d_2w PLASTIC TECHNOLOGY

FREQUENTLY ASKED QUESTIONS

The problems caused by plastic litter in the environment have compelled governments, manufacturers and brand owners to rethink the way plastic is produced, used and ultimately disposed of. Many are now looking for products and technologies that are inexpensive, non-disruptive to supply-chains, and can be reused and recycled at the end of their useful life, without increasing CO_2 emissions.

A technology called d2w biodegradable plastic has been invented, which destroys plastic at the end of its useful life if it has not been collected for waste-management and escapes instead into the open environment, where it enables bacteria to remove it from the eco-system. For a video introduction see https://www.youtube.com/watch?v=tL1TNFWdM_c&ab_channel=SymphonyEnvironmental (skip the ads)

A study for the UK Environment Agency by Intertek http://www.biodeg.org/life-cycle-assessments/life-cycle-assessments-2/ shows that if plastic bags were banned it would actually be worse for the environment, as the alternatives have a higher global warming potential and climate change is an even more serious problem than plastic litter. The message therefore is "don't ban plastics – upgrade them with d2w technology."

Academics agree that replacements could be vastly worse than plastic

A 40-strong group of academics from Heriot-Watt University in Scotland said that replacing plastics with other packaging such as glass or metal could double global energy consumption, adding that it could also lead to a tripling of greenhouse gas emissions.

In the process of degradation, d2w allows the transfer of valuable carbon material back to the eco-system via vegetation and micro-organisms. Studies have demonstrated that the organic materials developed as the result of the degradation mechanism are biodegradable and therefore absorbed by living organisms in and on the soil. This is not the case with conventional plastic, that tends to lock in the carbon for many decades, or hydro-degradable ("compostable") plastic that releases the carbon very rapidly to atmosphere as CO_2 gas or methane, which contribute to climate-change.

1. **Why do we need d2w plastic?**

Because thousands of tons of plastic waste are getting into the world's environment every day, and will remain there for decades. There is nowhere in the world where it is possible to collect every piece of plastic for recycling or for any other form of responsible disposal. d2w plastic has been specifically tested and found biodegradable in the oceans at Bandol laboratories in France, Queen Mary University in the UK, and at l'Observatoire Oceanologique de Banyuls sur mer (Lomic) in France. Most recently it has been proved beyond doubt in the three-year Oxomar study sponsored by the French government that d2w plastic will biodegrade, even in the oceans, much more efficiently than ordinary plastic https://www.biodeg.org/subjects-of-interest/agriculture-and-horticulture/the-marine-environment/

2. **What is d2w plastic?**

It is ordinary plastic to which a catalyst and stabilisers have been added during the manufacturing process. The resulting plastic is then made into products like carrier bags, produce bags or courier bags, straws, shrink-wrap, pallet-wrap and other short-life/single-use items. d2w is the lowest cost

alternative to ordinary plastics, and is best suited to low value plastics which are either unsuitable or uneconomic for recycling.

3. Definitions

There is a lot of confusion in the terminology relating to degradable plastics.

Oxo-degradation is defined by CEN (the European Standards authority) in TR15351 as "degradation identified as resulting from oxidative cleavage of macromolecules." This describes ordinary plastics, which abiotically degrade in the open environment, but do not become biodegradable except over a very long period of time.

Oxo-biodegradation is defined by CEN as "degradation resulting from oxidative and cell-mediated phenomena, either simultaneously or successively". This describes d2w plastic.
Bioplastics – are plastics which are made from vegetable-based materials or ordinary plastics which have been made biodegradable by adding d2w

Biodegradable plastic– this term is not useful, and should not be used, as it does not distinguish between the different types of biodegradable plastic, which have very different characteristics. Many people think that it means bio-based or compostable plastic, but this is not correct.

4. How does d2w work?

In the presence of oxygen, the catalyst accelerates the natural oxidation process and reduces the molecular weight of the polymer at a rapid rate, to the point where it is no longer a plastic and has become a waxy substance which can be bio-assimilated by bacteria and fungi in the natural environment. The process continues until the material has biodegraded to nothing more than CO_2, water, and humus. It does not leave fragments of petro-polymers in the soil, and it does not contain heavy metals.

It is tested by independent laboratories according to US Standard ASTM D6954 for degradation, biodegradation, non-toxicity and absence of metals in excess of prescribed limits. d2w plastic was tested on 27th July 2017 by Eurofins laboratory in Spain, which is accredited to ISO 17025. They found 88.86% biodegradation, with no prohibited metals and no ecotoxicity. It has also been tested by Intertek, with similar results.

