OXO-BIODEGRADABLE PLASTICS ASSOCIATION

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BRIEFING NOTE
on
BIODEGRADABLE PLASTICS

1st June 2008

Plastic is a familiar component of modern living, used in all sorts of packaging and household and commercial applications. Whilst the benefits of low cost, light weight, strength, imperviousness to gas and water, transparency, sealability, and printability are highly regarded, the very strength and durability which makes plastic such a useful and economic material can be a major problem when disposal is required.

Science has now found the answer to this problem.

It is important to distinguish between the different types of biodegradable plastic, as their costs and uses are very different

The two main types are oxo-biodegradable and hydro-biodegradable. In both cases degradation begins with a chemical process (oxidation and hydrolysis respectively), followed by a biological process. Both types emit CO2 as they degrade, but hydro-biodegradable can also emit methane. Both types are compostable, but only oxo-biodegradable can be economically recycled.

Hydro-biodegradable is much more expensive than oxo-biodegradable.

OXO-BIODEGRADABLE PLASTIC

This technology produces plastic which degrades by a process of OXO-degradation. The technology is based on a very small amount of pro-degradant additive being introduced into the manufacturing process, thereby changing the behaviour of the plastic. Degradation begins when the programmed-service life is

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over (as controlled by the additive composition) and the product is no longer required.

Oxo-biodegradable plastics degrade, then biodegrade, on land or at sea, in the light or the dark, in heat or cold, in whatever timescale is required, leaving NO fragments NO methane and NO harmful residues. Oxo-bio is made from a by-product of oil refining which used to be wasted, so nobody is importing extra oil to make it.

Degradation and biodegradation of an oxo-biodegradable polyethylene specimen consistent with changes expected by Tiers 1 and 2 of ASTM D 6954-04 has been found by RAPRA[8] Oxo-biodegradable plastic also passes the eco-toxicity tests prescribed by Tier 3 of ASTM d 6954-04, including seed germination, plant growth and organism survival (daphnia, earthworms).[9]

There is little or no additional cost involved in products made with this technology, which can be made with the same machinery and workforce as conventional plastic products.

The plastic does not just fragment, but will be consumed by bacteria and fungi after the additive has reduced the molecular structure to a level[10] which permits living micro-organisms access to the carbon and hydrogen. It is therefore "biodegradable." [11] This process continues until the material has biodegraded to nothing more than CO_2, water, and humus, and **it does not leave fragments of petro-polymers**.

In rivers, lakes and oceans oxo-biodegradable polyethylene films float on the surface, where they are oxidised with consequent fragmentation and biodegradation. Conditions in the ocean are ideal for oxo-biodegradation. There is plenty of oxygen and ultraviolet light, there are plenty of micro-organisms, and the wind and waves subject the material to stress

Specimens of oxo-biodegradable LDPE (low-density polyethylene) and PP (polypropylene)[12] and PS (polystyrene)[13] have been tested and demonstrated under the conditions of test to be fully compliant with the current European food contact material requirements[14] and US Food & Drugs Administration requirements[15]. Oxo-biodegradable bags are being bought and distributed by the UK Soil Association and UK supermarkets, and used for direct contact with food products.

Oxo-biodegradable plastic products are now being used by the leading UK supermarkets, Tesco and the Co-op[16]. In Portugal the country's largest retail group,

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8 Tier 1 (Degradability) test 46023 20th March 2006. Tier 2 - (Biodegradability) test 46303 7th June 2006. RAPRA Technology Analytical Laboratories are accredited by the United Kingdom accreditation authorities as meeting the requirements of International Standards Organisation norm no.17025

9 Organic Waste Systems NV Belgium - Reports 1812/93224 8th Mar 2006. See also G. Scott and D.M. Wiles, *Degradable Polymers: Principles and Applications*, Kluwer, 2002, Chapter 13, Section 9.11, page 472, et seq.

10 sub 40,000 Daltons

11 Oxo-degradation is defined by TC249/WG9 of CEN (the European Standards Organisation) as "degradation identified as resulting from oxidative cleavage of macromolecules." And oxo-biodegradation as "degradation identified as resulting from oxidative and cell-mediated phenomena, either simultaneously or successively."

12 RAPRA report 19th March 2007. RAPRA Technology Analytical Laboratories are accredited by the United Kingdom accreditation authorities as meeting the requirements of International Standards Organisation norm no.17025.

13 RAPRA report 12th April 2005

14 European Directive 2002/72/EC (as amended 2004/19/EC).

15 RAPRA confirmation 14th November 2007

16 In September 2007 the Commercial Packaging Manager of the Co-op said "I am happy to say that we are using oxobiodegradable polythene films for direct food contact applications. We currently use these materials for pre-packed produce, self serve produce, pre-packed bread, frozen vegetables and

Sonae, has adopted oxo-biodegradable plastic carrier bags for their Continente, Mondelo and Mondelo Bonjour supermarket chains. Other major users include TigerBrands South Africa, Zara, Marriott, BUPA, News International, Pizza Hut, KFC, and Walmart. Oxo-biodegradable plastic is ideal for frozen food packaging, as it can be kept for extended periods at low temperature, and will then quickly degrade when it becomes a waste product at normal temperatures.

