Critical review by the Oxo-Biodegradable Plastics Federation:

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

1. INTRODUCTION

On 29 April 2015 the European Parliament and the Council adopted Directive (EU) 2015/720 amending Directive 94/62/EC as regards reducing the consumption of lightweight plastic carrier bags.

The main objective of this Directive is to reduce the consumption of lightweight plastic carrier bags, thereby reducing the littering of these bags and their accumulation in the environment, where they aggravate the widespread problem of plastic waste in the environment and in particular marine pollution.

Article 20a (2) of the Packaging Directive tasks the Commission to present a report to the European Parliament and to the Council examining the impact of the use of oxo-degradable plastic carrier bags on the environment and, if appropriate, present a legislative proposal.

The purpose of the current report is to inform the European Parliament and the Council of the Commission's follow-up to the mandate.

The Commission examined the impact of so-called oxo-degradable plastic on the environment beyond plastic carrier bags and underpinned its assessment by a study published in April 2017, addressing the following three key issues:

- the biodegradability of oxo-degradable plastic in various environments,
- environmental impacts in relation to littering, and
- issues related to recycling.

Within these areas, a number of distinct hypotheses were defined, relating to claims and assumptions from the oxo-degradable industry about the material. On the basis of evidence gathered with respect to the hypotheses, these were analysed to ascertain whether they can be supported or refuted.

The study is based on an appraisal of literature, including scientific reports, and information from stakeholders and technical experts.

It is clear from the introduction to the final report regarding the effects of oxo-biodegradable plastic on the environment that the EC is reporting from a negatively pre-judged position by referring to these materials as "so-called oxo-degradable plastic" (which is repeated continually throughout the final report) when the report that the EC commissioned and is referred to as underpinning their judgement concluded that the biodegradation of oxo-biodegradable plastics has been proven beyond doubt.

2. BIODEGRADATION, COMPOSTING AND OXO-DEGRADATION

For a good understanding of the issues discussed it is necessary to define and explain the processes of biodegradation, composting and oxo-degradation.

'Biodegradation' is a process by which material disintegrates and is decomposed by micro-organisms into elements that are found in nature, such as CO_2, water and biomass. Biodegradation can occur in an oxygen rich environment (aerobic biodegradation) or in an oxygen poor environment (anaerobic biodegradation).

'Composting' is enhanced biodegradation under managed conditions, predominantly characterised by forced aeration and natural heat production resulting from the biological activity taking place inside the material. The resulting output material, compost, contains valuable nutrients and may act as a soil improver.

> ***While the definition of composting provided in the EC report is (technically) correct, it does not relate (misleadingly so in the context of the discussion of the biodegradation of plastic) to a compostable plastic in some key areas; a compostable plastic is one in which the plastic material will be first fragmented by enzymatic action which is then converted to CO_2. This process must proceed until at least 90% of the material has been converted into CO_2 in no more than 180 days; this process occurs under the synthetic conditions of 58°C, high moisture and high pH as per European Norm (EN) 13432. It is worth noting at this point that the ASTM equivalent, D6400, is under a process of urgent review (as unfit for purpose) as these conditions are rarely if ever met in an industrial composting environment, as the tendency is for composting units to operate at lower temperature and certainly much shorter turn round times. It may be considered that a compostable plastic utilises (former) "industrial composting" conditions to essentially be slowly incinerated. A "compostable" polymer does not add any "valuable nutrients" to the resulting material, and as most industrial composting facilities have considerably shorter turnaround times for the compost, it can be argued that if these plastics are collected and find their way into a composting facility, the resulting compost would have a high chance of being contaminated with fragmented "compostable" plastic material. Some industrial composters have started to turn away these materials, because of this exact fear.***

In theory, almost all materials ultimately may biodegrade, even in the open environment though some will do so only after sometimes hundreds of years or more. Looking at biodegradation of plastics as a means to avoid pollution hence only makes practical sense if this is linked to a "reasonable" time frame. It should also be assessed taking into account specific conditions and/or environments, such as the marine environment, where biodegradation is particularly challenging.

