on the environment".

INAINE is a NGO that has more than 30 years supporting society in environmental management, technical issues and communication in order to favor sustainability in benefit of the planet.

We herewith want to express to the ECHA the experience on oxo-degradable plastics that we have had for the last five years in Mexico:

1. We could determine without doubt, that the resulting particles after the whole process of oxo–biodegradation are not plastic in nature anymore, but the components of it like aldehyde, esters and ketones.

2. We observed that the resulting particles of oxo–biodegradation are colonized by bacteria and that these bacteria feed form the resulting particles.

3. BIMBO, the biggest bakery in the world, with Head Office in Mexico, has been using successfully oxo–biodegradable additives in their bread bags for the last five years.

4. We have scrutinized scientific papers that demonstrate that the resulting particles from oxo–biodegradation are non toxic for plants and marine organisms.

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We are convinced that the addition of oxo–biodegradable additives is part of an integral solution to the pollution caused by microplastics, and we wish to continue using them in Mexico to protect our environment from the long–term accumulation of plastic waste and plastic particles.

Luis Manuel Guerra
President

Pablo Hurtado
Scientific Director

STATEMENT BY RADU BACIU

Chief Technical Adviser
31st May 2018

I have specialised for the past 35 years in the science and practice of manufacturing polymer products, and for the past 17 years I have specialised in oxo-biodegradable plastics (OBP). I am the Chief Technical Adviser to the Oxo-biodegradable Plastics Association, and to Symphony Environmental Technologies Plc. I have been a member of the D20:96 Committee on Biodegradability of Plastics on the American standards body, ASTM International since 1998.

My technical education and technical employment are as follows:

- Master's Degree in Chemical Engineering, Main Subject: Polymer Science and Engineering, "Gheorghe Asachi" Technical University of Iaşi (TUIASI) - http://www.tuiasi.ro/en/
- Postgraduate Diplomas in Business Management (CEGOS International - http://www.cegos.co.uk/ and Stratford Career Institute - https://www.scitraining.com/) and International Marketing in Polymers and Petrochemicals (The University of Oxford - St Catherine's College - http://www.stcatz.ox.ac.uk/)
- Certified Professional Engineer with the Association of Professional Engineers and Geoscientists in Canada (https://www.egbc.ca/)
- Worked in Polymer Synthesis for 12 years (in capacities as: Process Engineer, Senior Process Engineer, R & D Department Head, Plant Manager)
- 2 years in R & D in Special Catalyst Systems applied in Polymerization Technologies
- 4 years in Plastics Processing Technologies for flexible and rigid finished products applications (R & D Department Director)
- 17 years in Special Additives implemented in the Plastic Processing Industry (in capacities: Product Development Manager, VP-Manufacturing and R &D, Project Manager, Consultant, Technical Director). During the last 17 years, my main field of work has been in Oxo-biodegradable Technology.

1. INTRODUCTION

1.1 All plastics will fragment when exposed in the open environment, but the problem with conventional plastics is that their fragments will lie or float around for decades before becoming biodegradable. During that time they break down into microplastics and may attract and carry toxins. Marine life often consumes these microplastics, mistaking them for plankton, which can begin the process of toxins moving into the human food-chain.

1.2 Oxo-biodegradable technology was therefore invented to speed up the degradation process, by adding a catalyst which promotes oxidation. The catalyst is dormant during the intended life of the product and activates on exposure to the open environment.

1.3 Oxidation reduces the molecular-weight of the polymer by dismantling the molecular structure and adds oxygen in the chemical composition of the short chain molecules in the form of organic functional groups (carboxylic acids, hydro-carboxylic acids, aldehydes, ketones, alcohols, esters). This is easy to prove, using the methods prescribed by international standards such as ASTM D6954-18, and is well-documented in the scientific literature. When the molecular weight has reduced to 5,000 Daltons or thereabouts, it is no longer a plastic material and is accessible to bacteria, fungi and algae, who recycle it back into nature. It definitely does not just produce fragments of plastic.

1.4 It is less easy to observe the action of the bacteria and fungi, but it can be done. In 2016, a sample of oxo-biodegradable plastic, which had degraded in seawater, was sent to Queen Mary University London, who observed it being consumed by bacteria that are commonly found on land and also by bacteria commonly found in the oceans. They see no reason why the bacteria should not continue to consume it until there is nothing left. The oxo-biodegradable plastic had no adverse effect on the bacteria.

1.5 As to timescale, no government has ever said what they regard as a reasonable time for plastic degradation. They accept that ordinary plastic takes decades to biodegrade, and this is why there is so much public concern about it. The reason why it takes such a long time is that the reduction of molecular weight from about 250,000 Daltons to 5,000 is such a slow process, and anything that speeds it up, as oxo-biodegradable technology does, must therefore be beneficial.

1.6 One thing is certain – that in the same place at the same time in the open environment, oxo-biodegradable plastic will become biodegradable at least ten times faster than ordinary plastic, and will not accumulate as a problem for future generations.

1.7 Oxo-degradable plastics (as distinct from oxo-biodegradable plastics) are plastics which degrade by oxidation, but do not biodegrade except over a very long period of time. Most of the conventional plastics and the "Braskem-type" plastics fall into this category, so why are they not being investigated?

1.8 For OBP generally see http://www.symphonyenvironmental.com/rethinking-future-plastics/

1.9 For Life-cycle Assessments see http://www.biodeg.org/lifecycleassessments.html

1.10 I have read the Intertek report "Oxo-Biodegradable plastics and the micro-plastics issue: towards a logical approach" which I understand they have sent to ECHA.

2. MICROPLASTICS

2.1 Microplastics are small fragments of high molecular weight plastic which are <5 mm in their longest dimension.

2.2 Microplastics are mostly produced either by fragmentation of larger (macro) plastic particles via oxidative degradation resulting in molecular-weight reduction and fragmentation, or by mechanical processes as erosion, abrasion, occurring in the environment. They do not therefore fragment as a result only of mechanical forces i.e. "wear and tear."

2.3 However, at the point where fragmentation occurs, the molecular weight of the conventional plastic remains too high to allow biodegradation.

2.4 The use of prodegradant catalysts accelerates the rate of oxidative degradation (the abiotic phase) and therefore increases the rate at which polymers transform into a material which is biodegradable. This process is irreversible.

2.5 when oxidative degradation results in a molecular-weight reduction to 5,000 g/mol or thereabouts, the material ceases to have a large molecular weight and ceases therefore to meet the definition of a plastic.[1] It has now converted to low molecular-weight, water-soluble short chain molecules (oligomers) which are biodegradable.

2.6 UV light will accelerate the abiotic process but is not essential.

2.7 Heat is not essential, but the abiotic process would proceed more slowly in very cold conditions.

2.8 Moisture is not essential for the abiotic phase.

2.9 When considering the oceans, or the environment as a whole - despite the quicker formation of plastic particles, the more rapid removal of the particles from the environment via faster oxidation and then biodegradation will result in significantly fewer microplastics in the environment if OBP is used.

2.10 OBP is intended in substitution for conventional plastic and not in addition to it. OBP does not therefore increase the amount of plastic or the number of fragments.

2.11 The environmental impact of OBP must be compared with conventional plastic, and also with "compostable" plastic such as "Mater-Bi" by Novamont, and "green" plastic by Braskem, all of which create fragments and microplastics.

3. ECHA

3.1 I am aware that the EU Commission has made a reference to ECHA in a letter dated 22nd December 2017 which says that: "So called oxo-plastics or oxo-degradable plastics are conventional plastics that contain additives to promote the oxidation of the material under certain conditions. They are used as agricultural films and in other agricultural

[1] See eg ASTM D883-08 page 7

applications (i.e. wrapping hay, potting containers, tree ties and vegetable sacks), as rubbish and carrier bags, as food packaging, landfill covers, etc. Oxo-plastics have been claimed to degrade rapidly to harmless substances into the environment." So far this is correct except that they seem to be referring to oxo-biodegradable plastics and not oxo-degradable plastics.