In May 2007 the Periodical Publishers Association of the UK[17] recommended to all its members that oxo-biodegradable film should be used for wrapping their newspapers and magazines for distribution.

The length of time it takes for oxo-biodegradable products to degrade can be 'programmed' at the time of manufacture and can be as little as a few months or as much as a few years. They are protected from degradation by special antioxidants until ready for use, and storage-life will be extended if the products are kept in cool, dark conditions.

Unlike PVC, the polymers from which oxo-biodegradable plastics are made do not contain organo-chlorine. Nor do oxo-biodegradable polymers contain PCBs, nor do they emit methane or nitrous oxide even under anaerobic conditions.

Fossil Resources

Oxo-biodegradable plastics are currently made from naphtha, which is a by-product of oil refining, and oil is of course a finite resource. However, this by-product arises because the world needs fuels and oils for engines, and would arise whether or not the by-product were used to make plastic goods.

Unless the oil is left under the ground, carbon dioxide will inevitably be released, but until other fuels and lubricants have been developed for engines, it makes good environmental sense to use the by-product, instead of wasting it by "flare-off" at the refinery and using scarce agricultural resources to make plastics.

A Life Cycle Assessment was carried out in January 2005 by GUA – (Gesellschaft für umfassende Analysen) of Vienna which shows that:

"Plastic products are made of energy resources. Additionally, their production needs further energy resources. Nevertheless, plastic products frequently enable energy *savings* from the perspective of the energy balance of the total life cycle compared to the energy balance of an alternative material. Examples for such energy savings by plastic products are:

• Substitution of materials which consume much more energy for production of the same functional unit (e.g. glass)
• Performance of a certain function with much less material (e.g. packaging)
• Fuel savings because of reduction in mass (transport)

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fresh turkeys as well as for carrier bags. The approval for use has been based on the very strict EU requirements under EU Directives 2002/72/EC and 2004/19/EC relating to plastic materials and articles intended to come into contact with foodstuffs. We have been using these materials for food contact use since 2004."
17 www.ppa.co.uk/cgi-bin/go.pl/news/article.html?uid=11657

• Energy savings due to thermal insulation (where insulation with other materials would be less effective, technically complicated or too expensive)
• Savings of resources by avoiding loss or damage of packed products."

Recently, interest has been shown in manufacturing sugar derived polyethylenes. These, like fossil-derived PE, are not biodegradable, but they can be made oxo-biodegradable in the same way, by the addition of a pro-degradant additive.

Deliberately and totally lost?

The argument that oxo-biodegradable plastics are undesirable because their components are designed to be deliberately and totally lost is a fallacy, because the advantages of oxo-biodegradable products are not mutually exclusive. If people want to incinerate with heat recovery, or mechanically recycle them, or re-use them, then that's OK, and they cost very little if anything more than conventional products. The key point is what happens to the plastic which is *not* collected, and gets into the environment as litter.

Oxo-biodegradability is not a disposal option. It is a low-cost insurance against the accumulation of plastic waste in the environment.

In any event Oxo-biodegradable plastics are not "deliberately and totally lost" even if they degrade in the environment, because biodegradation on land is a source of plant nutrients, just as is straw, grass, leaves etc.

HYDRO-BIODEGRADABLE PLASTICS

Hydro-biodegradation is initiated by hydrolysis.

Some plastics in this category have a high starch content and it is sometimes said that this justifies the claim that they are made from renewable resources. However, many of them contain up to 50% of synthetic plastic derived from oil, and others (e.g. some aliphatic polyesters) are entirely based on oil-derived intermediates. Genetically-modified crops may also have been used in the manufacture of hydro-biodegradable plastics.

Hydro-biodegradable plastics are not genuinely "renewable" because the process of making them from crops is itself a significant user of fossil-fuel energy and a producer therefore of greenhouse gases. Fossil fuels are burned in the autoclaves used to ferment and polymerise material synthesised from biochemically produced intermediates (e.g. polylactic acid from carbohydrates etc); and by the agricultural machinery and road vehicles employed; also by the manufacture and transport of fertilisers and pesticides. They are sometimes described as made from "non-food" crops, but are in fact usually made from food crops.

A disproportionate amount of land would be required to produce sufficient raw material to replace conventional plastic products, and a huge amount of water, which is in such short supply in so many parts of the world.

Residues from some native starches can be seriously toxic; bitter cassava for example (tapioca) has a high level of hydro-cyanic glucoside present, which has to be removed by careful washing. During growth the plant is toxic to wildlife. Cassava is exhaustive of potash[18].