These include materials resulting from artificial synthesis processes (e.g. plastics) and those resulting from natural synthesis processes ("biopolymers", such as cellulose and proteins), excluding rocks and metals.

Defining a 'reasonable' time frame might differ from product to product depending also on the use of the product and its impact on the environment; the environmental impact is correlated with the time taken for complete breakdown of the polymer.

Bio-based plastics have the same properties as conventional plastics but are derived from biomass, as defined in European Standard EN 16575.

Biopolymers biodegrade quickly, both under controlled conditions and in the open environment.

Consideration of this statement would mean that biopolymers would start biodegrading as soon as they are produced, and this would be accelerated when they encounter bacteria from contact with hands, the air etc. Obviously, this is not the case otherwise they would not be of any practical use.

Bio-based polymers do not have the same properties as conventional plastics in some key areas relating to oxygen and water barrier properties – important for food preservation.

Biopolymers do not biodegrade quickly in the open environment as they are designed to biodegrade in the synthetic conditions as described above. One of the most common biopolymers, poly (lactic acid) is very stable in ambient conditions and is typically used in biopolymer compounds to slow down the rate of biodegradation at the conditions found in the industrial composting environment.

Biodegradation of materials resulting from artificial synthesis, such as conventional plastics, is theoretically possible when the material is broken down into small particles and the molecule mass of the material is sufficiently reduced to enable biodegradation. Factors such as light, humidity, oxygen and temperature determine the degradation rate. In the open environment it may take a long time, up to hundreds of years, for conventional plastics to biodegrade. Plastics marked as "biodegradable" only biodegrade under specific environmental conditions. Biodegradation does not depend on the resource basis of a material: biodegradable plastic (as conventional plastic) can be fossil-based or bio-based.

So called oxo-plastics or oxo-degradable plastics are conventional plastics which include additives to accelerate the fragmentation of the material into very small pieces, triggered by UV radiation or heat exposure. Due to these additives, the plastic fragments over time into plastic particles, and finally microplastics, with similar properties to microplastics originating from the fragmentation of conventional plastics.

The oxidative degradation of plastics has been recognised and the mechanisms understood ever since the development of plastic several decades ago. The use of anti-oxidant additives to stabilise plastics from the effects of UV and heat is a common and necessary practice and are manufactured globally by many large chemical companies (such as BASF an EU based company).

This oxidative degradation, as with most chemical reactions, can be accelerated by certain additives, hence oxo-biodegradable additives do not cause the fragmentation of plastics into smaller pieces of plastic, but for the conventional plastics to change both chemically (introducing oxygen into the molecule) and structurally (reducing the

average molecular weight of the polymer as is required for all large carbon based molecules, including wood and biopolymers) to enable biodegradation to take place by microbial action.

This accelerated fragmentation would also accelerate biodegradation. Some stakeholders present "oxo-biodegradation" as the solution to environmental impacts of plastic in the open environment. They claim that even when littered, oxo-degradable plastic fragments and biodegrades in the open environment without leaving any toxic residues or plastic fragments behind.

The question is however whether in uncontrolled conditions in the open environment, in landfills or in the marine environment, the plastic fragments will undergo full biodegradation within a reasonable time-frame. If this is not the case, oxo-degradable plastic will contribute to the microplastics release in the (marine) environment while misleading consumers. As recent research shows, microplastics released in the marine environment get into the food chain and end up being consumed by humans.

There is also a question of whether the claimed biodegradation of oxo-degradable plastics may impact on consumers' littering behaviour.

Furthermore, questions relating to the recycling process arise, as the inherent and even programmed fragmentation through oxidising agents in the plastic waste streams may have a negative impact on plastic recycling.

