A Scientifically Proven Biodegradable Technology

Special Report: January 2019 Edition

Making Plastic Smarter
Symphony environmental

Contents

A Global Issue

In recent years people have become acutely aware of the destructive impact of plastic which escapes into the environment. They want change and are looking for technologies that can be implemented without further negative consequences.

As a result, the world is rethinking the way plastic is produced, used and disposed of, ideally adopting products and technologies that are low cost and non-disruptive to manufacture and that can be reused and recycled at the end of their useful life, **without increasing CO_2 emissions in the process.**

Governments around the world have recognised these concerns, including the EU which now has a strategy for plastics, adopted in January 2018. This recognises the need to move to a more sustainable way to use resources and to adopt a circular economy model for production, use and disposal of plastic products.

90% of plastic waste comes from just ten of the largest water networks in the world, of which 7 are in Asia and 3 are in Africa, contributing to a staggering 8 million tonnes of plastic ending up each year in our oceans.

Remove, Reduce, Reuse, Recycle

Symphony are committed to reducing unnecessary plastic and re-using/recycling wherever possible. However, the fact is that some plastic will always escape collection and end up littering the natural environment. Part of the solution is to change the type of plastic we use, to one which fits with circular economy principles.

Adding only 1% of Symphony's d_2w® biodegradable masterbatch to the normal plastic production method accelerates the natural process of oxidation, reducing the molecular weight of the polymer in a much shorter timescale.

Until it is no longer a plastic and can be gradually bio-assimilated by bacteria and fungi on land and in the oceans, with most of the carbon being sequestered by living organisms and ultimately recycled back in to the eco-system.

This is a drop-in technology, which can be added into the production of virtually any conventional plastic, to control the service life of the product within a timescale specified at manufacture. Products can be made in existing plastic factories with existing machinery and workforce, and they can be recycled if collected, alongside regular plastic.

Products made with d_2w® have all the benefits of conventional plastic that we have grown accustomed to, but with the added advantage that if they escape collection and end up as litter in the natural environment, they will degrade and biodegrade in a continuous, irreversible and unstoppable process. Symphony Environmental is a UK Plc, and the UK's leading producer of d_2w® oxo-biodegradable technology. d_2w® was the first product of this type to be awarded an internationally-recognised Eco-label, and plastic items made with this technology provide the same preservative, hygiene, optical and convenience properties of regular plastic.

An independent report was recently published by the distinguished lawyer and former deputy Judge of the High Court in England, Peter Susman QC, which declared the scientific case for oxo-biodegradable technologies as 'clear and compelling'

Products made with d_2w® are available in over 100 countries in many different types of applications. Furthermore, eleven countries in Asia, Africa and the Middle East have made oxo-biodegradable technology mandatory for a wide range of plastic items, because it makes environmental and economic sense to do so.

Summary

- Does not create persistent microplastics
- Meets all current standards for biodegradability and non-ecotoxicity
- Complies with the EU Packaging and Packaging Waste Directive 94/62/EC as amended
- Can be recycled and can be made with recyclate
- Preferred bio based solution in over 100 countries
- Looks and feels like ordinary plastic
- Is a low cost, drop-in technology with no disruption to the supply chain

Oxo-biodegradable v ordinary plastic

Conventional Packaging	Oxo-Bio Packaging (OBP)
Plastic – is a material made of high molecular weight organic polymer(s).	**Oxo-biodegradable plastic (OBP) – is made of high molecular weight organic polymer(s) plus a harmless catalystt a very low concentration (less than 0.1%)**
Conventional plastics are hydrophobic (incompatible with water) and cannot be biodegraded.	The catalyst in OBP will degrade the polymer, making it hydrophilic (water-absorbant) and suitable for biodegradation.
Wind, rain, wave motion and sunlight cause erosion and abrasion of ordinary plastic, fragmenting it into small pieces, but the molecular weight stays much the same so they remain as plastics.	The catalyst in OBP accelerates the natural process of oxidation reducing the molecular weight of the polymer, until it is no longer a plastic. No special environmental conditions are necessary, as oxygen is available everywhere in the open environment.
Oxidation and molecular weight reduction occurs very, very slowly, so small pieces of plastic persist as 'microplastics' in the environment for many decades.	Molecular weight reduction leads to continuous loss of mechanical properties and the materials are now hydrophilic.
Microorganisms cannot consume hydrophobic plastic with a high molecular weight so conventional plastics persist on land and in the marine environment.	Reduction in molecular weight and incorporation of oxygen allows microorganisms to colonise the material and begin consuming it on land and in aqueous environments. Again, no special conditions are necessary, as bacteria and fungi are ubiquitous.
Plastic litter and microplastics will accumulate, posing a threat to wildlife in terrestrial and marine environments, and will leave a problem for future generations.	OBP products are assimilated by bacteria and fungi and the only residues left are carbon-dioxide, water and natural biomass.
Plastic persists and accumulates	**Plastic is recycled back into nature**

plastic treated with **d_2w** does not create microplastics!