5. Does d2w plastic biodegrade, or does it just fragment?

See 4 above. The process has been described as follows by Professor Ignacy Jakubowicz, one of the world's leading polymer scientists who has studied D2W for more than 20 years: *"The degradation process is not only a fragmentation, but is an entire change of the material from a high molecular weight polymer, to monomeric and oligomeric fragments, and from hydrocarbon molecules to oxygen-containing molecules which can be bioassimilated."* [1]

The European Chemicals Agency has studied d2w plastic, and said on 30th October 2018 that it is not convinced that it creates microplastics.

d2w plastic degrades, and then biodegrades in the open environment in the same way as nature's wastes. If it merely fragmented without biodegrading, CEN (European Committee for Standardization) would not have defined oxo-biodegradability as "degradation resulting from oxidative and cell-mediated phenomena, either simultaneously or successively" and the American,

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

British and French standards organisations would not have included tests for *bio*degradability in ASTM D6954, BS8472 and ACT51-808.

6. **Is d2w technology supported by the science?**

Yes. This type of plastic has been studied by scientists for at least 20 years. Recently a former judge of the High Court in England was asked to review the scientific evidence, and he concluded[2]:

• that D2W does facilitate the ultimate biodegradation of plastics in air or seawater by bacteria, fungi or algae, within a reasonable time, so as to cause the plastic to cease to exist as such, far sooner than ordinary plastics, without causing any toxicity;

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

• that D2W is compatible with composting and recycling;

Since then, the French Oxomar study has been published which provides confirmation of biodegradation beyond doubt, even in the marine environment https://www.biodeg.org/subjects-of-interest/agriculture-and-horticulture/the-marine-environment/

7. **Do any countries legislate in favour of D2W?**

Yes. Many governments in the world have realised that d2w plastic offers a solution to plastic waste that escapes into the open environment and cannot realistically be collected. Several countries in the Middle East have already legislated to make this type of plastic mandatory. It is not now possible to export to these countries a wide range of plastic products or goods wrapped in ordinary plastic.

8. **What does it cost?**

Very little, because the masterbatch containing the catalyst and stabilisers represents only 1% of the polymer,

9. **Won't it put existing factories out of business, with loss of jobs?**

No, because d2w products can be made with the same machines and workforce as ordinary plastic. Commercial customers can continue to use the same factories which supply them with ordinary plastic products. d2w is a "drop-in" technology – it does not disrupt an established supply chain.

10. **What types of biodegradable plastic exist?**

The two main types are d2w (oxo-biodegradable) and hydro-biodegradable. In both cases degradation begins with a chemical process (oxidation or hydrolysis respectively), followed by a biological process.

Hydro-biodegradable plastic (HBP) – is usually starch-based, and marketed as "bioplastic" or "compostable." However, the original vegetable materials have been polymerised and have become plastics. This is not a useful alternative to ordinary plastic because it is designed to be taken to an industrial composting or anaerobic digestion unit, and to biodegrade in the special conditions found in those facilities. It does not therefore address the problem of plastic litter in the open environment. Also:

(1) HBP cannot be recycled with ordinary plastics, so anyone who is in favour of recycling should be against them. Even if intended for industrial composting, some of this plastic gets into the oil-based plastic recycling stream and contaminates it.

(2) HBP is too expensive for everyday use – costing up to 400% more than ordinary plastic. Even if this cost were substantially reduced in the future it is far too expensive for ordinary people and there is no justification for subsidising it out of taxpayers' money.

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[2] https://www.symphonyenvironmental.com/resource/uk-judge-finds-the-case-for-oxo-biodegradable-plastic-proven/