[18] Pyxis CSB "Comparative Life Cycle Analyses for a variety of Degradable Food Packaging Materials" June 2007

Three recent articles in the international press have drawn attention to the danger of using "renewable" resources derived from plants as a substitute for petroleum products. They focus on the use of corn and palm oil to make "biofuels" for motor vehicles, but the same danger arises from the use of corn and other agricultural products to make hydro-biodegradable plastics.

The International Herald Tribune wrote on 31st January 2007 *"Just a few years ago politicians and green groups in the Netherlands were thrilled by the country's adoption of "sustainable energy" by coaxing electricity plants to use biofuel. Spurred by government subsidies, energy companies designed generators that ran exclusively on this fuel, which in theory would be cleaner than fossil fuels because it is derived from plants.*

But last year, when scientists studied plantations in Indonesia and Malaysia, this green fairy-tale began to look more like an environmental nightmare. Rising demand for palm oil in Europe caused the razing of huge tracts of southeast Asian rain forests, and the over-use of chemical fertilisers there. Worse still, space for the plantations was often created by draining and burning peat land, which sent huge carbon emissions into the atmosphere.

In Mexico on 25th January the **financial newspaper "24 ORE"** asked *"Food or fuel? Is maize better on the table as tortillas or in the tanks of cars, converted into ethanol and then bio-fuel? The price of the cereal has doubled in a year because of the high demand for ethanol obtained from maize to produce bio-fuels. It has created a real food crisis because the price of tortillas has increased greatly. They used to cost seven pesos per kilo but now exceed 18 pesos. Tortillas are the basic element of the Mexican diet.*

According to the Earth Policy Institute, "The trade off between food and fuel risks creating chaos in the world market of food products" and they predict that shortages and higher food prices will lead to starvation and urban riots

Business Week 5 Feb 2007 edition *"The rise in the price of corn that's hurting US pig farmers isn't caused by any big dip in the overall supply. In the U.S., last year's harvest was 10.5 billion bushels, the third-largest crop ever. But instead of going into the mouths of pigs or cattle or people, an increasing slice is being transformed into fuel for cars. The roughly 5 billion gallons of ethanol made in 2006 by 112 U.S. plants consumed nearly one-fifth of the corn crop." US chicken producers are also being hit. The industry's feed costs are already up $1.5 billion per year. Ultimately, these increases will be passed on to consumers, and there could be dramatic inflation in food costs.*

The UK House of Commons Environmental Audit Committee has found[19] ***that "the stimulation of biofuels production by the [UK] Government and EU is reckless in the absence of effective mechanisms to prevent the destruction of carbon sinks internationally"***

The Committee continued [20] ***"A large biofuel industry based on current technology is likely to increase agricultural commodity prices and, by displacing food production, could damage food security in developing countries."***

The use of biofuels in the EU have come under assault once again, this time from the European Commission's own scientific institute, the Joint Research Centre.[21]

[19] Report 15th January 2008 (HC 76-1 of 2007-08). Para 53 http://www.publications.parliament.uk/pa/cm200708/cmselect/cmenvaud/76/76.pdf
[20] ibid para 63

An unpublished internal report from the research body questions whether the cost of their use is worth the benefits.

The report buttresses worries over biofuels expressed by environment commissioner Stavros Dimas and research from environmental campaign groups that suggests biofuels may actually contribute to global warming through the deforestation and peat bog burning that is required for biofuel sources such as corn or oil palm trees.

The British Royal Society for the Protection of Birds is also highly critical of using land and water resources for this purpose[22] "Driven by the thoughtless policies of governments around the world, biofuels production is decimating swathes of important habitat and threatening the survival of many species, including Sumatran tigers, orang utans and countless bird species.

Biofuels advocates justify this destruction by citing their potential for combating climate change. However, whilst biofuels can play a part, many of those on the market today don't deliver the greenhouse gas savings they promise and some are even more polluting than the fossil fuels they're meant to replace. There is also evidence to suggest that taking land used for growing food, and converting it to growing biofuels, is reducing the amount of food produced and contributing to increasing prices."

On 6th March 2008 the United Kingdom's Chief Scientific Adviser warned that if this continues the world will soon be unable to feed itself.[23]

Recycled plastics are OK, but they are not degradable and will still lie around in the environment for decades. However, ordinary plastic and recycled plastic can now be made oxo-biodegradable.

This is done by including d2w additive (see www.degradable.net) which makes it degrade, then biodegrade, on land or at sea, in the light or the dark, in heat or cold, in whatever timescale is required, leaving NO fragments NO methane and NO harmful residues. Oxo-bio passes the tests in American Standard 6954, and is made from a by-product of oil refining which used to be wasted, so nobody is importing extra oil to make it.

There is little or no additional cost.

Plastics made from crops, are up to 400% more expensive, they are not strong enough for use in high-speed machinery, and they emit methane (a powerful greenhouse gas) in landfill. Also, it is wrong to use land, water and fertilisers to grow crops for bioplastics and biofuels, which drives up the cost of food for the poorest people. See also The Guardian 26th April 2008[24]

The same applies to growing cotton or jute to make durable bags. These rapidly become unhygienic if a tomato is squashed or milk spilled, and they become a durable form of litter, but they can be made from washable oxo-bio plastic, to last up to 5 years.