Glossary:

Biodegradable: Capable of being decomposed by bacteria or other living organisms

Catalyst: Substance which speeds up a chemical reaction

Hydrophilic: Having a tendency to mix with, dissolve in, or be wetted by water

Hydrophobic: Repels Water

Microorganisms: A microscopic organism, especially bacteria, and fungi.

Microplastic: Persistent pieces of plastic less than 5mm at their longest point

Molecular weight: Relative molecular mass (measured in Daltons)

Oxidation: Chemical changes caused by the addition of oxygen

Plastic: A material made of high molecular weight organic polymers

What is oxo-biodegradable technology?

d_2w - Added at only 1% during the manufacturing process

1. Turns ordinary plastic (at the end of its useful life, in the presence of oxygen) into a material which is biodegradable in the open environment (not just in a composting facility).
2. Meets all relevant international standards (See Standards and Certifications)
3. Has the same characteristics in terms of aesthetics, strength and flexibility as ordinary plastics.
4. Recycles carbon-based organic materials back into the eco-system
5. Will become biodegradable within the approximate timescale specified at manufacture.
6. Will have a long storage life if stored correctly, and will not degrade prematurely

- A non-disruptive, drop-in technology, means litte or no extra cost.
- Finished product can be re-used, and safely recycled with conventional plastic during its useful life.
- No need for new machinery nor to re-train workforce.
- Seamless integration into the manufacturing process.
- No change to strength, performance, colour or optical properties.
- No need to change suppliers – Symphony works with the customer's existing manufacturer.

Definitions

CEN - European Committee for Standardisation (Comité Européen de Normalisation) has established the following definitions in their Technical Report CEN/TR 15351:

1 - Oxo-degradable is defined as "degradation resulting from oxidative cleavage of macromolecules."

2 - Biodegradation is degradation of a polymeric item due to cell-mediated phenomena.

3 - Oxo-biodegradation is "degradation resulting from oxidative and cell-mediated phenomena, either simultaneously or successively.

Note: OBP polyolefin plastic film (polyethylene, polypropylene and all their combinations), incorporating a catalyst that ensures fast oxidative cleavage of its macromolecules, will become biodegrade by cell-mediated phenomena (bacteria and fungi) in the environment much more quickly than ordinary plastic. Heat and UV radiation (sunlight) will accelerate the abiotic process but they are not essential.

www.biodeg.org/lifecycleassessments

Carbon Emmissions

d_2w has the most beneficial carbon performance of any biodegradable solution.

In the process of degradation, d2w (a low-cost biodegradable additive) allows the transfer of valuable carbon material to the eco-system. Studies have demonstrated that one of the benefits of d_2w oxo-biodegradable technology is that the carbon content of the plastic is ultimately shared with living organisms in the environment.

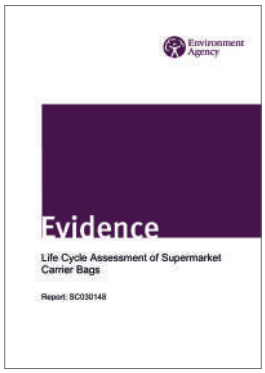
Further investigations have shown that the carbon-based organic materials developed as the result of the degradation mechanism are biodegradable and therefore absorbed by living organisms in the soil. This is not the case with conventional plastic that tends to capture the carbon for many decades or hydro-degradable that release the carbon immediately as CO_2.

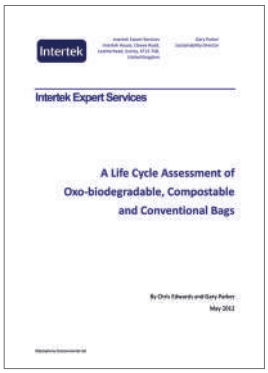
Not many people are aware of the true facts behind the carbon foot print of plastic bags. The UK Environment Agency study shows how plastic bags are the most environmentally friendly. If these were banned, it would be worse for the environment as the alternatives to plastic bags have a higher Global Warming Potential.