3. ISSUES RELATING TO BIODEGRADABILITY OF OXO-DEGRADABLE PLASTIC, INCLUDING PLASTIC CARRIER BAGS

3.1 Fragmentation and biodegradation in the open environment

A considerable number of studies have demonstrated that oxo-degradable plastic in the open environment, when exposed to heat and/or UV light for an extended period, indeed oxidises to the point where the plastic becomes brittle and fragments.

This first stage of degradation prepares the oxo-degradable plastic for biodegradation by reducing the molecular weight of the plastic to the point where it may be consumed by biological organisms.

While oxidising additives will, in an open environment, accelerate fragmentation of traditional polymers, the pace of fragmentation varies significantly depending on conditions determined by temperature, light intensity and moisture. It is clear that oxo-degradable plastic is prohibited from degradation if not first exposed to UV radiation and, to a certain extent, heat. As these conditions vary from day to day and according to local conditions, it is very difficult, if not impossible, to specify timescales in which e.g. an oxo-degradable plastic carrier bag will fragment in the open environment. There is therefore no conclusive evidence of a degree of fragmentation resulting in a sufficiently low molecular weight of the plastic that may enable a possible biodegradation.

A major issue for oxo-degradable plastic is the trade-off between the intended service life and the period that might be needed for degradation in the open environment. Even if biodegradation may be facilitated by careful engineering of the chemical package, evidence is not available to definitely conclude that this will happen in real world situations. If the circumstances for fragmentation to take place are absent or insufficient, biodegradation will not take place.

This section demonstrates a worrying lack of understanding by the author(s). The description of the oxidative degradation mechanism while correct, does however proffer a confused inference that the UV and heat required may not be available in the open environment, when

of course they are ubiquitous to everyday life. The degree of fragmentation (as it is incorrectly referred to) or more accurately the degree of oxidation degradation required to cause biodegradation has been conclusively proven many times with evidence provided to the EC consultants Eunomia who provided such in their final report of April 2017 (which reportedly underpins this final report from the EC) and is a key requirement of the oxo-biodegradation standard BS8472:2011 and the standard test guide for plastics which degrade in the environment through a process of oxidation and biodegradation, ASTM D6954-04 (2013), which it is worth noting here (that unlike ASTM D6400) has just been revised and renewed for a further 5 years at ASTM.

3.2 Composting

Composting requires material not only to biodegrade, but to also become part of usable compost and provide the soil with nutrients. The evidence suggests that oxo-degradable plastic is not suitable for any form of composting or anaerobic digestion and will not meet the current standards for packaging recoverable through composting in the EU10. Remaining plastic fragments and potentially generated microplastics might adversely affect the quality of the compost.

The above description also demonstrates a lack of understanding, as a compostable plastic is one in which the plastic material is converted to CO_2 to a degree of at least 90% in no more than 180 days; this process occurs under the synthetic conditions of 58°C, high moisture and high pH as per European Norm (EN) 13432. There is no requirement for the plastic material to contribute or become part of the usable compost. This has been dealt with in detail in the introduction. Furthermore, no oxo-biodegradable additive producer claims that such oxo-biodegradable plastics are suitable for disposal through industrial composting.

3.3 Fragmentation and biodegradation in landfills

The fragmentation of oxo-degradable plastic requires oxygen. In most parts of a landfill, especially the inner parts, little oxygen is present. Evidence to date suggests that in the deeper layers of landfill (where the material has no access to a sufficient amount of air and only anaerobic degradation is possible) there is little or no biodegradation of oxo-degradable plastic. In the outer layers of a landfill, where the material has access to air, aerobic degradation is possible.

The key distinction from an environmental protection point of view is that aerobic degradation produces CO_2 whereas anaerobic degradation produces methane, which is a greenhouse gas 25 times more harmful (on a 100 years' time horizon) than CO_2.