3.2 The letter continues "However, as demonstrated in a recent Commission study[2] there is evidence that such plastics:
A. may not degrade under all relevant environmental conditions and
B. within a reasonable time period.
C. Instead, they appear to fragment into very small particles,
D. potentially contributing to the environmental contamination by microplastics.
E. In addition, the fragmentation properties imparted to the plastics makes their re-use difficult
F. and they could negatively impact on the quality of plastic recyclates and
G. of compost, if they enter these recycling streams.

3.3 The additives commonly used in OBP plastic are included as masterbatches added typically at 1% by weight. The masterbatch incorporates a prodegradant catalyst and a stabilization package finely dispersed in a polymeric matrix of PE or PP.

4. ASSERTIONS IN THE COMMISSION'S LETTER

The assertions are based mainly on three Reports:

- "The impact of the use of "oxo-degradable" plastic on the environment" Eunomia Consultants, September 2016
- Report from the Commission to the European Parliament and the Council on "The impact of the use of oxo-degradable plastic, including oxo-degradable plastic carrier bags, on the environment" 16th Jan 2018.
- "Oxo-degradable plastic packaging is not a solution to plastic pollution, and does not fit in a circular economy" Ellen MacArthur Foundation (EMF) Nov 2017. Annexed to my present statement are the detailed reasons why I do not agree with the authorities cited by EMF.

5. ASSERTION A (may not degrade under all relevant environmental conditions)

5.1 OBP is designed to degrade abiotically if accidentally or deliberately disposed of as litter in the open environment on land or sea, with access to oxygen, and it has been proved to my satisfaction to do so. Heat and light will accelerate the process but they are not essential, and OBP does not require special environmental conditions. OBP is designed for use with polyethylene or polypropylene with a maximum thickness of 250 microns. It is not designed for use with PET.

5.2 For many years OBP have been successfully used for mulching films in agriculture, so that the used film will degrade and biodegrade in situ without the need to remove and dispose of many square kilometres of plastic contaminated with mud and other contaminants.[3] Conventional plastics for mulch films can be down-gauged to 4 microns but for compostable plastics this would be 9 microns. The amount of material being used as a result of density differences as well as thickness would result in at least 100% more material being used. The PE density is 0.92 and Compostable is 1.3.

5.3 OBP is not designed or marketed to degrade in landfill because if a plastic item is in a landfill it has already been properly disposed of. Further, OBP is not designed to degrade in anaerobic conditions and will therefore behave in the same way as conventional plastic deep in landfill. Biodegradation is undesirable deep in landfill because methane will be generated under anaerobic conditions. Fragmentation is irrelevant in a landfill.

5.4 According to the Eunomia Report "Whilst [OBP] plastic may biodegrade in the upper levels of a landfill in aerobic conditions and therefore produce CO_2, it has already been demonstrated that this happens at a very slow rate, and only if abiotic degradation has already occurred. The limited evidence that is available suggests that deeper in landfill

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[2] 16th January 2018
[3] See report by CIBA and report by Symphony Environmental's Technical Dept on agricultural film dated 15th March 2012. See also "The Role of Biodegradable Plastics in Agriculture - A brief review" by Professor Gerald Scott of Aston University, UK.

under anaerobic conditions there will be little or no biodegradation taking place. In this case, the carbon is effectively sequestered, avoiding the direct release of GHGs to the atmosphere."[4]

5.5 OBP is not designed or marketed to be sent to a composting plant. However, it is always possible that some OBP and some conventional plastic, and some "Braskem-type" plastic, will find its way into an aerobic composting plant, in which case they will all fragment, but the OBP will become biodegradable much more quickly. Even crop-based plastics designed and marketed to be sent to a composting plant have been known to leave fragments of plastic.

6. ASSERTION B. (within a reasonable period of time)

6.1 The Commission maintains that biodegradation in the open environment should occur within "a reasonable period of time" but has never defined what it means by this. Clearly a hundred years is not a reasonable period of time, and conventional plastic is therefore unacceptable. So would 100 weeks be a reasonable period of time? Conditions in the open environment are variable, but we can be quite certain about one thing - that in the same place at the same time in the open environment an OBP will become biodegradable very much more quickly than conventional plastic. In my view it makes much more sense for fragments of plastics to biodegrade, than to be left to float around adsorbing toxins and harming wildlife for a hundred years.

6.2 The key point therefore is how long does OBP take to become biodegradable? i.e. how long is the abiotic process? Once it has become biodegradable it will biodegrade in the same period of time as natural material (a conventional plastic which has become biodegradable (after exposure for several decades).

7. ASSERTION C (Instead, they appear to fragment into very small particles,)

7.1 The Commission's 2018 Report says that OBP "fragments over time into plastic particles, and finally microplastics, **with similar properties to microplastics originating from the fragmentation of conventional plastics**" but this is a serious error, as their properties are significantly different. The process is described[5] by Prof. Ignacy Jakubowicz, one of the world's leading polymer scientists in his criticism of the Ellen MacArthur Report, which had made the same mistake. He says of oxo-biodegradation "The degradation process is **not only a fragmentation, but is an entire change of the material** from a high molecular weight polymer, to ... oxygen-containing molecules which can be bioassimilated." I agree with his statement.

7.2 It is now well understood that OBP which has suffered abiotic degradation can then be biodegraded to harmless degradation products by the natural action of micro-organisms commonly found on land and sea. It would not be practicable to measure biodegradation in the open environment, so it is tested in the laboratory. The industry has developed standard test methods to simulate conditions likely to be found in the real world and to assess the degradability, biodegradability and eco-toxicity of oxo-biodegradable plastic products. These procedures are designed to test whether in outdoor real-life conditions the plastic product will degrade, biodegrade and leave no toxic residues.

7.3 The Eunomia Report says: "without exception, the scientific evidence suggests that the conditions present during the abiotic stage (which in most studies is simulated by some form of accelerated pre-treatment) of degradation will have a significant impact on the materials' ability to subsequently biodegrade." I agree.

7.4 Once the material has become biodegradable in the open environment it really does not matter how long it takes to biodegrade completely if it has been proved to be non-toxic. This would matter only in the unlikely situation that there were large quantities of plastic residues in the same place, and the Eunomia Report acknowledges that this is not likely in the case of carrier bags. Nor is it likely in the case of other plastic products for which OBP is used.

7.5 As to whether the micro-organisms will bioassimilate the whole of the low molecular-weight material, biodegradation of 91% has been observed at the Technical Research Institute of Sweden and the Swedish University of Agricultural Sciences, and 88.9% at the Eurofins laboratory in Spain. This is complete biodegradation for all practical purposes. (the limit specified for compostable plastic in EN13432 is 90% of the maximum degradation of a suitable reference material, which would be significantly less than 90% of the actual material).

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[4] Eunomia Report

[5] Review of the position paper "Joint position against oxo- and photo-degradable additives in plastics", Professor Ignancy Jakubowicz, 21st August 2017

7.6 The Eunomia Report comments on the Swedish study that “with the results of the laboratory study showing over 91% conversion to CO_2, the [Swedish] author contends that the “risk of plastic fragments remaining in soil indefinitely is very low.” Nowhere is such a claim for complete bio-assimilation proven in practice though.” “Although it can be believed that biodegradation can be facilitated by careful engineering of the chemical package in PAC plastic, evidence is not available to definitively conclude that this will happen in real world situations with PAC plastic products being placed on the market.”

7.7 The opinion of the distinguished academic team in Sweden cannot be so easily dismissed, having regard also to the scientific studies in Spain and elsewhere. What does the author of the Report mean by “proven in practice?” Evaluation of biodegradation has to be done in laboratory conditions (as is also the case with compostable plastic) – it cannot be done in a field or an ocean or a compost heap. These tests are very expensive and are not done for the amusement of scientists. They are designed to replicate conditions in the real world. There is no reason to think that in the open environment the micro-organisms will stop before they have consumed all of the available material, and it is for those who think so to provide some credible reasons.