Oxo-bio plastics degrade in the upper layers of a landfill, but they are completely inert deeper in the landfill in the absence of oxygen. They do not emit methane at any stage.

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[21] EU Observer.com 18 Jan 2008
[22] http://campaigning.rspb.org.uk/eactivist/user/userJ.jsp?CLS@74YQcNH906cWOsj3K3
[23] The Times 7th March 2008 http://www.timesonline.co.uk/tol/news/environment/article3500954.ece
[24] http://www.guardian.co.uk/environment/2008/apr/26/waste.pollution?gusrc=rss&feed=networkfront

Paper bags use 300% more energy to produce, they are bulky and heavy and are not strong enough, especially when wet. They will also emit methane in landfill

For the reasons given under "Composting" below, compostability of plastics is an irrelevance

Also, for the reasons mentioned below, oxo-biodegradable products are in many respects more useful and cost-effective than hydro-biodegradable.

PHOTO-DEGRADABLE PLASTICS

These react to ultra-violet light, but unless they are also oxo-biodegradable they will not degrade in a landfill, a sewer, or other dark environment, or if heavily overprinted.

ENVIRONMENTAL BENEFITS OF OXO-BIODEGRADABLE PLASTICS

There are several areas where oxo-biodegradable plastic can have a major beneficial impact on the environment:

1 RECYCLING

Oxo-biodegradable plastics can be recycled together with other clean commercial polyolefin wastes, and can be made from recyclate, but hydro-biodegradable plastic (normally made from crops) cannot.

If the product to be made from the recyclate is intended to be degradable, the process is quite straightforward. This applies particularly to closed-loop systems where used oxo-biodegradable "back-of-shop" plastics (eg shrink-wrap and pallet-wrap) are sent back for recycling into the same oxo-biodegradable products.

Similarly, if the product to be made from recycled oxo-biodegradable plastic has a very thick cross-section, (such as road cones, garden furniture etc) the process is also straightforward, as any residual pro-degradant effect would be negligible.

Where the product to be made from recycled oxo-biodegradable plastic is a thin film which is not intended to be degradable, such as damp-proof membranes, there will be no problem provided that regard is had to the ratio of degradable to non-degradable in the feedstock. Stabilisers should be added where necessary, either by the recycler or by the manufacturer of the product being made with the recyclate.

By contrast, Hydro-biodegradable plastic cannot be recycled with other polymer components of waste. It would therefore have to be extracted from the waste stream and treated separately, at prohibitive cost. It is difficult for recyclers to physically distinguish hydro-biodegradable from other types of plastic so, the more that hydro-biodegradable plastic gets into circulation, the greater the problem for recyclers

Hydro-biodegradable plastics have been called into question by recyclers[25] and "Recoup's" project manager warned that starch-based plastics could "have a negative impact on plastics recycling as a whole."[26] With compostable plastic packaging made from degradable starch-based materials and traditional plastics from oil-based ones, the fear is that bioplastics will increasingly find their way into

[25] Materials Recycling Week 20 Nov 2006

[26] Addressing the Local Authority Recycling Advisory Committee conference in November 2006. RECOUP (www.recoup.org) is the UK's national NGO developing plastics-recycling, promoting best practices and providing educational and training tools.

the plastics recycling stream – impacting on quality and un-doing the work done on raising public awareness of plastics recycling."

2. LITTER

Policymakers need always to consider what happens to waste plastic products which escape collection and end up as litter. What supermarket director wants his grandchildren to find on a beach a plastic bag with his company's name on it, which has been floating around the oceans for 50 years?

According to The Independent Newspaper[27] a "plastic soup" of waste floating in the Pacific Ocean is growing at an alarming rate and now covers an area the size of the continental United States.

Discarded conventional plastics remain in the environment for many decades, and are often impossible or too expensive to collect, so recycling, landfill, composting, and incineration are not options for dealing with them. If collected, oxo-biodegradable plastics can be recycled or incinerated, and if not collected they will degrade and disappear, leaving no harmful residues.

Exposure to sunlight accelerates degradation, but the process of oxo-bio-degradation, once initiated, continues even in the absence of light, so long as air is present. The plastic will degrade much more quickly in the open than in a building, and in warm weather will disappear more quickly. Of course, if the product has been exposed to air for some time before being discarded it will disappear in an even shorter time thereafter.

Hydro-biodegradable plastics will not readily degrade unless they are in a highly-microbial environment, and will instead merely fragment for example in a field or a street.

More Careless disposal?

Degradable plastic bags have been dispensed by supermarkets for more than four years, but there is no evidence that people dispose more carelessly of them (whether oxo or hydro biodegradable) and they have not been encouraged to do so.