Consequently, if some biodegradation were to take place in the deeper layers of a landfill, oxo-degradable plastic would be marginally worse than conventional plastic from a greenhouse gas point of view, because conventional plastic does not biodegrade in these conditions.

This discussion is very confused in paragraph 1, since it seems to suggest that no biodegradation can occur as there is little or no oxygen to cause oxidative degradation of the polymer molecules, but then suggests in the final paragraph that biodegradation will occur producing methane, a potent greenhouse gas.

Firstly, the finer points of these paragraphs are written in language of pure conjecture that, we suggest, the average person would not differentiate from fact;

Secondly anaerobic digestion producing methane is a result of the types of bacteria that inhabit oxygen depleted areas of landfills and these bacteria would produce methane from any carbonaceous food source; be it an oxo-biodegradable plastic, compostable plastic or carrots etc! That methane production from anaerobic digestion is not reserved only for oxo-biodegradable plastics but any carbonaceous substance due to the nature of the microbes present.

3.4 Fragmentation and biodegradation in the marine environment

There is currently insufficient evidence to provide assurance that oxo-degradable plastic, including plastic carrier bags, will biodegrade in the marine environment within reasonable time.

Few tests have been conducted, and currently no recognized standards exist that could serve as benchmark and allow a certification.

Even if assuming that oxo-degradable plastic may fragment in the marine environment to a level where biodegradation may be possible, any biodegradation in the marine environment is expected to be much slower than in land based open environments, due to the lower concentrations of oxygen and bacteria present. Furthermore, before a plastic carrier bag fragments, the damage caused to marine ecosystem marine fauna (e.g. turtles, seabirds or whales) can be substantial.

There is no conclusive evidence about the time needed for oxo-degradable plastic to fragment in marine environments, neither about the degree of fragmentation. Moreover, as for any other plastic ending up in the marine environment, there is the risk that plastic fragments remain for a very long period in that environment and cause significant environmental damage and potential negative health impacts.

There is currently insufficient evidence to provide assurance that ANY type of plastic in whatever form will biodegrade in the marine environment within reasonable time, whatever that "reasonable" time may be defined as – though this report uses this phrase continually it does not however define its meaning.

The damage caused to the marine ecosystem and marine fauna is reserved purely for a plastic carrier bag, however as every study (and common-sense consideration) has shown ANY plastic in ANY form that is littered and finds its way to the marine environment has the potential to cause significant environmental damage. The issue here is littering – people not plastic.

As mentioned in the intro, a recent study into the "origins" of the plastic that is polluting the Pacific Ocean is coming from 5 specific countries. These results would indicate that because the majority of plastic waste in the ocean is not evenly distributed, then plastic isn't

truly to blame; it is the behaviour of specific regions that cause a disproportionate amount plastic litter.

3.5 Conclusions on biodegradation and composting of oxo-degradable plastic, including plastic carrier bags, in uncontrolled conditions in different environments

There is general agreement amongst both the scientific community and industry that in open environments oxidising additives will accelerate the fragmentation of traditional polymers.

However, for none of these environments a full biodegradation process has been documented. Most experiments were carried out over a too short time span to demonstrate full biodegradation and the results of measurements of molecular weight reduction in the initial stage of fragmentation were extrapolated following certain models. Therefore, no conclusive evidence is currently available to confirm that the fragmentation is sufficiently rapid and leads to a reduced molecular weight that allows subsequent biodegradation taking place within a reasonable time-frame.

The evidence also suggests that oxo-degradable plastic is not suitable for any form of composting or anaerobic digestion.

The conclusions reported in section 3.5 are incorrect and are not supported by the extensive evidence provided to Eunomia for the final report of April 2017.