7.8 The Eunomia Report itself refers to the work done at Queen Mary University London which shows that “small levels of biodegradation were observed which if left to continue at the same rate would lead to full biodegradation in around 2 years.”

7.9 The Report continues “It is, however, unclear how these results can be translated to behaviour in the real world. One strain of bacteria is used in the test whereas in the open environment there may be many more, as well as fungi which may also attack and break down the plastic—**and therefore it may biodegrade quicker.”** … “From the information studied, the authors of this report can believe that it is possible for a [OBP] plastic to fully mineralise in an open environment, with the prodegradant additives encouraging this action, and thus the polymers and entrained substances can be assimilated into the natural environment.”

7.10 The Commission have advanced no reasons why biodegradation found in the laboratory should not take place in the real world. Similarly they have given no reasons why biodegradation should not continue until all the material has been consumed.

7.11 The Eunomia Report says “It seems likely that the fragmentation behaviour of [OBP] plastics will exacerbate issues related to microplastics.” However, the truth is the exact opposite. Microplastics have become a problem because conventional plastic has been eroding and fragmenting and accumulating for decades, and the fragments are still fragments of plastic because their molecular weight has not sufficiently reduced. This is not the case with OBP.

7.12 The chemical package in OBP is indeed carefully engineered, and that is a skill acquired from tests and experiments carried out over more than twenty years by reputable suppliers and academics. If the Eunomia Report is suggesting that only OBP placed on the market by reputable suppliers can be relied upon, we would agree.

7.13 OBP does not increase the number of particles, because OBP and conventional plastic would create the same number of particles. The difference is that OBP will fragment more quickly and the particles would become biodegradable in a much shorter time and would be less likely to adsorb PCBs or other toxins.

8. ASSERTION D. (potentially contributing to the environmental contamination by microplastics).

8.1 It is not clear what is meant by “environmental contamination.” Clearly, if the fragments of plastic simply join the trillions of other fragments of all kinds of material on the surface of the planet it is difficult to see what harm they do, but it is sometimes said that they can have either (a) an adverse mechanical effect and/or (b) an adverse toxicological effect:

(a) Mechanical effect. It could presumably be said that the fragments could cause a blockage in the essential systems of a very small creature, or fill its stomach (if it has one) and cause starvation or impair its reproductive capacity. I’m not aware of any credible evidence to support this idea, but the same would be true of the fragments of conventional or bio-based plastics or “green plastics”, or indeed fragments of almost anything else. The difference is that fragments of OBP would not be in the environment for anything like as long.

(b) Toxicological. The reference to ECHA does not allege that the components of OBP are themselves hazardous – only that their incorporation into OBP creates an (unspecified) “risk to human health or the environment.”

8.2 The OBP industry is as much concerned as anyone that its products should not introduce toxicity into the environment, and for this reason the standards for OBP require testing to confirm that the residues are harmless. Oxo-biodegradable additives do not contain any of the hazardous substances listed in Art 11 of the Packaging Waste Directive 94/62/EC nor in Annex A.1.2 of EN13432 (which is the European standard for plastics intended for composting for growing food). Also, oxo-biodegradable plastics are tested according to the same eco-toxicity tests prescribed by EN13432 Annex E for plastics intended for composting. They are shown to be non-toxic by OECD standard testing.

8.3 The Eunomia Report says "it does appear that the [OBP] plastics industry can create products that have minimal toxic impact on flora and fauna. … and it is at least encouraging that almost all existing test standards for PAC plastic specify some form of toxicity test using established methods (such as germination and earthworm survival tests)."

8.4 The Report continues, "this does not mean that all products on the market avoid negative toxic effects, as there is no regulatory control currently exercised in this regard. Problems remain that accreditation is not mandatory for products on the EU market. This is a criticism not of the OBP industry, but of CEN which has failed to write a standard for OBP, and of the regulatory authorities in Europe who have not sought to ensure that OBP is supplied only by reputable manufacturers, who can produce evidence that their products have been tested by recognised laboratories according to well established standards such as ASTM D6954-18. It is also a criticism of regulatory authorities who have not specified for all relevant tests what test results they would and would not find acceptable. (They have done so only in the case of testing for metals by specifying in Art 11.1 of 94/62/EC the maximum concentrations allowed).

8.5 There may be hazardous substances incorporated into finished plastic products which might be released into the environment on fragmentation, but this is true of all kinds of plastics (and other materials) and is not a matter peculiar to OBP. The regulatory authorities need to restrict the incorporation of such substances e.g. Bisphenol A – which they are doing.

8.6 There is a theory advanced by Thompson and others, that fragments of plastic, especially in the sea, will adsorb toxins from their immediate environment, and that if the fragments are ingested, the toxins will find their way into the human food-chain. This research relates to fragments of conventional plastic, but OBP is less likely to adsorb toxins, because its dwell-time in the environment will be much shorter, and its chemical structure is different.[6]

8.7 It is difficult to see why plastics should be singled out, as there are likely to be other fragments in the sea which would adsorb toxins and then be ingested. In addition, a marine creature is likely to be adsorbing toxins from the water for most of the time as it moves around, and the only difference might be that the toxins could be more concentrated on the surface of a fragment of solid material. Of course, the longer the dwell-time in the ocean the more likely this will be.

8.8 The Eunomia Report notes that "during pre-ageing under water, PAC plastic is much more susceptible to UV degradation than conventional plastic (as demonstrated by the large difference in molecular weight). The biodegradation tests also indicate that bacteria can feed off plastic measured with a higher molecular weight than the 5,000 Daltons limit often used to characterise this."

8.9 The Eunomia Report says that "should full biodegradation on land occur, this would reduce the quantity that may otherwise transfer to the marine environment." We agree.

8.10 In the terrestrial environment the adsorption of toxins from the immediate environment would be less likely, and they could also be adsorbed by other material which is eaten by animals, birds and insects.

8.11 The Eunomia Report says: "The [OBP] plastic is more likely to fragment quicker so the impacts associated with microplastics are concentrated within a shorter period of time." "this could ultimately be worse than spreading out the impacts over a longer period of time due to an increase in the proportion of individuals, species and habitats

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[6] Plastics in the marine environment, Oxo-biodegradable Plastics Association (http://www.biodeg.org/marineenvironment)

affected, as well as the burden of impacts for an individual of a species." In my view the opposite would be the case. Fragments of conventional plastic will exist as a problem for decades, but OBP rapidly becomes a food source for micro-organisms.

8.12 Further, 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.

8.13 The increased pore-size and free volume also means that if the toxin is adsorbed to the conventional polymer, it will not readily desorb, and thus over long periods of time the polymer will break down by friction, shear, and weathering, and the potential for the plastic material to adsorb toxins increases. Takada et al demonstrated in a field experiment in Tokyo Bay that 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).

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

8.15 This information helps to build a picture of what would be expected for oxo-biodegradable polymer materials in the oceans. Under the action of oxygen, UV light, and ambient heat, polyethylene and polypropylene containing oxo-biodegradable additives will change their molecular structure and break down. 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 susceptible 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.

8.16 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.

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

8.18 According to the Netherlands Institute for Public Health & the Environment,[7] an essential characteristic of a microplastic is that it is insoluble in water and not degradable. In the case of OBP fragments, they are degradable, and they do become soluble in water. In the same report at p 13 The Netherlands Institute says "From the perspective of the marine environment, microplastics that disappear quickly by natural processes (e.g. dissolving, biodegradation to harmless degradation products) …….are not of concern."

9. ASSERTION E. (the fragmentation properties imparted to the plastics makes their re-use difficult).

The balance between the catalyst and the stabiliser in the masterbatch of OBP ensures that in normal use the OBP product will retain its strength and be fit for purpose for whatever period is desired. Otherwise nobody would buy it. During that period, it can be re-used many times.

10. ASSERTION F. (and they could negatively impact on the quality of plastic recyclates)

[7] Towards a definition of microplastics, RIVM Letter report 2015-0116 A.J. Verschoor

10.1 A conventional plastic, or a "green" Braskem-type plastic, which had been exposed to sunlight for a short time and had lost its strength would negatively impact on the quality of plastic recyclates. So would a starch-based plastic even without exposure.