But suppose for the sake of argument that 10% more were discarded. If 1,000 conventional and 1,100 oxo-biodegradable bags were left uncollected in the environment, 1,000 conventional bags would remain in the rivers, streets and fields for decades, but none of the oxo-biodegradable bags would be left at the end of the short life programmed into them at manufacture.

There will always be people who will deliberately or accidentally discard their plastic waste. What will happen to all the plastic waste that will not be recycled or will not be incinerated, and instead will litter the countryside - would it not be better if the discarded plastic were all oxo-biodegradable?

To limit or discourage the availability of all types of plastic bags is not the answer, as there are so many purposes for which they are ideal. For the following reasons paper bags and re-usable bags should not be encouraged.

ALTERNATIVES

[27] **05/02/2008**
http://www.independent.co.uk:80/environment/the-worlds-rubbish-dump-a-garbage-tip-that-stretches-from-hawaii-to-japan-778016.html

Compare different materials, according to criteria like weight, energy and volume of reduction. If we take 100% as a starting point - without plastic we would have about 484% in terms of **weight**. In terms of **energy consumption**, with plastics if we take 100%, without plastic we will have around 300%. The same in **volume** of waste - with plastic and without plastic we have almost 300%. [28]

Paper Bags

The process of making paper bags causes 70% more atmospheric pollution than plastic bags. Paper bags use 300% more energy to produce, and the process uses huge amounts of water and creates very unpleasant organic waste. When they degrade they emit methane and carbon dioxide.

A stack of 1000 new plastic carrier bags would be around 2 inches high, but a stack of 1000 new paper grocery bags could be around 2 feet high. It would take at least seven times the number of trucks to deliver the same number of bags, creating seven times more transport pollution and road congestion.

Also, because paper bags are not as strong as plastic, people may use two or three bags inside each other. Paper bags cannot normally be re-used, and will disintegrate if wet.

Re-usable Bags

Long-term re-usable shopping bags are not the answer. They are much thicker and more expensive, and a large number of them would be required for the weekly shopping of an average family. They are not hygienic unless cleaned after each use. Whilst sometimes called “Bags for Life” they have a limited life, depending on the treatment they receive, and become a very durable form of litter when discarded.

Shoppers do not always go to the shop from home, where the re-usable bags would normally be kept, and consumers are unlikely to have a re-usable bag with them when buying on impulse items such as clothing, groceries, CDs, magazines, stationery etc.

However, for those who believe in long-term re-usable bags, they can be made from extended-life oxo-biodegradable plastic and will last for five or more years.

Risk Of Persistency And Bio-Accumulation?

Fragmentation occurs during degradation of both oxo-biodegradable and hydro-biodegradable plastics.

It is not of course acceptable to apply conventional plastics to the soil even if they are fragmented, since physical shredding alone does not transform plastic into a biodegradable product. However, the properties of oxo-biodegradable plastic on exposure to the environment are quite different from those of the original plastic. The transformed plastic behaves in the same way as nature’s wastes. It is bio-assimilated by the same bacteria and fungi, and they convert the degraded plastic to cell biomass, just like lignocellulosic materials such as straw, leaves and twigs.

[28] Prof. Emo Chiellini, Professor of Fundamentals of Technologies, University of Pisa. Simpósio Internacional de Plásticos Degradáveis 6th June 2007. See also Polymers and the Environment, 1999, Chapter 4, Management of Polymer Wastes, p. 78-81 and Degradable Polymers 2nd edition, Chapter 1)

Eco-toxicity tests[29] have demonstrated that oxo-biodegradable plastic produces no immediate, or cumulative, adverse effects on the soil, whether from the plastic itself or from the additive. The major elements of organic additives are naturally bio-degradable, and the traces remaining after degradation are in such minor parts per million (in some cases, per billion) that no harmful effects will occur. Some of these materials can also be found in hydro-biodegradable products.

Oxo-biodegradable plastics do not contain "heavy metals.[30]" Metal compounds used in oxo-biodegradable polymers and listed in European Directive 67/548/EC are not banned. The Directive simply controls their marketing and use, and they are marketed and used accordingly.

The UK Food Standards Agency's Expert Group on Vitamins and Minerals[31] has carried out a risk assessment which shows that the metal salts used in commercial oxo-biodegradable plastics are trace-elements necessary for healthy plant and human growth.

Like lignocellulose (and unlike the hydro-biodegradable plastics which discharge their CO_2 to atmosphere during composting), oxo-biodegradable plastics are sequestered by the soil and enhance the "land carbon sink"

3 **LANDFILL**

The main benefit of oxo-biodegradable is not for plastic waste which gets into landfill, but for plastic waste which gets into the environment, where it will accumulate for many decades.

Not all plastic bags are simply thrown away. Many of them reach landfill only after they have been used as bin-liners or re-used for some other purpose.

Hydro-biodegradable plastics will degrade and emit CO_2 in the surface layers of a landfill if there is enough microbial activity. However, in the depths of a landfill, in the absence of air, hydro-biodegradable plastics generate copious quantities of methane, which is a powerful greenhouse gas. Methane is also highly combustible and is a cause of explosions, sometimes affecting housing built on old landfills.