1. ***The catalytic action of oxo-biodegradable additives with regards to the oxidative degradation of the polymer molecular structure has been studied and accepted as scientific fact – not just general agreement as reported here - for several decades.***

2. ***There have been many tests reported over many years which have demonstrated full biodegradation – conversion of the plastic to carbon dioxide, water and biomass - of oxo-biodegradable plastic as both peer-reviewed academic studies and industrial (independent) laboratory and field tests. A selection of these studies was provided by the Oxo-Biodegradable Plastics Federation (OBPF) to Eunomia and included in their final report submitted to the EC.***

3. ***Oxo-biodegradable plastics are not promoted as suitable for composting environments or anaerobic digestion facilities, so this conclusion is irrelevant (n.b. as discussed earlier current so-called "compostable" plastics are not suitable for industrial composting environments as they are designed to meet criteria which do not occur in these environments.)***

4. ISSUES RELATED TO PLASTIC LITTERING

4.1 Potential toxic effects of the oxidising additives

Potential toxic effects on soils of residual additives from oxo-degradable plastics have been identified as a concern.

Conclusions valid for all oxidising additives used can however not be drawn, because different oxidising additives are used in different concentrations.

From the available evidence it appears that the oxo-degradable plastics industry can create products with minimal toxic impact on flora and fauna; however, it has not been conclusively proven that there are no negative effects.

A few test standards for oxo-degradable plastic specify some form of toxicity test, but these standards are not obligatory for products on the EU market; moreover, some of the standards describe checklists without defining pass/fail criteria for the toxicological test results.

In the absence of adequate standards in the EU, there is no guarantee that all oxo-degradable plastic on the market avoid negative toxic effects and uncertainty about real world toxicological impacts remains.

> ***Oxo-biodegradable plastics are tested in accordance to OECD eco-toxicity testing as per requirements of BS8472:2011 and of Tier 3 of ASTM D6954-04 (2013). This is the same requirements as used for compostable plastics tested to EN13432. It therefore follows that, if the criteria of these tests for eco-toxicity are acceptable for industrially compostable plastics, then the same criteria should be used for verifying the non-ecotoxicity of oxo-biodegradable plastics.***

4.2 Potential increase in littering

Even though no conclusive information is currently available on the disposal or littering of plastic according to the type of plastic, or on the influence of marketing oxo-degradable plastic on the disposal behaviour of consumers, presenting oxo-degradable plastic as the solution for plastic waste in the environment may influence littering behaviour by making it more likely that it is discarded inappropriately. For specific oxo-degradable products such as agriculture mulches the littering issue is a given as those products are sold to farmers with the aim not to be collected after use (cf. take-back schemes for conventional plastics) but to be left on the land.

> ***There is no reason to support this speculative argument that oxo-biodegradable plastic will result in more littering than conventional plastics or industrial compostable plastics. A study was done and discussed in Degradable Polymers: Principles and Applications, where they showed that oxo-biodegradables are not the solution for littering because it's a cultural problem, but that oxo-biodegradables do help control litter pollution. ****

Additionally, farmers who have used conventional PE mulch films may or may not collect them from the field. If they do collect the film, they are more likely than not to be piled in an unused portion of their property and/or burned rather than being recycled. If they don't collect the film, then it's usually because it's contaminated with soil, dirt and sand and is of little value to recyclers. Instead, oxo-biodegradable plastics in mulch film applications, while being a cost effective solution to this problem, reduce the accumulation of plastics in soil, which otherwise depletes soil quality and affect plant growth, quality and yield in the long term.

****J.E. Guillet, Plastics in the Environment, Degradable Polymers: Principles and Applications, G. Scott, D. Gilead(ed), pp216-246(1995)***

4.3 Marine litter

The marine environment is where potentially most damage by plastic waste could arise, including fragmented plastic and microplastics; at the same time, subsequent collection or recovery of the plastic is least probable.

As oxo-degradable plastic is designed to fragment faster than conventional one it is less likely to be recovered during litter clean-up exercises, and likely to be more easily transported by wind and water. As these factors may contribute to oxo-degradable plastic being transported into the marine environment easier than conventional plastic it can be said that oxo-degradable plastic contributes to microplastics pollution and therefore poses environmental risks.