10.2 According to the recycling charity RECOUP[8] "In cases 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." These are the very products in which OBP is commonly used, and OBP is therefore largely irrelevant to recycling.

10.3 Nevertheless, the Commission is concerned that oxo-bio plastic should be identifiable and separated from other plastics collected for recycling, and the Eunomia Report says "The evidence available does not support the suggestion that [OBP] plastic can be identified and sorted separately by reprocessors with the technology that is currently available. Furthermore, manual sorting would be time-consuming and is unlikely to be economically viable." In that case a marker could easily be included in OBP if separation were desired.

10.4 This is not however necessary, because OBP has been designed to be recyclable during its useful life. However, according to Eunomia "Evidence suggests that oxidised OBP plastic can significantly impair the physical qualities and service life of the recycled product." In fact, OPA members have been successfully recycling OBP for more than ten years to my knowledge, with no adverse reports, and scientific tests have proved to my satisfaction that it can be safely recycled together with conventional plastic without separation.[9] Last year alone it is estimated that more than 800,000 tonnes were processed worldwide. The recyclers have produced no scientific evidence to justify their concerns about oxo-bio, and they should be more concerned about starch-based plastics.

10.5 Separation is a problem with all types of plastic film, and is one reason why post-household plastic film is not attractive to recyclers. Other reasons are that the material is often contaminated and it would not be cost-effective to clean it, given that the material from which it is made is inexpensive and readily available. It is also too costly in financial and environmental terms to collect it, transport it, sort it, bail it, store it, and reprocess it, so – as the Eunomia report confirms – it is generally exported as mixed plastic for low grade uses (not for long life uses such as building films or pipes, which are normally made from virgin polymer or used-plastics of known type and provenance). The separation of OBP film derived from carrier bags and packaging is therefore a non-issue.

10.6 The Eunomia Report continues: "Evidence suggests that the impacts of prodegradant additives on recyclates can under certain circumstances be avoided with the inclusion of stabilisers. The appropriate quantity and chemistry of stabiliser would depend on the concentration and nature of the prodegradants in the feedstock." However, the Eunomia report misunderstands the role of stabilisers. It is clear from the scientific reports made available to Eunomia[10] that it is not necessary to add stabilisers unless the recyclate is being used to make long-life products, in which case the manufacturer of those products would be adding stabilisers anyway. These stabilisers are in a quantity and with a chemistry which it would normally use, and no special arrangements are necessary for recyclate containing OBP.

10.7 Most waste plastics of all kinds will have been exposed to UV radiation - and in particular agriculture film, and could well have oxidised to some extent. Recyclers of mixed plastic wastes have no way of knowing which have been exposed and for how long. It is also known that printing inks, and other chemicals will affect the recycling process. Therefore, the industry already has the problem of identification when dealing with post-consumer plastic films, and deals with it by using those materials for low-value/short-life applications such as carrier bags and garbage sacks, or by adding fresh stabilisers if used for longer-life applications.

10.8 If an OBP carrier bag is going to be collected for recycling at all it will be collected during its useful life. During that time it will not have oxidised because the stabilisers in the OBP masterbatch are designed to ensure a minimum useful life before oxidation commences, even with some exposure to sunlight during use. It will have been stored before use in light-proof boxes or wrappers. If collected for recycling very late and if the plastic had oxidised, it would have generated a strong odour and would be falling apart and would not be used for recycling. Oxidised polymer would in any event have to form a substantial proportion of the feedstock to have any effect at all.

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[8] Recyclability by Design 2017 ISBN 978-0-9558399-7-9
[9] http://www.biodeg.org/recycling.html
[10] ibid

10.9 The Eunomia report adds: "Recyclate made from mixtures containing unknown PAC plastic should not be used for long-life products, due to the lack of evidence surrounding the long-term impact in secondary products." There is no lack of evidence. The TCKT report from Austria dated 27th July 2016 considered this very issue, and concluded that provided a UV-stabiliser has been included (which the Report says should always be the case with plastic products intended for outdoor use) there will be no negative effects from the inclusion of oxo-biodegradable recyclate. These studies also demonstrate that even without UV stabiliser the presence of oxo-biodegradable recyclates has no effect within the body of thick cross-section plastic, where oxygen is not available, nor when the plastic is buried or otherwise enclosed with no access to oxygen. (The authors of the Eunomia Report had read the 17th March 2016 TCKT report, but have not cited the 27th July 2016 report).

10.10 The position of the OBP industry is based on scientific reports by specialist researchers, and we have seen no evidence of any deleterious effect on any product made from recyclate containing OBP.

10.11 The Eunomia Report is concerned with plastic film used to make carrier bags, not with PET packaging or bottles, for which OBP is not sold.

10.12 Anyone who wants to promote recycling should certainly be concerned about starch-based plastic, because it cannot be recycled together with oil-based plastic, and separation would be required. Some of it will get into the plastic waste recycling stream – especially as it is now being promoted for carrier bags and packaging - but we are not aware of any proposal to restrict the marketing of starch-based plastic for that reason.

11. ASSERTION G. (and of compost, if they enter these recycling streams).

11.1 See Assertion A above. In any event, composting of plastics cannot be regarded as recycling, because the plastics are required by EN13432 to convert into CO_2 in a short period of time and they do not therefore produce anything of value for the soil.

11.2 Conventional plastic (and the Braskem-type of plastic which has the same performance characteristics) would certainly impact negatively on the quality of compost if it entered a composting facility. OBP is not supplied for composting, but OBP would become biodegradable much more quickly than either of these plastics in a composting facility and would continue to biodegrade on or in the soil.

12. CONCLUSION

12.1 There is no evidence sufficient to justify a ban of oxo-biodegradable plastic, and it would cause a negative effect on the environment and be harmful to those countries that are encouraging the use of the technology.

12.2 It would be far-fetched to argue that assertions E and F could cause "risk to human health or the environment" within the meaning of Art. 69(1) of REACH.

13. DEFINITIONS

i. Degradation (of plastic), n—a deleterious change in the chemical structure, physical properties, or appearance of a plastic. (ASTM D883-11)

ii. Degradable (of plastic) n –a plastic designed to undergo a significant change in its chemical structure under specific environmental conditions resulting in a loss of some properties that may vary as measured by standard test methods appropriate to the plastic and the application in a period of time that determines its classification. (D883 – 11)

iii. Degradability n – the quality of being degradable

iv. Biodegradation (of plastic), n—degradation of a polymeric item as a result of cell-mediated phenomena. (CEN TR 15351)

v. Biodegradable, n – capable of biodegradation

vi. Biodegradability, n - the quality of being biodegradable

vii. Oxidation, n—process promoted thermally or by ultraviolet (UV) radiation or both in the presence of oxygen. (CEN TR 15351)

viii. Oxo-degradation, n—degradation resulting from oxidative cleavage of macromolecules. (CEN TR 15351)

ix. Oxidatively degradable plastic, n—a degradable plastic in which the degradation results from oxidation (D883-11).

x. Oxo-biodegradation, n—degradation resulting from oxidative and cell-mediated phenomena either simultaneously or successively. (CEN TR 15351)

xi. Oxo-biodegradable, n – capable of oxo-biodegradation

xii. Oxo-biodegradable plastic n- a polymer capable of oxo-biodegradation

xiii. Oxo-biodegradability, n - the quality of being oxo-biodegradable

xiv. Plastic(s), n— material that contains as an essential ingredient one or more organic polymeric substances of large molecular weight, is solid in its finished state, and, at some stage in its manufacture or processing into finished articles, can be shaped by flow. (ASTM D883)

xv. Microplastic, n- Plastic particle in the size range 1 nm to <5 mm (GESAMP 2015))

xvi. Fragmentation, n - The process or state of breaking or being broken into fragments.

xvii. Brittle point, n—in degradable polyethylene/polypropylene film, that point in the history of a material when 75 % of the specimens tested have a tensile elongation at break of 5 % or less. (ASTM D3826).