By contrast Oxo-biodegradable plastics fragment and partially biodegrade in the upper layers of the landfill, but the residues are completely inert deeper in the landfill in the absence of oxygen. They do not emit methane at any stage.

Governments are concerned to reduce the amount of waste going to landfill, but oxo-biodegradable plastic waste does not have to be sent to landfill at all. It can be recycled (see above), but the recycling option is not practicable for hydro-biodegradable plastics.

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[29] See G. Scott and D.M. Wiles, *Degradable Polymers: Principles and Applications*, Kluwer, 2002, Chapter 13, Section 9.11, page 472, et seq

30 The term "heavy metal" has never been defined by any authoritative body. Over the 60 years or so in which it has been used in chemistry, it has been given such a wide range of meanings by different authors that it is effectively meaningless……Even if the term "heavy metal" should become obsolete because it has no coherent scientific basis, there will still be a problem with the common use of the term "metal" to refer to a metal and all its compounds. This usage implies that the pure metal and all its compounds have the same physicochemical, biological, and toxicological properties. Thus, sodium metal and sodium chloride are assumed by this usage to be equivalent. However, no one can swallow sodium metal without suffering life-threatening damage, while we all need sodium chloride (salt) in our diet. (Pure Appl. Chem., Vol. 74, No. 5, pp. 793–807, 2002).

[31] UK Food Standards Agency (May 2003) *Expert Group on vitamins and minerals" Part 3 Trace Elements, Risk Assessment.*

The aim of the EU Landfill Directive 1999 (as amended 2003) is that:

(3) the prevention, recycling and recovery of waste should be encouraged as should the use of recovered materials and energy so as to safeguard natural resources and obviate wasteful use of land;

Oxo-biodegradable plastics would help to achieve these objectives because, they can be recycled and they can be incinerated with high energy-recovery.

Oxo-biodegradable plastic sheet would also reduce the wasteful use of land in a landfill. At present a six to eight inch layer of earth has to be spread over the waste at the end of each day's work. This is very expensive to do, and it uses up a high proportion of the available space in the landfill pit. Oxo-biodegradable plastic sheeting can now be used as daily landfill covers instead of earth, to cover the waste, and less fuel is burned by the machines employed.

Conventional plastic bags take up more space in a landfill because they trap air, they do not readily disintegrate, and they inhibit the decomposition of their contents in the landfill.

(4) further consideration should be given to the issues of incineration of municipal and non-hazardous waste, composting, biomethanisation, and the processing of dredging sludges;

Oxo-biodegradable plastics can be incinerated with energy recovery.

(12) protective measures [should] be taken against any threat to the environment in the short as well as in the long-term perspective, and more especially against the pollution of groundwater by leachate infiltration into the soil.

Oxo-biodegradable plastics do not cause harmful leachate infiltration

(16) measures should be taken to reduce the production of methane gas from landfills, inter alia, in order to reduce global warming, through the reduction of the landfill of biodegradable waste and the requirements to introduce landfill gas control;

Unlike normal organic waste, and hydro-biodegradable plastics, oxo-biodegradable plastics do not produce methane as they degrade.

The Report on "The impacts of degradable plastic bags in Australia" prepared by ExcelPlas/ Nolan-ITU on 11 September 2003 for the Australian Government noted at 7.3 that:

degradable polymers with starch content have higher impacts upon **greenhouse** due to methane emissions during landfill degradation and N_2O emissions from fertilizing crops. Methane is 23 times more potent for global warming[32] than CO_2

4 AGRICULTURE AND HORTICULTURE[33]

[32] IPCC (Inter-Governmental Panel on Climate Change) Report page 47 www.ipcc.ch/pub/wg1TARtechsum.pdf

[33] see also COMPOSTING (section 7 below).

Oxo-biodegradable plastic has useful applications in agriculture and horticulture.

For many years farmers and growers have used plastic sheets to protect their crops and to inhibit weeds, but after the crop has been harvested many thousands of square kilometres of dirty plastic have to be removed and disposed of. This is a very expensive process, and creates huge quantities of contaminated waste, which cannot be burned, or recycled into useful products.

Oxo-biodegradable plastic sheets can however be programmed at manufacture to degrade soon after the harvest. The degraded material can then be ploughed into the soil where it completes the biodegradation process and becomes a source of carbon for next year's plants**.**

Oxo-biodegradable plastics have been used as protective films in agriculture in many countries (including USA, China, Japan and the EU). They are applied to the land in the same way as straw to retain moisture and to increase root temperatures.

On 20th May 2003 the Development and Cooperation Committee of the European Parliament passed a resolution calling on the European Commission not to fund environmentally harmful projects in the ACP (Africa, Caribbean and Pacific) countries. The Committee specifically called on the Commission to encourage the use of biodegradable materials in the banana-growing process in ACP countries who benefit from the EU's Special Framework of Assistance for suppliers of bananas. Oxo-biodegradable plastic films are being used as banana bags in commercial operations.