Bio-based plastics are not necessarily biodegradable in the open environment, unlike d2w which is a commercially viable solution for the Global Packaging Industry. The polymers making up plastic packaging with d2w additives are derived from oil refining or natural gas. When it is added to PE or PP (whether derived from oil or sugar cane), it will break down the molecular structure, in the presence of oxygen.

Therefore, d_2w has the most beneficial carbon performance of any biodegradable solution at the present time.

Bag type	Ave CO2 equivalent per 1 kg of bags rage bag weight (g)	CO2 equivalent per 1 kg of bags	CO2 equivalent per bag (kg)
HDPE vest carrier	8.12	1.578	0.0128
Oxo-degradable vest carrier	**8.27**	**1.750**	**0.0145**
Starch based biodegradable vest	**16.49**	**4.184**	**0.0690**
Paper bag	**55.2**	**5.525**	**0.305**
LDPE 'Bag for Life'	34.94	6.924	0.242
Non woven PP bag	115.83	21.510	2.491
Woven PP Bag	120	23.088	2.770
Cotton bag	183.11	271.533	49.720
Jute bag	190	273.111	51.891





Report 1 (far left) from Environmental Agency before litter and recycling added.

Report 2 (left) Intertek showing the calculations with litter and recycling.

Rating of Oxo degradable increased to number 1 when calculations for recycling and litter where added (Intertek report 2).

Standards

The main standards for testing oxo-biodegradable plastics are:

American Standard ASTM D6954-18 – "Standard Guide for Plastics that Degrade in the Environment by a Combination of Oxidation and Biodegradation"

JUST RENEWED 2018

Variants of this standard have also been adopted in other countries (see below). There is no EU standard for OBP because the technical committees of CEN are dominated by representatives of the bio-based plastics industry. Accordingly the OBP industry has worked in the other standards organisations around the world to assist in developing new and better standards.

British Standard 8472 "Packaging – Method for determining the degradability, oxo-biodegradability and phyto-toxicity of plastics"

Variants of these standards have also been adopted in other countries (see below). There is no European standard for OBP because the technical committees of CEN are dominated by representatives of the bio-based plastics industry. Accordingly the OBP industry has worked in the other standards organisations around the world to assist in developing new and better standards.

The below two standards, which include PASS/FAIL criteria are the most recent oxo-biodegradable standards in use around the globe.

SAUDI STANDARD: SASO 2879 /2016 Saudi Arabian Standards, Metrology and Quality Org.(SASO) has developed, implemented and enforced this Standard as from April 2016.

UAE No 5009/2009 The Emirates Authority for Standards & Metrology (ESMA) has developed, implemented and enforced this Standard as from October 26, 2009 with the title: **"Standard & Specification for Oxo-Biodegradation Of Plastic Bags And Other Disposable Plastic Objects."**

French Accord: T51-808 - 'Plastics Assessment of oxo-biodegrability of polyolefinic materials in the form of films. Symphony's d_2w has been found to comply with this Accord by CNEP (Centre National d'Evaluation de Photoprotection) which is an independent laboratory at the University Blaise Pascal in France. Also by Eurofins Laboratories in Spain.

French Standard XP T 54 890 F for oxo-biodegradable applications in agricultural applications.

AFNOR Accord T51-808

Assessment of oxo-biodegradability of polyolefinic materials in the form of films to demonstrate:

1 - Abiotic Degradation:

Phase 1 - Storage in the dark and under controlled temperature conditions - No oxidation

Phase 2 - Use - Initiation of photothermal oxidation and fragmentation.

Phase 3 - End-of-life - Continuation of thermal oxidation to reach a sufficient oxidation state to allow bio assimilation

2. Acquired biodegradability:

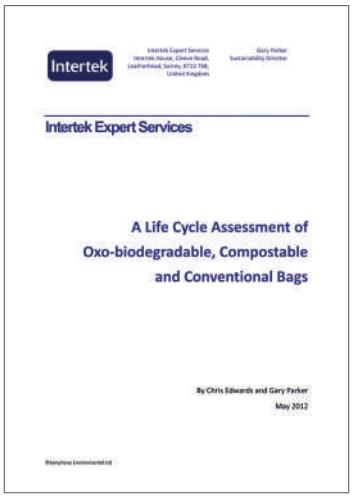
ATP/ADP Activity – Demonstrate function and viability of microorganisms after 180 days where degraded plastic is the sole source of Carbon

Swedish Standard SPCR 141 - 2010 Polymeric waste degradable by abiotic and subsequent biological degradation - Requirements and Test Methods.