14. OTHER PUBLISHED REFERENCES:

i. B.Gewert, et al., Pathways for degradation of plastic polymers floating in the marine environment, Environ. Sci.: Processes Impacts, 2015, 17, 1513

ii. B.Eyheraguibel, et al., Characterization of oxidized oligomers from polyethylene films by mass spectrometry and NMR spectroscopy before and after biodegradation by a rhodococcus rhodochorous strain, Chemosphere 184 (2017) 366-374.

iii. B.Eyheraguibel, et al., Environmental scenarii for the degradation of oxo-polymers, Chemosphere 198 (2018) 182-190.

iv. SEVN (2015) "Comparison of behaviour of low density polyethylene films containing oxo-additive or not, when submitted to wet environment (sea water) – Summer" (Bouillet, F). Report 151101.

v. SEVN (2016) "Comparison of behaviour of low density polyethylene films containing oxo-additive or not, when submitted to wet environment (sea water) – Winter" (Bouillet, F). Report 160801.

vi. Wiles DM, Scott G. Polyolefins with controlled environmental degradability. Polymer Degradation and Stability. 2006;91:1581-92.

vii. Chiellini E, Corti A, D'Antone S, Baciu R. Oxo-biodegradable carbon backbone polymers - Oxidative degradation of polyethylene under accelerated test conditions. Polymer Degradation and Stability. 2006;91:2739-47.

viii. Albertsson A-C, Andersson SO, Karlsson S. The mechanism of biodegradation of polyethylene. Polymer Degradation and Stability. 1987;18:73-87.

ix. Scott G, Wiles DM. Programmed-Life Plastics from Polyolefins: A New Look at Sustainability†. Biomacromolecules. 2001;2:615-22

x. Chiellini E, Corti A, Swift G. Biodegradation of thermally-oxidized, fragmented low-density polyethylenes. Polymer Degradation and Stability. 2003;81:341-51.

APPENDIX

The reasons why the OPA does not agree with the November 2017 report of the

Ellen MacArthur Foundation

Endnote 1

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
Oxo-degradable plastics are conventional polymers (e.g. LDPE) to which chemicals are added to accelerate the oxidation and fragmentation of the material under the action of UV light and/or heat, and oxygen.
Response (Oxo-Biodegradable Plastics Association)
In the text the composition of an oxo-biodegradable finished product is described, but the endnote refers to oxidation and fragmentation which is only part of the process, and their quotation from TR15351 more accurately describes a conventional plastic. They should have cited the CEN definition of oxo-biodegradation, which is "degradation identified as resulting from oxidative and cell-mediated phenomena, either simultaneously or successively."

Endnote 2

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
This biodegradation process depends on multiple criteria, including the fragment size, the quantity of additives, and the environmental conditions to which the material is subjected (e.g. temperature, biotic factors) - conditions that vary significantly in practice.
Response (Oxo-Biodegradable Plastics Association)
They have failed to distinguish between degradation and biodegradation, and have used the wrong definition. In oxo-biodegradable plastics the lower molecular weight fragments are produced not by the action of naturally occurring microorganisms, but by an abiotic process of oxidation, accelerated by a catalyst. Biotic factors are not relevant. They also incorrectly refer to "the quantity of additives" instead of the balance of ingredients within the masterbatch. They also incorrectly refer to the fragment size. Biodegradation does not depend on the fragment size, but on the molecular weight of the fragment. In the case of any material in the environment (whether natural or synthetic), the rate of property change depends on environmental conditions, which may vary based on geographical, seasonal and random factors, but the abiotic phase of oxo-biodegradation does not depend on light, heat, moisture, or biotic factors. The fundamental principle of oxo-biodegradable plastics is that they undergo oxidation in precisely the same way as conventional plastics, but under any given conditions in the open environment, they will do so in a much shorter timeframe. The time difference may be as much as 100 years.

Endnote 3

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
Packaging applications of oxo-degradable plastics include carrier bags, blister packaging, bottles, labels, and caps.

Response (Oxo-Biodegradable Plastics Association)
Correct. OBP is also suitable for drinking straws, cups, and many other applications. In the USA the Environmental Protection Agency has approved oxo-biodegradable plastic landfill covers as an application to reduce the soil waste - the 7 - 10 inches of soil which are applied between layers of garbage dumped at a landfill site. They replace 10 inches of soil with a 60 micron PE film.

Endnote 4

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
Oxo-degradable plastics and similar materials are marketed and referred to in different ways, including so-called oxo-biodegradable, photo/thermo-degradable, oxo-fragmentable or pro-oxidant additive containing plastics - a terminology prone to confuse consumers, policymakers and companies.
Response (Oxo-Biodegradable Plastics Association)
The OPA supports the use of a single term 'Oxo-biodegradable Plastic' for all plastic finished products or articles which contain a masterbatch promoting oxidative degradation in the open environment and producing materials which are no longer plastics and are non-toxic and biodegradable. It does not approve other descriptions - which do cause confusion. The MacArthur foundation are causing confusion themselves, because throughout this paper they use the term oxo-degradable plastic when they are referring to oxo-biodegradable plastic. Products which only physically fragment and do not produce biodegradable end products, i.e. fragmentable or photo-degradable products are not acceptable to the OPA. In fact conventional plastics can be described as oxo-degradable or oxo-fragmentable since they undergo degradation in the environment but do not become biodegradable except over a very long period of time. The FTC Green Guide is concerned only with advertising, and each company selling oxo-biodegradable products is responsible for compliance with the laws relating to advertising in the country or countries concerned. The reference by EMF to claim 260.8 is misleading, because a claim of oxo-biodegradability made in accordance with 260.8 (b) – (d) is perfectly acceptable. References by EMF to "Photo-degradable" or "Enzyme-mediated degradable plastics" are not relevant to their paper, nor this enquiry by ECHA, and the OPA makes no comment about them.

Endnote 5

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
Over the past decade, oxo-degradable plastics have gained attention as a potential solution to soil and marine pollution, with the material made mandatory in several countries and regions worldwide, and marketed in many more.
Response (Oxo-Biodegradable Plastics Association)
Substantially correct. The EMF are again confusing oxo-biodegradable plastics with oxo-degradable plastics, and they refer to the OPA incorrectly as the Oxo-degradable Plastics Association.

Endnote 6

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
Few experts support the claim of effective biodegradation of oxo-degradable plastics.
Response (Oxo-Biodegradable Plastics Association)
It is incorrect to say that “few experts” support the claim of effective biodegradation of oxo-degradable plastics. The experts mentioned by EMF are scientists who have made a detailed study of oxo-biodegradable technology over many years, and there are many others, including Dr. Anne-Marie Delort, Dr. Dominique Fromageot, Dr. Boris Eyheraguibel, Dr. Graham Swift, Dr. David Wiles, Dr. Stephane Fontanella, Dr. Norman Billingham, Dr. Graham Chapman, and Professor Gerald Scott, the author of “Degradable Plastics – Principles and Applications” (ISBN 1-4020-0790-6) who can be said to be the inventor of the technology. The industry has a well-developed testing methodology and assessment schemes to assess the degradation, biodegradation, and non eco-toxicity of oxo-biodegradable plastic The use of accelerated testing is often used to produce sufficient degraded material for tests, but that does not mean that the tests are not useful or instructive. Elevated temperature is used to accelerate the rate of chemical processes in order to save time and cost in the laboratory, and is well understood. Any criticism of current laboratory practice can be equally applied to testing of other materials, including testing of compostable plastic in accordance with EN13432. The work cited by the experts mentioned has been performed by academic scientists in the employment of independent universities or testing institutions, who have their own high level validation procedures, and the fact that some of the testing has been requested and paid for by commercial companies does not make it unreliable. By comparison, much of the evidence cited by EMF against oxo-biodegradable plastics is by authors who may be experts in polymer science but have not made a detailed study of oxo-biodegradable technology, and it is presented by organisations with a commercial interest against oxo-biodegradable plastic. These include the “Biodegradable Products Institute,” Bioplastics Magazine, European Plastics Converters, SPI Bioplastics Council, and Sustainable Plastics Coalition.