5. ENERGY RECOVERY

In some countries, including Germany, incineration is popular, and the necessary equipment is in place. Oxo-biodegradable plastic can be incinerated with energy recovery in the same way as conventional plastic, and has a higher calorific value than the hydro-biodegradable alternative.

6. WASTE COLLECTION

There has to be a collection method for organic waste. Transparent oxo-biodegradable sacks are currently in common use for this purpose and are much better than wheeled bins or conventional plastic sacks. Oxo-biodegradable sacks are much better than bins because:

They are quicker and easier to collect than bins, which require the collectors to walk the distance from vehicle to house four times.
They can be produced in a wide variety of sizes to suit particular requirements
They do not need expensive vehicles with bin-lifting equipment
They are easy for householders to store, and can be supplied in rolls
They can be sealed when filled, so eliminating smells and flies which usually attend conventional waste bins
Transparent sacks enable collectors to see the contents
They are not as visually-intrusive as bins
Bins need to be washed
Bins are bulky items, which are expensive to purchase, store, and transport
The bins themselves, usually made from heavy non-degradable plastic, eventually have to be disposed of.

7. COMPOSTING

Compostability of plastics is really an irrelevance because compostable plastics are far too expensive for everyday use, and there are very few industrial composting

facilities available. Moreover, as it is difficult and expensive to separate compostable plastics from other plastics, many industrial composters do not want plastic of any kind in their feedstock. Home composting of plastic packaging is dangerous and should not be encouraged, as it is often contaminated with meat, fish, or poultry residues, and temperatures do not rise high enough to kill the pathogens.

European standard EN 13432[34] applies to composting of plastic packaging, but it is not appropriate for testing oxo-biodegradable plastics. This is because it is based on measuring the emission of carbon dioxide during degradation. Hydro-biodegradable plastic is compliant with EN 13432, precisely because it emits CO_2 (a greenhouse gas) at a high rate.

If a leaf were subjected to the CO_2 emission tests included in EN13432 it would not be considered biodegradable or compostable!

Another problem with EN 13432 is that it requires almost complete conversion of the carbon in the plastic to CO_2, thus depriving the resulting compost of carbon, which is needed for plant growth, and wasting it by emission to atmosphere.

Conversion of organic materials to CO_2 at a rapid rate during the composting process is not “recovery” as required[35] by the European Directive on Packaging and Packaging Waste (94/62/EC as amended),[36] and should not really be part of a standard for composting. Nature’s lignocellulosic wastes do not behave in this way, and if they did the products would have little value as soil improvers and fertilisers, having lost most of their carbon.

EN 13432, does not however require that plastics biodegrade during and after composting within any particular time-scale. Paragraph 5 of EN 13432 says: "It is important to recognise that it is not necessary that biodegradation of packaging material or packaging be fully completed by the end of biological treatment in technical plants but that it can subsequently be completed during the use of the compost produced"

This is what oxo-biodegradable plastic does, and it is consistent with the behaviour of nature's waste products such as twigs, leaves and straw, which take years to biodegrade fully. Oxo-biodegradable plastics will biodegrade much more quickly.

The EU Directive does NOT require that when a packaging product is marketed as “degradable” or “compostable” conformity with the Directive must be assessed by reference to EN13432. In the first place although the Directive[37] provides that conformity with its essential requirements may be presumed if EN 13432 is complied with, it does not exclude proof of conformity by other evidence, such as a report from a reputable testing institution. Indeed Annex Z of EN13432 itself says that it provides only **one means of conforming** with the essential requirements.

Secondly, EN 13432 does not apply at all to applications other than *composting* of *packaging*. Para. 1 of EN13432 itself makes it clear that it does not apply to packaging waste which may end up in the environment through uncontrolled means, ie as litter.

On 11th September 2003 a Report to the Australian Government by the Nolan-ITU Consultancy concluded that:

[34] and its US equivalent ASTM 6400. There are also other national equivalents eg in Australia.
[35] Annex II para. 3
[36] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1994L0062:20050405:EN:PDF
[37] Article 9(2)

"oxo-biodegradable plastics based on polyolefins contribute to the amount and nutritive value of the compost because much of the carbon from the plastic is in the form of intermediate oxidation products, humic material and cell biomass. This is in contrast to plastics such as hydro-biodegradable polyesters (eg starch-based) that biodegrade at rates comparable to purified cellulose. At the end of the commercial composting process, all of the carbon from the latter has been converted to CO_2 so there is a contribution to greenhouse gas levels but not to the value of the compost."

The same Report concluded[38] that "*degradable polymers manufactured from renewable resources (e.g., crops) have greater impacts upon* ***eutrophication*** *due to the application of fertilizers to land."*

Oxo-biodegradable plastic does not degrade quickly in low temperature "windrow" composting, but development is ongoing for "in-vessel" composting of oxo-biodegradable plastic at the higher temperatures required by the EU animal by-products regulations. Indeed it is likely that windrow composting will soon have to be phased out except for grass, leaves, and other garden waste.