Life Cycle Assessment (LCA) Intertek Expert Services

Main features

- d_2w was evaluated by Intertek and confirmed to provide the best LCA of all materials used for making carrier bags and bread bags.
- The LCA concluded that the best way to reduce the impact of plastic carrier bags is to re-use them more often, minimize the transportation and energy input needed for recycling, and make them oxo-biodegradable.
- Bio-based plastic cannot be recycled with conventional plastic as part of a mixed, post-consumer waste stream without compromising the recycling process.
- The bio-based bag had the worst performance in 10 of the 11 environmental impact categories.



www.biodeg.org/UK%20EA%20publishes%20LCA%20of%20supermarket%20carrier%20bags%20(1)%20(1).pdf

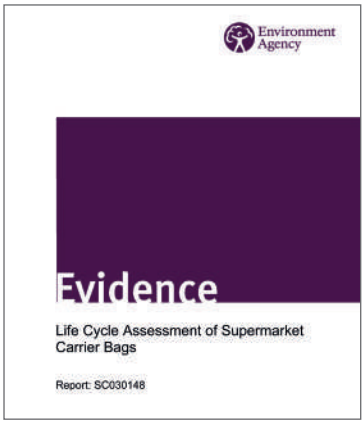
The oxo-bio bag performed 75% better than the conventional bag in the litter category. In all other categories the performance of the oxo and conventional bags were similar.

Carbon value

d_2w has the most beneficial carbon performance of any biodegradable solution.

Polyethylene used for plastic packaging with d_2w masterbatch is derived from oil refining or natural gas. It is a by-product of a material that will be extracted for fuels, whether plastics are made or not. The carbon content of these hydrocarbons will typically escape to atmosphere after combustion but when a d_2w plastic biodegrades most of the carbon will be sequestered by living organisms and is thus recycled into the eco-system. (See AFNOR Accord 51-808 ADP/ATP methodology – consumption of degraded 'oxo' material by living organisms).

Carbon footprint of plastic bags



This UK Environment Agency study shows how plastic bags* are environmentally friendly. If these were banned, it would actually be worse for the environment as the alternatives to plastic bags have a higher Global Warming Potential. See also plastic bag bans and taxes*. The message therefore is "don't ban plastic bags – upgrade them with d_2w technology."
*.

*www.biodeg.org/bagbansandtaxes

*www.gov.uk/government/uploads/system/uploads/attachment_data/file/291023/scho0711buan-e-e.pdf

All grades of d_2w are compliant for food-contact with:

European Union Regulation (10/2011)

US - Regulations (21 CFR 175.300, 177:1520, and 178:2010) except for use during cooking.

Brazil - ANVISA (The Brazilian Health Regulatory Agency) Resolution number 105 of 19th of May 1999 and RDC number 17 of 17th March 2008. The first and only Oxo-biodegradable technology to be approved.

Canada - CFIA Regulation.

Other Certifications

Africa - First oxo-biodegradable technology to be approved in Ghana, Rwanda and Togo.

Middle East - The first oxo-biodegradable technology to be approved in the Middle East (by ESMA in the UAE).

Saudi Arabia - First to be approved by SASO.

- **Certified Biodegradable** - tested according to the test methods prescribed by ASTM Standard 6954, BSI 8472, AFNOR ACCORD T51-808, and UAE 5009-2009. Biodegradability of oxo-biodegradable polymers has been studied at laboratories worldwide, including: Applus (Spain); RAPRA (UK); SPI (Sweden); Blaise Pascal University - CNEP (France); University of Pisa (Italy); Euro Laboratoire (Spain) and Universita Autonoma Metropolitana (Mexico).
- **Certified Non-Ecotoxic** and free of restricted chemicals. Tested according to OECD 207, 208 and EN13432 by independent laboratories RAPRA (UK) Applus, Eurofins (Spain) and OWS (Belgium).
- Symphony is certified by the **Oxo-biodegradable Plastic Association** ("OPA") as qualified for membership.
- The Green Apple Award for Environmental Best Practice.
- **Quality system** certified to ISO 9001 for quality management and ISO14001 for environmental quality.


ADIV
viande performances

Technical Feasibility Study linked to use of oxo-biodegradable technology packages ($d_2w^{®}$) for packaging of meats and meat products in modified atmospheres

Final report

May 2011

Packaging of meat products

Technical Feasibility Study: This study shows that oxo-biodegradable technology is **capable of being used for the packaging of meat products** without altering the quality of those products. The materials were subjected to alimentary (SGS), degradability and non-toxicity tests (OECD 208).

d_2w technology, makes the trays biodegradable but also recyclable. It is now a relevant, safe and inexpensive answer to the environmental problem of packaging which becomes litter.