Endnote 7

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
However, a wide range of academics (from universities including California State University, Michigan State University, University of Loughborough), international and governmental institutions (e.g. UN Environment, European Commission, UK Government), testing laboratories (e.g. Organic Waste Systems), trade associations of plastics manufacturers, recyclers and converters (e.g. PlasticsEurope, SPI Bioplastics Council, European Plastics Converters), non-profit organisations (e.g. Sustainable Packaging Coalition) and multiple other experts have provided or collected evidence that oxo-degradable plastics are not a solution to plastic packaging pollution, and that they are not suited for effective long-term reuse, recycling at scale or composting.
Response (Oxo-Biodegradable Plastics Association)
In general, reports and literature reviews by researchers who are not experts in oxo-biodegradable technology show a lack of understanding of the mechanism by which oxo-biodegradable plastics acquire biodegradability via initial oxidation in the open environment, and

the function of the stabilisation package. This leads to testing in conditions, and according to standards, inappropriate for oxo-biodegradable plastics.

A case in point is the study carried out by Michigan State University. See https://www.symphonyenvironmental.com/wp-content/uploads/2018/05/MSU-Reponse-24-April-2015.pdf

In addition, oxo-biodegradable plastics (conventional polyolefins made with a prodegradant catalyst) are often confused and conflated with very different technologies, such as the addition of small amounts of inherently biodegradable material (i.e. starch, enzymes) to conventional plastics which result in the biodegradation of that additive only.

Oxo-biodegradable plastics are sometimes assessed and rejected on the basis that they do not meet industrial composting standards or will not degrade in landfill, but they are not designed or intended for composting or landfill. Furthermore, meeting the requirements of tests for composting, or for degradation in anaerobic conditions, is not evidence of degradation or biodegradation in the open environment.

Oxo-biodegradable plastics (conventional polyolefins made with an effective prodegradant catalyst) are often confused and conflated with very different technologies, such as the addition of small amounts of inherently biodegradable material (i.e. starch, enzymes) to conventional plastics which result in the biodegradation of that additive only.

Specific reports cited by EMF:

California State University, Chico Research Foundation, Performance Evaluation of Environmentally Degradable Plastic Packaging and Disposable Food Service Ware - Final Report (2007):

Compostable test: not relevant to OBP

Marine test: The authors seem unsure whether fragmentation is desirable or not. In their experiments only the PHA bag sample showed any significant fragmentation. Even Kraft paper control, PLA lids, sugar cane lids, corn starch trash bags, and Ecoflex bags showed no fragmentation after 60 days.

This experiment needs to be redesigned.

R. Narayan, Fundamental Principles and Concepts of Biodegradability - Bioplastics Magazine, Vol. 4 (2009);

No scientific evidence or data is presented regarding the efficacy of oxo-biodegradable plastics, only unsubstantiated opinion. Narayan is an expert in bio-based plastics, but not in oxo-biodegradable technology. Reference is made to finding no degradation according to standards for industrial composting (EN13432, ISO 17088) but such testing is irrelevant as OBPs are not designed to degrade in such environments and they are not comparable to littering in the open environment.

N.L. Thomas, J. Clarke, A.R. McLauchlin and S.G. Patrick, Loughborough University, Oxo-degradable plastics: degradation, environmental impact and recycling, Proceedings of the Institution of Civil Engineers Waste and Resource Management 165, Issue WR3, Pages 133–140 (2012);

Literature review only, which confirms the relationship between molecular weight reduction and biodegradability. The evidence presented in the review does not support the conclusion that OBP cannot make a contribution to dealing with plastic packaging pollution, nor that they are not suited for effective long-term reuse or recycling at scale.

Reference to biodegradation in composting is irrelevant.

ASTM D6954 requires <5% cross-linked fraction, but observed values are much less than this. Concerns re fragmentation/pollution residues are misplaced since conventional plastics are well understood to undergo fragmentation, yet remain more persistent than OBPs. OBPs can in the worst case be no worse than conventional plastics.

Recycled “membranes used in construction, and medium-life applications, such as garden furniture” are rarely made from unknown/PCR/mixed recyclate and certainly not without taking measures to ensure stability. See TCKT report 27.7.16
http://www.biodeg.org/Report_20160727_final_corr%20-%209-8-16.pdf

The report by Thomas et al says “At present there seems to be very little post-consumer recycling of the sort of plastic film products where oxo-degradable plastics are usually used. This is mainly because such material is difficult to collect, is generally of poor quality and is therefore not economically viable for recyclers.”

An important point made by the authors is that “There was not found to be any evidence that the type of carrier bag (oxo-degradable or not) affects the way in which they are disposed of by the public”

“As the plastics will not degrade for 2–5 years, the plastics will still cause litter within this timeframe.” Of course the plastic item must have a period of time within which it can be used, re-used and recycled. Actual timescale will depend on a variety of factors and can be much shorter, but even five years is very much less time than for conventional plastics.

The comparison with the degradation rates of compostable plastics in industrial compost conditions is deeply flawed and misleading.

United Nations Environment Programme (UNEP), Biodegradable Plastics and Marine Litter (2015). Misconceptions, concerns and impacts on marine environments;

Following this report the oxo-biodegradable plastics industry has entered into a dialogue with UNEP to explain misunderstandings about the technology and to show how it can contribute to a significant reduction in the burden of plastic fragments in the oceans.

The author of the 2015 report is correct that PE and PP will not readily biodegrade in marine environments, and that is why oxo-biodegradable versions of these plastics have been invented - because people do not always dispose of their waste responsibly.

There is no oxo-biodegradable PVC.

The micro-particles of plastics being found in the oceans are from conventional plastics and there is no evidence that oxo-biodegradable plastics are more harmful. In fact, for the reasons given at http://www.biodeg.org/marineenviornment.html they are less harmful.

There are no references in the report to the work of Jakubowicz, Scott, Ojeda and Lemaire or their academic groups, all of whom are experts in the science of oxo-biodegradation. The report relies on the work of Thomas, who also has no expertise in oxo-biodegradable plastics, but she did say that there was no evidence that biodegradable plastics of any kind would encourage people to litter.

The report provides no evidence that OBPS are more harmful than conventional plastics.
The author is a geologist not a polymer scientist, and we are disappointed that he did not ask the industry for information before publishing.

European Commission, Eunomia, Study to provide information supplementing the study on the impact of the use of "oxo-degradable plastic" on the environment (2017); This report does not substantiate the claims made by EMF, and it has been reviewed by the OPA at https://www.symphonyenvironmental.com/wp-content/uploads/2018/05/OPA-Comment-on-EUNOMIA-REPORT-4.9.171.pdf

Department for Environment, Food & Rural Affairs of the UK Government (DEFRA) (2010) This report does not substantiate the claims made by EMF. The OPA has reviewed the report at https://www.symphonyenvironmental.com/wp-content/uploads/2018/05/SYM-RESPONSE-TO-LOUGHBOROUGH-18-3-2010.pdf

Plastics Europe/OWS Report – Aug 2013

This is a literature review performed by experts in compostable materials, not oxo-biodegradable technology.

The French Centre National d'evaluation de Photoprotection (CNEP) commented on this http://www.biodeg.org/French%20university%20critical%20of%20OWS%20report%20-%207.10.13.pdf

CNEP confirm that the mechanism (and therefore products) of polymer degradation is constant between 20-80C, and that only the rate of degradation is increased. Within this temperature range, accelerated ageing can be used to evaluate the relative rate of polymer oxidation and the behaviour and impacts of the residues of polymer degradation.

"Based on the above, a reduction in molecular weight of oxo-degradable plastics cannot be questioned if these are oxidized under the influence of light, heat and/or oxygen. The question is how far this reduction continues and whether a sufficiently low level is reached at which the plastic does indeed becomes biodegradable."