(3) When something is described as compostable an ordinary person would think that it can be converted into compost, but the Standards for this type of plastic (ASTM D6400, EN13432 etc.) require it to convert into CO_2 gas within six months. You cannot therefore make compost from it – only greenhouse gas. This process contributes to climate change but does nothing for the soil, and it cannot be described as organic recycling. Plastic should not therefore be described as "compostable."
(4) HBP should not be described as "biodegradable" because although it will fragment into microplastics in the open environment, it is tested for biodegradation in the special conditions found in industrial composting or anaerobic digestion.
(5) HBP is not suitable for shopper bags because they need to be strong and inexpensive, and to be capable of re-use many times before final disposal.
(6) HBP cannot be made by plastics factories with their existing machinery and workforce, and any large-scale introduction of this type of plastic would lead to disruption of supply-chains and job-losses in the plastics industry.
(7) HBP is not "renewable." See 18 below.
(8) Deep in landfill HBP can generate methane, which is a greenhouse gas much more powerful than CO_2.
(9) It is not desirable to use land and water resources to grow crops to make plastic. Those resources should be used to produce food for people in the world who do not have enough to eat. The European Parliament has resolved not to encourage the use of land and water resources for producing bio-fuels (and the same reasoning applies to bio-plastics). The UN issued a report to the same effect on 31st March 2014. Nestlé believes that allocating agricultural land and water to biofuel production will severely impact food and water security. In their view "Forecasts of food production suggest that significant challenges exist for the world to feed future generations….. Even a small percentage of energy from crop-based biofuels has a devastating effect on the food market."
(10) There is not nearly enough arable land and water available to grow crops to make enough crop-based plastic to replace ordinary plastic, even for shopping bags.
(11) It is sometimes claimed that the crops being grown to make crop-based plastics will absorb CO_2, but that would be true of the vegetation which was there before.
(12) HBP is not really suitable for agricultural mulch films, because (unlike d2w) the degradation time cannot be controlled in line with the growing cycle.
(13) HBP is thicker and heavier for the same strength, so it needs more trucks to transport it, using more road space, consuming more fuel, and emitting more CO_2 and other forms of pollution to atmosphere.
(14) HBP will not comply with the laws of the United Arab Emirates, Saudi Arabia, and other countries which require short-life plastic goods and packaging made in or exported to those countries to be oxo-biodegradable.
(15) An LCA by Intertek, published by the UK Government in 2011 and a further LCA by Intertek in 2012 found that ordinary plastic and d2w plastic have a better LCA than crop-based plastic or paper bags.
(16) A consortium consisting of Friends of the Earth, Surfrider Foundation, Zero Waste Europe, Ecos, and the European Environmental Bureau published a paper in 2017 in which they say "The bioplastics industry use their green-sounding credentials to position themselves as helping to speed the reduction in fossil fuel use and solving the ever-growing plastic pollution and marine litter issues. However, there is clear evidence that bioplastics do not solve many of these problems and in fact may create new ones."

11. **Surely education is the way to solve the litter problem?**

Hopefully education will reduce the litter problem over several generations, but there is a huge amount of plastic getting into the open environment today and there will always be some plastic litter – even in the developed countries. Action needs to be taken today to switch to d2w before millions

more tons of plastic waste accumulate in the environment. This what the United Arab Emirates, Saudi Arabia, and other countries have now done by law, and other countries will be doing.

12. **Isn't it better to recycle plastic than to let it biodegrade?**

Yes, but if the plastic is not collected it cannot be recycled, so d2w has been invented to make it degrade instead of accumulating in the environment as microplastics. However, one of the benefits of oxo-biodegradable plastic is that it can be recycled as part of a normal plastic waste stream if collected during its useful life[3]

13. **What about energy recovery?**

In some countries incineration is popular, and modern equipment is in place. d2w plastic can be incinerated for energy recovery in the same way as conventional plastic, and has a higher calorific value than the compostable alternative or damp paper.

14. **Can d2w be composted?**

D2w plastic has been found by industrial composters, to compost satisfactorily, and it has been successfully tested according to ISO 14855. However, it does not emit CO_2 quickly. This is an environmental advantage, but prevents d2w passing the tests in EN13432 or ASTM D6400, which are designed for hydro-biodegradable plastic. The market for compostable plastic expects to see tests according to those standards, so d2w plastic is not marketed for composting.

Hydro-biodegradable ("compostable") plastic is compliant with EN 13432 and D6400, precisely because it emits CO_2 (a greenhouse gas) at a rapid rate. Another unsatisfactory feature of 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

15. **What happens to d2w plastic in a landfill?**

D2W is intended to deal with plastic litter which escapes into the open environment, and biodegradation is not necessary for plastic which has been collected and disposed of in landfill, where it can not be described as litter. D2W will fragment and partially biodegrade to CO_2 and water in the parts of the landfill where oxygen is present, but degradation cannot continue deeper in the landfill in the absence of oxygen. This is an advantage over hydro-biodegradable (starch-based) plastics and paper, because in the depths of a landfill those materials will generate methane, which is a more powerful greenhouse gas than CO_2. Most of the landfills are not designed to capture the gas.

16. **Does d2w contain "heavy metals"?**

No. It contains metal salts, which are trace elements required in the human diet. They should not be confused with toxic heavy metals such as lead, mercury, cadmium and hexavalent chromium, which are never used in oxo-biodegradable plastics. D2W plastic does not contain any elements at all over the limits allowed by Art. 11 of the EU Packaging Waste Directive.

17. **Is d2w made from oil?**

D2w plastic products are usually made from a by-product of oil or natural gas. These are of course finite resources, but the by-product arises because the world needs fuels, and would arise whether or not the by-product were used to make plastic products. Until other fuels and lubricants have been developed for engines, it makes good environmental sense to use the by-product to make plastic, instead of using agricultural resources to make plastics.