Recycling

Four major studies prove that Oxo-biodegradable plastic can be safely recycled and be made from recyclate.

TCKT Report – European recycling study from Austria confirms that oxo-biodegradable products can be safely recycled for thin and also thick cross-section products. This complements the earlier studies in the UK and South Africa.

The study by TCKT, reported in July 2016 that recyclate from d_2w oxo-biodegradable plastic can safely be used in the manufacture of plastic products intended for long term use outdoors, such as building films, plastic lumber, garden and municipal furniture, and signage. They reported that plastic products intended for outdoor use have to be stabilised against sunlight and that the products so stabilised show no difference after a weathering cycle of 1,000 hours, whether or not they contain oxo-biodegradable plastic recyclate.

This is the fourth positive study of its kind on the recyclability of oxo-biodegradable plastic. TCKT had itself reported in March 2016 that recyclate from oxo-biodegradable plastic can safely be used in the manufacture of thin plastic film products.

TCKT are the European specialists in application-oriented research and development in plastics engineering.

Further recycling studies

PTL and Roediger

The Polymer Training Report (UK) dated October 2009 and the Roediger reports (South Africa) dated May 2012 and December 2013 all confirm that plastic products made with oxo-biodegradable technology may be recycled together with conventional oil-based polymers without any significant detriment to the newly formed recycled product. Separate collection is not therefore necessary, but separation can easily be achieved by including an optical tracer in the oxo-biodegradable plastic if so desired.

2012 study in ScienceDirect

In 2012, a peer reviewed study entitled 'Effects of reprocessing oxo-biodegradable and non-degradable polyethylene on the durability of Recycled Materials' (ScienceDirect)*, Investigated whether a mixture of 10% or 20% oxo-biodegradable additive would have any adverse effects on the recyclate and found that it would not.

More than 500,000 tonnes of oxo-biodegradable plastic has been recycled in the last 5 years!

Test Reports and Studies

Eurofins ASTM D6954 - Compliance Report

Test on film with d_2w (Study finalised on 25th July 2017)

Eurofins Laboratory in Spain have carried out a full series of tests according to ASTM D6954, and have proved that a d_2w plastic is degradable, biodegradable, and non-toxic.

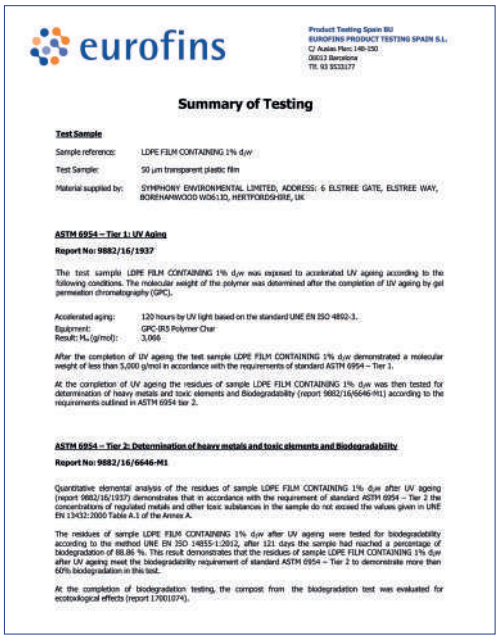
The test requirement is for **60%** biodegradation within 2 years.

The test was continued to demonstrate a greater extent of biodegradation, **88.86%** after 121 days.

d_2w exceeded this requirement by showing **63.63%** biodegradation after 90 days

OECD testing on plants & earth worms found no toxicity

ASTM D6954
Biodegradation tests.
Proof of compliance.



eurofins

Product Testing Spain BU
EUROFINS PRODUCT TESTING SPAIN S.L.
C/ Aulas Marc 148-150
08013 Barcelona
Tlf. 93 3533177

Summary of Testing

Test Sample

Sample reference: LDPE FILM CONTAINING 1% d2w
Test Sample: 50 µm transparent plastic film
Material supplied by: SYMPHONY ENVIRONMENTAL LIMITED, ADDRESS: 6 ELSTREE GATE, ELSTREE WAY, BOREHAMWOOD WD6 1JD, HERTFORDSHIRE, UK

ASTM 6954 – Tier 1: UV Aging

Report No: 9882/16/1937

The test sample LDPE FILM CONTAINING 1% d2w was exposed to accelerated UV ageing according to the following conditions. The molecular weight of the polymer was determined after the completion of UV ageing by gel permeation chromatography (GPC).