The demonstration of biodegradation in recent reports (Eyheraguibel 2017 and many others) continues to demonstrate specifically the biodegradability of the residues of polymer degradation which is accelerated by use of a prodegradant additive.

Eurofins (July 2017) evaluation of OBD film according to the requirement of ASTM D6954 demonstrates 88.9% mineralisation.

European Plastics Converters (EuPC), (2012)
OPA Response: http://www.biodeg.org/RECYCLING%20General%20-%20Jan%202014.pdf

Oxo-fragmentable is an oxymoron. If the polymer is undergoing oxidation then it is undergoing a fundamental change it its chemistry – not simply breaking up into smaller parts as is implied by 'fragmentable'.

Further work undertaken by TCKT in March 2016 which demonstrates that oxo-biodegradable plastic can be safely recycled with conventional plastic without any need for separation.

This report does not substantiate the claims made by EMF. It seems that EuPC were testing mainly biobased plastics, and their report confirms our view that bio-plastics cannot be recycled with oil-based plastics. We have not seen anything which invalidates the expert advice which we have received on oxo-biodegradable plastics – that they can be safely recycled during their useful life with ordinary oil based plastics.

If an oxo-biodegradable plastic was tested, the type of polyethylene and the masterbatch formulation is not specified, which makes the report meaningless in relation to oxo-biodegradable plastic. It is incorrect to suggest that adding 2% of oxo-bio plastic to ordinary plastic would create a visible difference in the new product, as there is no visible difference even in a 100% oxo-bio product. Moreover, 2% of oxo-bio plastic contains only .002% of prodegradant additive, which is too small to have any effect at all.

Michigan State University Susan Selke et al., Evaluation of Biodegradation-Promoting Additives for Plastics (2015); Sustainable Packaging Coalition (SPC), Position against Biodegradability Additives for Petroleum-Based Plastics (2015);

This report does not substantiate the claims made by EMF. It was reviewed by the OPA at https://www.symphonyenvironmental.com/wp-content/uploads/2018/05/MSU-Reponse-24-April-2015.pdf

Sustainable Packaging Coalition (2015)

Suggests that composting is superior to environmental biodegradation because useful material is recovered, but the standards for composability (EN 13432, ASTM D600) require at least 90 conversion to CO2, which produces nothing of value for the soil. In any event it is not possible to compost plastic which has escaped into the open environment and cannot realistically be collected. This is the plastic for which OBP is designed.

OBP is an insurance policy for whatever proportion may end up in the environment as litter, reducing persistence and accumulation in the environment. Biodegradation in the environment is not however the intended outcome. Re-use and recycling is to be preferred and encouraged in all cases.

Since OBPs require oxygen in order to undergo oxidative chain cleavage resulting in molecular weight reduction, they do not biodegrade in anaerobic conditions or produce methane.

Society of the Plastics Industry (SPI) Bioplastics Council (2016), Position paper on degradable additives.

This is a lobby group for the bio-based plastics industry.

The report does not substantiate the claims made by EMF. The authors continually cite specifications for compostable plastics in industrial composting conditions as the criteria for confirmation of biodegradability. This is a misunderstanding since the conditions in these tests are not relevant to conditions in the environment and meeting such requirements cannot be considered as evidence of rapid degradation in the environment, where OBPs are designed to degrade if they are littered and cannot be collected.

In the only example given of an actual test, biodegradation is assessed by anaerobic degradation (ASTM D5511). Anaerobic degradation is not suitable for OBPs, which degrade by oxidation, and is not relevant to degradation in the aerobic environment as litter.

We agree that fragmentation is not a solution to littering, but SPI ignore the well-established fact that conventional plastics undergo oxidation in the environment to form persistent microplastic fragments which remain the environment for a very long time.

The authors make the point that marketing packaging as biodegradable may encourage littering of plastics, but there is no evidence that this is the case and even if it were true, such evidence would need to demonstrate that any proportional increase in littering offsets the benefits of more rapid bio assimilation. We encourage the use of education to prevent littering and the use of environmentally biodegradable solutions which will eliminate whatever remaining proportion of litter, no matter how small, from the environment as quickly as possible.

Endnote 8

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
Oxo-degradable plastics are often marketed as a solution to littering by claiming they are degradable - a marketing statement which is prone to confuse consumers and the wider public and may actually incentivise littering.
Response (Oxo-Biodegradable Plastics Association)
The meaning conveyed by this statement is that manufacturers of oxo-biodegradable plastic falsely market their products as degradable, which confuses the public and may incentivise littering (the implication being that if consumers are misinformed by manufacturers that the products will degrade, they may see no harm in discarding them into the natural environment). The fact that they do degrade and become biodegradable is the single most important feature of oxo-biodegradable plastics and therefore it is a key theme of their marketing. These products are not however marketed as a solution to littering, but as the only way to protect the open environment from long-term plastic pollution if other measures fail, as they clearly do at present and will continue to do for some time into the future, even in Europe. The allegation that describing a plastic as degradable may actually incentivise littering is based on pure speculation: 1. this argument is rarely advanced as an objection to bio-based plastics; and 2. degradable plastic products (both oxo and hydro biodegradable) have been available to the public for more than ten years, but there is no evidence that people dispose more carelessly of them and they have certainly not been encouraged to do so. It is fanciful to suppose that the type of person who causes litter will bother to ascertain whether a plastic product is biodegradable before throwing it out of a car window. Furthermore, this statement does not take account of unintentional littering by the general public and more significantly the litter which has escaped from the waste streams from industry and commerce. The idea that this assertion is sufficient to warrant an outright ban or restriction of oxo-biodegradable plastics is wholly unreasonable. Clearly there is at present an issue with conventional plastic litter in the environment which has accumulated over many decades without any claims of biodegradability. The answer to these concerns is strong education and waste-management practices which encourage proper handling, reuse and recycling of all plastics where at all possible and appropriate.

Endnote 9

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
In the environment they fragment into smaller pieces, including microplastics.
Response (Oxo-Biodegradable Plastics Association)
This is a fundamental understanding, which essentially invalidates the conclusions of the EMF Report. The reasons are given in detail under Assertion C above.

Endnote 10

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
Studies show that the entire biodegradation process varies, as environmental conditions inevitably do, and often takes (much) longer than claimed.
Response (Oxo-Biodegradable Plastics Association)
See response to Endnote 7 above Some of the papers cited in endnote 10 are not representative of oxo-biodegradable technology. For example, in the studies in the marine environment cited, the specification used refers to compostable plastics which are a completely different type of plastic. Also, they have higher density than PE/PP so they sink, while PE and PP float. Again, using wrong testing methods and specifications, leads to wrong results and wrong conclusions The degradation behaviour of all materials in the environment is subject to significant variation due to situational, geographical, and seasonal variation in exposure conditions. Unlike the degradation of conventional plastics leading to the formation of microplastics, degradation of oxo-biodegradable plastics is not dependant on continued and sustained exposure to sunlight. Often the minimum period of shelf-life stability in storage conditions is confused with time to the onset of degradation. In fact, the onset of degradation before the end of the useful life is trigged by sunlight exposure, but will occur eventually and much sooner than for a conventional plastic even if exposure to sunlight never occurs. The OPA supports the development of more test methods and international standards for the performance oxo-biodegrade plastics, in the form of tests that may reasonably be performed on all oxo-biodegradable finished products and articles intended to be placed on the market. The OPA and its members already implement minimum degradation requirements so that plastic marketed as oxo-biodegradable meets a minimum requirement for performance.

Endnote 11

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
During this time microplastics remain in the environment, including the ocean. As with all microplastics in ecosystems, there is a risk of bioaccumulation, including into the food chain, with potential negative impacts on human health and the environment.
Response (Oxo-Biodegradable Plastics Association)
Oxo-biodegradable plastics significantly reduce the dwell-time and persistence of plastic litter, as compared to that generated by the conventional plastics which they are intended to replace; therefore reducing the extent of accumulation and the concentration of plastic litter in the sea at any time. Therefore, the risk and effect of bioaccumulation are significantly reduced.