There is no conclusive evidence of full biodegradation in a reasonable time of oxo-degradable plastic in the marine environment.

There is also insufficient evidence to conclude whether oxo-degradable plastic would increase or decrease absolute quantities of plastic in marine environments. In the hypothesis that full biodegradation occurs on land, the quantity that may otherwise transfer to the marine environment would be reduced. However, full biodegradation on land is not proven to occur. Consequently, there is a risk that the fragmentation behaviour of oxo-degradable plastic exacerbates issues related to the presence of microplastics in the marine environment.

Furthermore, while rapid fragmentation may lead to less entanglement of animals in plastic, it at the same time increases physical ingestion of microplastics by marine animals.

As oxo-degradable plastic is likely to fragment quicker than conventional plastic, the negative impacts associated with the presence of microplastics in the marine environment are concentrated within a shorter period of time. This could ultimately be worse than spreading out the impacts over a longer period, due to an increase in the proportion of individuals, species and habitats affected, as well as the burden of impacts for an individual.

The vast majority of plastic pollution found in the sea and marine environments are caused by conventional plastics, not oxo-biodegradable plastic. It is estimated that 8-20Mtpa of plastic enters the oceans, representing at the most 6% of global plastic production. If the same criteria were used to assess the potential level

of oxo-biodegradable plastic entering the oceans this would be 30ktpa, that is 0.15% of plastic entering the oceans may be oxo-biodegradable material. This fraction is further reduced when consideration is given to the types of plastics that enter the oceans. Most marine pollution is from discarded fishing equipment, (illegally) dumped ship waste and other products where oxo-biodegradable additive technology is not generally used. There is no reason to make unrealistic assumption that oxo-biodegradable plastic will cause more marine littering than it would otherwise if conventional plastics are used.

On the same accord, microplastics found in the seas and oceans are caused by decades of conventional plastics pollution in the marine environment. Microplastic will continue to be a problem and harm marine life so long as plastic pollution in the marine environment is not solved and this will happen regardless if the plastic used is conventional, oxo or hydro based.

Furthermore, studies have been performed which demonstrated that plastic containing oxo-biodegradable additives are proven to be biodegradable in aquatic environments. While these tests were not done in ocean conditions, it still proves that biodegradation can occur in an aquatic environment.

One such study, an article published by Environmental Science & Technology called, "Life in the Plastisphere": Microbial Communities on Plastic Marine Debris, describes finding multiple colonies of microorganisms living on plastic in the ocean. This plastic did not contain oxo-biodegradable additives but stresses the point that biodegradation of plastic DOES OCCUR. It stands to reason then that biodegradation will occur on plastic that has had its molecular weight reduced to a reasonable size, precisely how oxo-biodegradable plastics behave.

5. ISSUES RELATED TO THE RECYCLING PROCESS

5.1 Identifying oxo-degradable plastic

The inherent and programmed fragmentation as intended with the oxidising additives is not desirable for many products made of recycled plastic. Oxo-degradable plastic should therefore be identifiable and separated from other plastics collected for recycling.

Currently available technology can however not ensure identification and separate sorting of oxo-degradable plastic by re-processors. Consequently, recycling of oxo-degradable plastic will take place mixed with conventional plastic.

There is no relevant evidence to support the author's suggestions in this section. However, there are quite a few studies that would suggest recycling an oxo-biodegradable additive will have no ill effects on the outcome of the recyclate itself.