Accelerated aging: 120 hours by UV light based on the standard UNE EN ISO 4892-3.
Equipment: GPC-IR5 Polymer Char
Result: M_n (g/mol): 3,066

After the completion of UV ageing the test sample LDPE FILM CONTAINING 1% d2w demonstrated a molecular weight of less than 5,000 g/mol in accordance with the requirements of standard ASTM 6954 – Tier 1.

At the completion of UV ageing the residues of sample LDPE FILM CONTAINING 1% d2w was then tested for determination of heavy metals and toxic elements and Biodegradability (report 9882/16/6646-M1) according to the requirements outlined in ASTM 6954 tier 2.

ASTM 6954 – Tier 2: Determination of heavy metals and toxic elements and Biodegradability

Report No: 9882/16/6646-M1

Quantitative elemental analysis of the residues of sample LDPE FILM CONTAINING 1% d2w after UV ageing (report 9882/16/1937) demonstrates that in accordance with the requirement of standard ASTM 6954 – Tier 2 the concentrations of regulated metals and other toxic substances in the sample do not exceed the values given in UNE EN 13432:2000 Table A.1 of the Annex A.

The residues of sample LDPE FILM CONTAINING 1% d2w after UV ageing were tested for biodegradability according to the method UNE EN ISO 14855-1:2012, after 121 days the sample had reached a percentage of biodegradation of 88.86 %. This result demonstrates that the residues of sample LDPE FILM CONTAINING 1% d2w after UV ageing meet the biodegradability requirement of standard ASTM 6954 – Tier 2 to demonstrate more than 60% biodegradation in this test.

At the completion of biodegradation testing, the compost from the biodegradation test was evaluated for ecotoxicological effects (report 17001074).

Biodegradability using marine bacteria

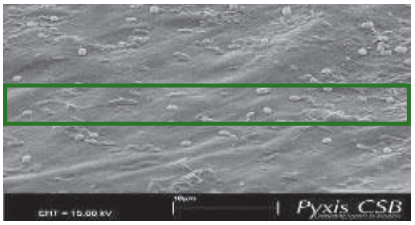
Queen Mary University of London

Symphony has made a substantial investment in a completely new study of the bio-degradation of d_2w plastics at Queen Mary University, London (2017).

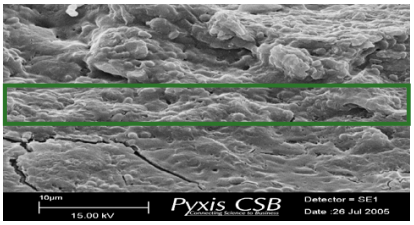
The study shows clearly that d_2w plastics are biodegradable and non-toxic on land and in the ocean. The authors intends to submit a paper to a peer-reviewed scientific journal.

Photographs taken with an electron-microscope show bacteria anchored to the plastic, which showed evidence of pitting from biotic degradation.

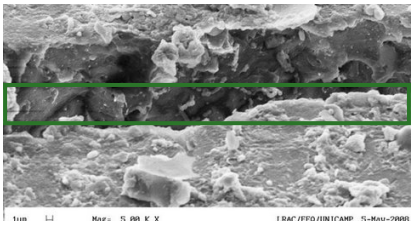
The holes in the plastic are roughly the same diameter as a single bacterium (1µm).



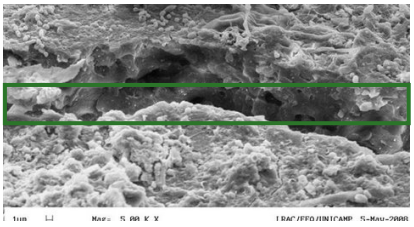
Un-oxidised film. Film intact and limited microbial activity on surface due to the surface being hydrophobic



Cracks and fissures on surface of oxidised, hydrophilic film



Furrows and ridges eroded into the surface of the film by microbial activity



Microbial colonisation on surface of oxidised, hydrophilic film

Evidence to show that marine microoganisms consume organic residual material resulting from abiotic degradation of plastics incorporating d_2w