Endnote 12

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
Reuse: Oxo-degradable plastics are designed to start fragmenting within a few months or years. Therefore, even though the addition of stabilisers can delay the intended fragmentation effect, oxo-degradable plastic packaging is - by its very design - not meant for long-term reusable applications.

Response (Oxo-Biodegradable Plastics Association)
The description of OBP with reference to recycling is not correct. OBP have a useful life which is designed as per the finished product's specification, from months, to years. Until the useful life ends, the plastic is still reusable and recyclable. The use of stabilisers in oxo-biodegradable plastics is more complex than simply delaying the onset of degradation. Oxo-biodegradable plastics are designed to start to oxidise at an accelerated rate if and when they are littered in the environment, when they are unlikely to be collected for recycling. Independent scientific studies have proved the complete compatibility of post-consumer PE and PP with the recyclability process. http://www.biodeg.org/recycling.html The degradation starts only after the product escapes into the waste stream and is exposed to outdoor, environmental conditions. The NAPCOR reference to PET recycling is not relevant, as OBP technology does not apply to PET products.

Endnote 13

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
Recycling: Recyclers and converters have widely recognised that oxo-degradable plastics negatively affect the quality and economic value of plastic recyclates, and are advising against their use.
Response (Oxo-Biodegradable Plastics Association)
See above under Assertion F and http://www.biodeg.org/recycling.html There is a general confusion in the recycling industry between bioplastic recycling with commodity resins and oxobiodegradable plastics recycling with commodity resins. While the bioplastics are totally incompatible with commodity resins (PE, PP), the OBP are perfectly compatible. Studies have proved that OBD can be recycled together with commodity resins or by itself, re-stabilized and it will perform as any regular recycled plastic material. In the UAE, the OBD has been mandatory for 9 years and the recycling industry functions with no issues. Oxo-biodegradable plastics are fundamentally compatible with conventional fossil plastics as they are predominantly (>99.9%) made using conventional polymers, this is not true of alternative materials such as biobased polymers. Just like conventional plastic, until the onset of degradation oxo-biodegradable plastics can be recycled in conventional waste streams. Conventional and oxo-biodegradable plastics which have been littered in the environment for a time sufficient to bring about the onset of degradation are very unlikely to be collected from the environment for recycling. Furthermore post-consumer unidentified mixed recyclate, particularly those which have been exposed to conditions conducive to advanced degradation, are very unlikely to be used for the manufacture of long-life applications where stability is critical (i.e building films, irrigation pipe, etc.) and is likely to be used for low cost, short life applications such as bags and packaging. However, the TCKT report of 27th July 2016 deals specifically with long-life plastic products. Testing has demonstrated that in the extreme scenario of recycling of up to 100% oxo-biodegradable plastics, is successful and results in a functional recycled product[11]. Further testing

[11] Effect of mechanical recycling on the properties of films containing oxo-biodegradable additives, TCKT March 2016 http://www.biodeg.org/recycling.html

demonstrates that current protection systems required for the stabilisation of conventional plastics recyclate for long-term, outdoor use are fully effective in the protection of 100% oxo-biodegradable recyclate in the same application and conditions.[12]

Endnote 14

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
They reported that oxo-degradable plastic packaging cannot be detected by current technology at sufficient scale to be sorted out from conventional plastics. While the intended fragmentation effect can be delayed, this is not a long-term solution for recycling at scale: it is difficult to estimate the proportion of stabilisers added and the extent of degradation already induced in the material - a challenge expected to worsen with every recycling loop.
Response (Oxo-Biodegradable Plastics Association)
OBP could be easily detected by adding a tracer when the OBP products are being made, but there is no reason to separate them from the recycling stream of commodity resins as they are perfectly compatible. According to the recycling charity RECOUP ("Recyclability by Design" 2006) "In cases 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 producing new plastics. In such cases recycling may not be the most environmentally sound option." These are the very products in which OBP technology is commonly used and they are not plastics in high-value use. Members of the Oxo-biodegradable Plastics Association (OPA) and their customers have been successfully recycling OBP for more than ten years with no adverse reports, but so as to address external concerns extensive scientific tests were done by Roediger Laboratories of Stellenbosch, South Africa. They concluded that "Plastic products made with OBP technology may be recycled without any significant detriment to the newly formed recycled products, and further test by the Transfercenter fur Kunssttstofftechnic Gmbh (TCKT) laboratory in Austria came to the same conclusion. See http://www.biodeg.org/recycling.html There is therefore no need for separation of OBP from conventional plastics. These were "worst-case-scenario" tests, using up to 100% recyclate; and 100% oxo recyclate, but neither of these conditions are likely to occur in practice. These tests were designed to be representative of internal and external industrial recycling, and post-consumer recycling including kerb-side collection i.e. scenarios where there has been no significant exposure to outdoor conditions which would promote the onset of degradation. Plastic products of any kind which do escape into the environment and remain there for long enough for significant degradation to occur, are unlikely to be recycled. There have been several stories in the trade press recently about recyclate from Southern European countries causing defects and ruptures in new film. When you look a little closer it becomes clear that the defects were caused by substances used in the manufacture of "bio-plastics" made from starch, polylactide (PLA) and which are not used in the manufacture of OBP. This is a problem that is likely to get worse, as governments in France, Italy, Spain and now Greece have been persuaded by the manufacturers of "bio-plastics" to prefer their products.

[12] Weathering study on LDPE (with and without d2w/oxobiodegradable additive), TCKT – July 2016

Endnote 15

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
Composting: Oxo-degradable plastics do not fulfill the requirements of relevant international standards for plastic packaging and plastics recovery through composting, such as ISO 18606, EN 13432, ASTM D6400, AS 4736 or GreenPla, as their biodegradation takes too long, and plastic fragments can remain in the compost.[15]
Response (Oxo-Biodegradable Plastics Association)
Oxo-biodegradable plastics, like conventional plastics, are not intended for composting. This comment in the EMF report is therefore irrelevant.

Endnote 16

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
If added to a composting stream, they adversely affect the quality and market value of the compost, and potentially enable the release of plastics into the natural environment.
Response (Oxo-Biodegradable Plastics Association)
Oxo-biodegradable plastics, like conventional plastics, are not intended for composting. This comment in the EMF report is therefore irrelevant.

Endnote 17

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
Therefore, oxo-degradable plastic packaging should not be included in the material stream intended for composting. This incompatibility is also clearly stated by many manufacturers of oxo-degradable additives and by the Oxo-biodegradable Plastics Association.
Response (Oxo-Biodegradable Plastics Association)
Oxo-biodegradable plastics, like conventional plastics, are not intended for composting. This comment in the EMF report is therefore irrelevant.

Endnote 18

Assertion (Ellen MacArthur Foundation/New Plastics Economy)
In summary, the evidence to date suggests that oxo-degradable plastic packaging goes against two core principles of the circular economy: designing out waste and pollution; and keeping products and materials in high-value use. In addition, claims made about benefits of oxodegradable plastics in landfills have been shown to be misleading.
Response (Oxo-Biodegradable Plastics Association)
Oxo-biodegradable plastics, are not intended to degrade in landfill. This comment in the EMF report is therefore irrelevant. Oxo-biodegradable plastics can be used in such a way that is compatible with the principles of a circular economy.

It is not suggested that new products be made with oxo-biodegradable plastics, only that oxo-biodegradable plastics should replace those products that are already made from conventional plastics, but which cannot sustainably be removed by redesign, materials reduction or replaced with superior materials and for which a degree of unavoidable escape or littering.

The goals of the circular economy are admirable and should be pursued. However, for as long as plastics continue to be used in their current form and while there is a global issue of plastic litter with no universal solution in sight, oxo-biodegradable plastics offer an addition to the toolkit which will help to remedy the effect of plastic litter. There is no evidence that oxo-biodegradable plastics cause a greater impact than current practices and a good deal of evidence that in many cases they will provide benefit.