In 2007, the Quebec government commissioned a study through "Recyc-Quebec" to determine if any biodegradable form of plastic was recyclable in conventional post-consumer recycling streams. They tested both industrial compostable plastic and oxo-biodegradable plastic against conventional plastic. Their findings indicated that plastic containing even 1% of an industrial compostable plastic were completely incompatible and would potentially ruin all resulting recyclate. Oxo-biodegradable plastic, on the other hand, was completely compatible with recycling streams containing traditional plastic. Quote from the study, "Accelerated aging affects the films containing oxo-biodegradable bags in a way similar to films made from traditional bags alone." *

M. Brunet, D. Grenier, L. Cote, "Evaluation of the Impact of Biodegradable Bags on the Recycling of Traditional Plastic Bags", CRIQ File No. 640-PE35461, Quebec, Centre de recherche industrielle, (2007)

5.2 Quality issues and marketability of recyclates

Significant concerns exist within the recycling industry that oxo-degradable plastic negatively affects the quality of recycled plastics. Tests have demonstrated that the presence of oxo-degradable plastic in a conventional plastic recycling system can lead to poor quality recyclate. Even though it also appears possible to produce high quality recyclate, there is no certainty about the absence of negative impact of the oxo-degradable plastic on the recyclate.

Evidence suggests that the impacts of oxidising 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 oxidising additives in the feedstock. However, as the concentration of oxo-degradable plastic in recyclate in real world situations is unknown, it is difficult to know the correct dosing of stabilisers.

A major issue is furthermore that it is impossible to fully control the level of aging experienced by oxo-degradable plastics during the product use phase, prior to products becoming waste and entering recycling processes.

The existence of oxo-degradable plastic and the global nature of markets for secondary materials present risks to a more generalised use of recovered plastic in long-life products. The uncertainty of whether the recyclate may contain oxo-degradable plastic and of the degree of oxidation and degradation that might have occurred prior to recovery limits the end-use for the recyclate, having a negative impact on the price of the recyclate and on the competitive position of the plastic recycling industry.

It is interesting that the author of this report seems to reference a few different studies, but doesn't cite the particulars of those studies, or their conclusions. He leaves his inference up to his interpretation of the unpresented results.

****In 2012, a peer reviewed study entitled, "Effects of reprocessing oxobiodegradable and non-degradable polyethylene on the durability of recycled materials" was published in the journal, SciVerse ScienceDirect. Their study investigated whether a mixture of 10% or 20% oxo-biodegradable additive would have any ill effects. They compared the resulting recyclate to that of recyclate from normal resin that didn't contain an oxo-biodegradable additive.***

Their results:

- ***"Based on the results obtained in this study, it is concluded that the stabilizer content is a crucial factor for the thermo-oxidative stability of plastic mixtures containing OBD materials."***
- ***"The results show that all mixtures of OBDs in the stabilized LDPE displayed estimated service lives of at least 10 years despite having significantly higher contents of OBDs than may be experienced in real life."***
- ***[It is] "concluded that the incorporation of minor fractions of OBD materials in the existing recycling streams will not present a severe effect on the stability of the recyclates, as long as the polymer mixture possesses a reasonable degree of stabilization."***

Because it's almost impossible to find a recycler that doesn't use a stabilizer package when processing recycled material, it's a pretty safe assumption that products containing 1-3% oxo-biodegradable additives will be unnoticeable in a recyclers recylate.

****I. Jakubowicz, J. Enebro, Effects of reprocessing oxobiodegradable and non-degradable polyethylene on the durability of recycled materials, Polymer Degradation and Stability, SciVerse ScienceDirect, pp316-321 (2012), SP Technical Research Institute of Sweden, Chemistry and Materials Technology.***

6. CONCLUSIONS

Taking into consideration the key findings of the supporting study as well as other available reports14, there is no conclusive evidence on a number of important issues relating to beneficial effects of oxo-degradable plastic on the environment.

It is undisputed that oxo-degradable plastic, including plastic carrier bags, may degrade quicker in the open environment than conventional plastic. However, there is no evidence that oxo-degradable plastic will subsequently fully biodegrade in a reasonable time in the open environment, on landfills or in the marine

environment. Sufficiently quick biodegradation is in particular not demonstrated for landfills and the marine environment.