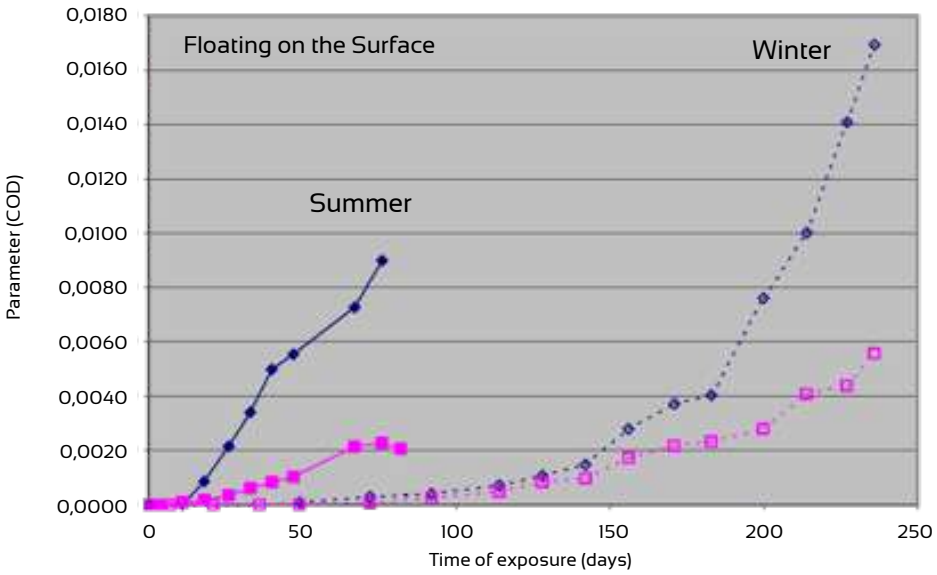
Bandol Study - Natural ageing in sea water

Station d'essais de Vieillissement Naturel de Bandol on the Mediterranean coast of France

Evidence from Bandol shows that oxo-biodegradable plastic will degrade to low molecular-weight materials under natural conditions in water.

Samples aged under those conditions in real time have been studied at Queen Mary University London, where the degraded plastic was the only source of carbon available to bacteria.

The samples were proved to be biodegraded by bacteria commonly found in the oceans, and separate samples, by bacteria commonly found on land. The material was also proved to be non-toxic to those bacteria.



7 Year Study

Testing samples of plastic floating on the surface of water

OxoLDPE LDPE: non-treated

Sample	COD = 0.0100 / >95% Loss EaB
OXO LDPE (Summer)	76 Days
OXO LDPE (Winter)	210 Days

FTIR analysis demonstrates the capability of LDPE film to degrade quickly in outdoor environments when containing 1% d2w additive.

A weathering test on the sea water surface was performed to show the behaviour of samples containing d w prodegradant masterbatch in aquatic environments (films and bags accidentally released into oceans, rivers or lakes), points out very positive results.

As there is a correlation between oxidation rate and elongation at break, film FA6224 would present a 50% loss of mechanical properties in three weeks, and a total loss in three months, when exposed in the summer period in a Mediterranean climate. These durations are extended to four months and seven months respectively, in the winter period.

Caring for the oceans

A substantial amount of work has been done over the last 10 years studying the effects of oxo-biodegradable plastics in the aquatic environment (both in salt and fresh water). Many governments and organizations, including the United Nations and the French Government are in support of these studies.

Oxomar (First Ever European Study)

A detailed study on plastics in the marine environment is being carried out with the support of the French Government at l'Observatoire Oceanologique de Banyuls sur mer (Lomic). Oxo-biodegradable plastic technology has also been studied for many years at CNEP, and the Institut De Chemie de Clermond Ferrand (University Blaise Pascal). The participants include:

To create new norms for proving biodegradation in oceans

- Symphony Environmental Ltd (Expertise in oxo-biodegradable technology)
- LOMIC Institute, Banyuls, France (Expertise in marine microbiology)
- CNEP, Clermont-Ferrand, France (Expertise in polymer ageing and durability)
- IFREMER (Monitoring, use and enhancement of coastal waters).
- Inst. Di Chemie de Clermond Ferrand (University Blaise Pascal - Expertise in microbiology)

This study of oxo-biodegradable plastic in the marine environment was approved in 2016. It is led by Dr Jean-Francois Ghiglione at the LOMIC Laboratory of the Oceanologic Observatory of Banyuls, France (who is in no doubt of the marine biodegradability of oxo plastic). This is a Euro 750,000 project to create new scientific knowledge and new industry standards.

Oxomar scientists have published two papers this year. They are:

Dussud and 14 colleagues: 'Colonisation of Non-biodegradable and Biodegradable Plastics by Marine Organisms', published in 'Frontiers in Microbiology' (peer-reviewed). Eyheraguibel and 9 colleagues, 'Characterisation of oxidised oligomers from polyethylene films by mass spectrometry and NMR spectroscopy before and after biodegradation by a Rhodococcus rhodochrous strain, published in Chemosphere (peer-reviewed), vol 184, page 366

Highlights

- Large-scale study of bacterial life on plastic debris in the Mediterranean Sea.
- High density of bacteria and patchy organization of biofilm on plastic surfaces.
- Characterization of 'plastic specific bacteria' compared to surrounding waters.
- New insights on potential bacterial functions linked with plastic habitat.