8. WASTE MINIMISATION

As oxo-biodegradable bags are thinner than hydro-biodegradable or paper bags of the same strength, they produce a much smaller tonnage of plastic waste. Also, as they will totally degrade, they cease to exist at the end of their programmed life. As noted above, a stack of 1000 new plastic carrier bags would be around 2 inches high, but a stack of 1000 new paper grocery bags could be around 2 feet high.

9. COUNTERFEITING

Many high-value cosmetics and other products are sold in plastic bottles, jars, and other plastic containers. Often these empty containers are collected and refilled with an inferior product and sold as the genuine article.

Manufacturers of high-value products are now demanding oxo-biodegradable containers which will degrade soon after use and will therefore make counterfeiting more difficult.

ADVANTAGES OF OXO-BIODEGRADABLES

To summarise, **oxo**-biodegradable plastics have the following advantages:

They will degrade in any outdoor or indoor environment where air is present, even in the absence of water. This is a very important factor in relation to litter, because a large amount of plastic waste cannot be collected.

Oxo-biodegradable plastic can be programmed at manufacture to degrade within a timescale to suit the user's requirements. The rate of degradation of hydro-biodegradable plastics cannot be controlled.

Oxo-biodegradable plastics are stronger and more versatile.

They are much cheaper

They are thinner, and use less space to store and transport, and less material to produce

[38] Para. 7.3

They can be transparent, so that the food or other contents within can be clearly seen.

They can be recycled and can be made from recyclate. (See above para 5).

Less energy is required to produce and transport them.

No genetically-modified ingredients

They do not emit methane when oxidising

No organo-chlorine or PCBs or “heavy metals”

Safe for direct food contact

Ideal for frozen food

Can be used in high-speed machinery (such as for bread packaging) but the performance of hydro-biodegradable plastics in these machines is often not acceptable.

Can be incinerated with much higher energy-recovery than hydro-biodegradable plastic

They can be made with the same workforce and machinery as conventional plastic products, but hydro-biodegradable products are made by a quite different process.

It seems wrong to divert agricultural resources away from food production when there is so much hunger in the world, and to use fertilisers and pesticides unnecessarily

OXO-BIODEGRADABLE PRODUCTS AVAILABLE

Carrier bags or “shopper-bags” which consumers use to take away their purchases from the shop
Refuse sacks, which consumers buy in rolls at the shop, and use for disposal of their ordinary household waste.
Aprons, for the protection of garments, in the home, hospitals, restaurants, workshops etc.
Bags to contain dog faeces collected in parks, gardens, etc
Bin liners
Gloves
Plastic sheeting for a variety of applications in agriculture and horticulture.
Plastic film for wrapping newspapers and magazines.
Bread bags
Frozen food bags
Wrappers for cigarette packets
Shrink-wrap and pallet-wrap
“Bubble-wrap”
Rigid products such as bottles and cups

More products will become available in due course.

STANDARDS

The French Standards organisation, AFNOR, published in July 2007 a Standard for oxo-biodegradable plastics in agriculture.[39]

A draft standard[40] capable of measuring oxo-biodegradation has also been published by the British Standards Institution.

Oxo-biodegradable plastic has been tested according to all three Tiers of American Standard ASTM D6954-04 for "Plastics that Degrade in the Environment by a Combination of Oxidation and Biodegradation."

European standard EN 13432[41] is not appropriate for testing oxo-biodegradable plastics. For a discussion of this standard see "Composting" above.

Packaging made from oxo-biodegradable plastic complies with para. 3(a), (b) and (d) of Annex II of the European Parliament and Council Directive 94/62/EC (as amended) on Packaging and Packaging Waste. This Annex specifies the essential requirements for the composition and the reusable and recoverable, including recyclable, nature of packaging.

Oxo-biodegradable plastic satisfies para. 3(a) because it can be recycled. It satisfies para. 3(b) because it can be incinerated. It satisfies para. 3(d) because it is capable of undergoing physical, chemical, thermal or biological decomposition such that most of the finished compost ultimately decomposes into carbon dioxide, biomass and water. It can even satisfy para. 3(c) if composted in an "in-vessel" process.

The then EU Environment Commissioner, Margot Wallstrőm, said, in a letter to the Irish MEP Avril Doyle on 18th February 2002 that "it would be consistent with the spirit of Community environment policy and legislation if a member state applying a plastic bag tax were to decide to adopt a more beneficial tax rate in relation to biodegradable carrier bags."

LEGISLATION

In Brazil, Argentina and India there is legislation which requires shopping bags to be degradable, and in Brazil supermarkets are being fined for continuing to use non-degradable plastic.

[39] XP T 54-980-1
[40] BS 8472
[41] and its US equivalent ASTM 6400. There are also other national equivalents eg in Australia.