A wide range of scientists, international and governmental institutions, testing laboratories, trade associations of plastics manufacturers, recyclers and other experts have therefore come to the conclusion that oxo-degradable plastics are not a solution for the environment and that oxo-degradable plastic is not suited for long-term use, recycling or composting.

There is a considerable risk that fragmented plastics will not fully biodegrade and a subsequent risk of an accelerated and accumulating amount of microplastics in the environment, especially the marine environment. The issue of microplastics is long acknowledged as a global problem in need of urgent action, not just in terms of clean-up of littering but also of plastic pollution prevention.

Claims presenting oxo-degradable plastic as an "oxo-biodegradable" solution to littering which has no negative impact on the environment, in particular by not leaving any fragments of plastic or toxic residues behind, are not substantiated by evidence.

In the absence of conclusive evidence of a beneficial effect on the environment and indeed indications to the contrary, given the related misleading claims to consumers and risks of resulting littering behaviour, EU wide measures should be considered. Therefore, in the context of the European plastics strategy, a process to restrict the use of oxo-plastics in the EU will be started.

While it is noble that the author has taken on the great task of researching the effectiveness of oxo-biodegradable additives, it's clear from this report that their research and conclusions have fallen far short. It is the opinion of the Oxo-Biodegradable Plastics Federation (OBPF) that the author should look more carefully into the information that is currently available to gleam more concise conclusions on a number of these topics.

It is also suggested that the author try to appreciate the positives and negatives of all materials discussed in this report. While it might seem like oxo-biodegradable (and they are called oxo-BIOdegradable) additives don't have all the answers, they certainly have a lot more than are discussed here.

The OBPF believes that there is no one perfect answer to the world of sustainable and environmentally friendly plastic. However, the idea that this report gives a fair representation of the options available on today's market, is a gross mischaracterization. Oxo-biodegradables should be considered part of the solutions since they offer biodegradation of plastic in a reasonably short period of time, are cost effective for every market using plastic, are proven to be recyclable with no ill effects on recyclate and are shown to curb litter accumulation.

Here is a starter list of studies for anyone who is interested in learning more about the research into oxo-biodegradable additives and how they can positively affect every single person's life.

- *Bonhomme, S., Cuer, A., Delort, A-M., Lemaire, J., Sancelme, M. and Scott, G. "Environmental Biodegradation of polyethylene“ Polymer Degradation and Stability, Elsevier. March 25, 2003*
- *Emo Chiellini, Andrea Corti, and Salvatore D’Antone "Oxo-biodegradable full carbon backbone polymers e biodegradation behaviour of thermally oxidized polyethylene in an aqueous medium“ Polymer Degradation and Stability, Elsevier. March 5, 2007*
- *Billingham, N.C, Chiellini, E., Corti, A., Baciu, R. and Wiles, D.M., "Environmentally Degradable Plastics Based on Oxo-biodegradation of Conventional Polyolefins“ NCB, Pisa Paper; 2002*
- *J-F Tung, D. M. Wiles, B. E. Cermak, J. G. Gho & C. W. J. Hare, “Totally Degradable Polyolefin Products” Addcon World, Prague, RAPRA Publishing, p. 17, (1999).*
- *N. C. Billingham, D. M. Wiles, B. E. Cermak, J. G. Gho. C. W. J. Hare, & J-F Tung, “Controlled – Lifetime Environmentally Degradable Plastics based on Conventional Polymers”, Addcon World, Basel, RAPRA Publishing, p. 6, (2000).*
- *D. M. Wiles, “Oxo-biodegradable Polyolefins”, “Biodegradable Polymers for Industrial Applications” Ray Smith(ed), CRC Press (2005)*
- *G. Swift and D. M. Wiles, “Biodegradable and Degradable Polymers and Plastics in Landfill Sites” in Encyclopedia of Polymer Science and Technology, J. I. Kroschwitz ed., John Wiley & Sons, (2004)*
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