[3] http://www.biodeg.org/recycling-and-waste/

Recently, interest has been shown, especially in Brazil, in manufacturing sugar-derived polyethylenes. These are not biodegradable, but they can be made biodegradable by adding d2w.

18. **Are hydro-biodegradable (compostable) plastics renewable?**

No – 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, and CO_2 is emitted, by the machines which clear and cultivate the land, and in the manufacture and transport of fertilisers and pesticides and in transporting the crop itself. Energy is also used by the autoclaves which polymerise material synthesised from biochemically produced intermediates (e.g. polylactic acid from carbohydrates etc). When the material biodegrades it emits CO_2 and can emit methane, so the total fossil fuels used and greenhouse gases emitted will be more than for conventional or d2w plastic.

In June 2009 Germany's Institute for Energy and Environmental Research concluded that oil-based plastics, especially if recycled, have a better Life-cycle Analysis than compostable plastics. This was also the conclusion of two LCAs done by Intertek http://www.biodeg.org/lifecycleassessments.html

Hydro-biodegradable ("compostable") plastics are sometimes described as made from "non-food" crops, but are usually made from food crops, and drive up the price of human and animal food.

19. **Does d2w plastic leave any harmful residues?**

No. d2w plastic passes all the OECD eco-toxicity tests, including seed germination, plant growth and organism survival (daphnia, earthworms).

20. **Deliberately and totally lost?**

The argument that d2w plastics are undesirable because their components are designed to be deliberately and totally lost is a fallacy, because if people want to mechanically recycle them, or incinerate with heat recovery, or compost them in-vessel, or re-use them, all of these are possible with d2w plastic products.

By contrast, hydro-biodegradable ("compostable") plastics ARE "deliberately and totally lost" because the applicable international standards require them to convert to CO_2 gas within 180 days. They do not therefore convert into compost or indeed anything useful for the soil.

21. **More Careless disposal?**

Degradable plastic bags have been supplied by supermarkets for more than ten 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. The type of person who causes litter will not bother to look for a biodegradable label before tossing it out of a car window.

But suppose for the sake of argument that 10% more were discarded. If 1,000 conventional and 1,100 d2w 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 d2w 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, so 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 plastic were all made with d2w?

22. **Is d2w plastic safe for food-contact?**

Yes. It has been certified by RAPRA Technology Analytical Laboratories as safe for long-term contact with any food type at temperatures up to 40°C according to European regulations. RAPRA is accredited to ISO17025. D2w plastics are also certified as compliant with FDA requirements in the US.

23. **Isn't it better to use paper packaging?**

No. 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 1,000 new plastic carrier bags would be around 2 inches high, but a stack of 1,000 new paper grocery bags would 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.

In addition, paper bags are not as strong as plastic, which means people use more bags. They also tear easily so cannot normally be re-used, and they will disintegrate if wet.

24. **Isn't it better to use durable re-usable bags?**

No. 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 problem 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 d2w plastic containing Symphony's d2p anti-microbial additive.

25. **How long does it take to degrade?**

It is not possible to say precisely how long a particular d2w plastic product will take to degrade in a particular place, because conditions in the open environment are variable. The key point is that it will degrade much more quickly than an ordinary plastic item in the same place. Heat and light will accelerate the d2w process, but they are not essential. Special conditions are necessary for compostable plastic but not for d2w, which needs only oxygen and bacteria.

An important advantage of d2w is that it can be programmed to degrade in whatever timescale is required. The useful life of a carrier bag is usually about 18 months (to allow for distribution, stocking, and re-use), but shorter or longer times are possible. During their useful life d2w bags are often re-used for shopping or as bin-liners etc.

26. **What products are available in d2w plastic?**

- 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. See https://www.biodeg.org/wp-content/uploads/2020/09/Pembroke-Mulch-Film-Trial-Report-30.09.13V1.pdf
- 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.

27. **What are the relevant national or international standards?**

Symphony's d2w plastic is tested according to American Standard ASTM D6954 for "Plastics that Degrade in the Environment by a Combination of Oxidation and Biodegradation." Also, according to British Standard 8472, or UAE Standard 5009/2009, or the French Accord T51-808, and comparable standards in other countries.

The French Standards organisation, AFNOR, has also published XP T 54-980, for d2w-type biodegradable plastics in agriculture.

The European standard EN 13432, the American standard ASTM D6400, the Australian standard 4736, and the ISO standard 17556 are not designed for testing plastics which biodegrade in the open environment. They are used for testing biodegradation of plastic in the special conditions found in industrial composting.

28. **What is biotransformation?**

It is another way of describing the d2w process, by which oxidation of the plastic is accelerated by a prodegradant additive, so that the plastic is converted to a waxy substance which can be transformed by bacteria into CO_2, humus, and water.

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