Scientific Reports

Two additional scientific reports have been published within the last few months (2018) in peer-reviewed journals and are therefore publicly available. These reports add additional evidence to the decades of other studies and in particular the marine environment data. The authors are Arraez, Dussud, Gewert, and Eyheraguibel. Further publications are expected within the next 3 months through the European Oxomar project and Queen Mary University London. The Carbon-13 (13C) studies are expected to publish some results in the first half of 2019. This is a novelty study and will provide the rate and extent of Oxo-PE biodegradation in real-life marine conditions.

Dussud, C., Meistertzheim, A., Conan, P., Pujo-Pay, M., George, M., Fabre, P., Coudane, J., Higgs, P., Elineau, A., Pedrotti, M., Gorsky, G. and Ghiglione, J. (2018). Evidence of niche partitioning among bacteria living on plastics, organic particles and surrounding seawaters. Environmental Pollution, 236, pp.807-816.

Mexico

Symphony carried out research in March 2016 with the Universidad Autonoma Metropolitana of Mexico to confirm that d_2w plastic complies with the Mexico DF law on solid waste.

Biodegradation and Ecotoxicity of Polyethylene Films Containing Pro-Oxidant Additive

A.Vazuex-Morillas M Beltran-Villavicencio[1] J. C. Alvarez-Zeferino[1] M. H. Osada-Velazquez[1]
A. Moreno[2] L. Martinez[3] J. M. Yanez[2]

The aim of the study was to evaluate the process of oxidation, biodegradation and potential Ecotoxicity of polyethylene films containing an oxo-biodegradable additive according to the standard ASTM D6954. This method establishes a procedure in which the samples are subjected to consecutive steps of oxidation, biodegradation and ecotoxicity assessment. Furthermore, the presence of printing ink on the polyethylene samples with oxo-biodegradable additive was evaluated and the results compared with those obtained from conventional polymer.

The study concluded that the presence of the oxo-biodegradable masterbatch in polyethylene samples increased the biodegradation feasibility, as evidenced by their higher mineralisation compared to conventional polyethylene. There is controversy regarding toxic effects of the degradation products of plastics, but; under conditions of this research, none of the samples liberated metals towards the substrate in higher levels than those contained in soil. Also, biodegradation of these plastics in a controlled compost system did not generate toxic metabolites affecting the rate of germination in plants of the two species studied.

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[2]Centro de Caracterization e Investigación en Materiales, Xochitepec, Morelos, Mexico
[3]Instituto de Ciencias Fisicas, Universidad Nacional Autónoma de Mexico, Cuernvaca, Morelos, México

Other independent studies

Published scientific studies by members of the Technical / R&D team at Symphony Environmental (Radu Baciu M.S.Ch.E. (Group Technical Director) and Perry Higgs BSc (senior scientist)

Oxo-biodegradable carbon backbone polymers – Oxidative degradation of polyethylene under accelerated test conditions
E. Chiellini, A. Corti, S. D'Antone, R. Baciu - Polymer Degradation and Stability 91(11):2739-2747 · November 2006
www.sciencedirect.com/science/article/pii/S0141391006001a509

Biodegradable Polymers: Are Sources and Structures Important?
Graham Swift, Radu Baciu - ACS Symposium Series · September 2006
www.scopus.com/record/display.uri?eid=2-s2.0-36849045635&origin=inward&txGid=e722159429378222779 6a090a3212c4b

Environmentally Degradable Polyolefins
Graham Swift, Radu Baciu, Emo Chiellini - ACS Symposium Series 48:2-16 · January 2009
www.scopus.com/record/display.uri?eid=2-s2.0-84904785955&origin=inward&txGid=84d52e04e48534ffeae4b9b3dabbfb88

Dussud, C., Meistertzheim, A., Conan, P., Pujo-Pay, M., George, M., Fabre, P., Coudane, J., Higgs, P., Elineau, A., Pedrotti, M., Gorsky, G. and Ghiglione, J. (2018).
Evidence of niche partitioning among bacteria living on plastics, organic particles and surrounding seawaters. Environmental Pollution, 236, pp.807-816.

Dussud, C., Hudec, C., George, M., Fabre, P., Higgs, P., Bruzaud, S., Delort, A., Eyheraguibel, B., Meistertzheim, A., Jacquin, J., Cheng, J., Callac, N., Odobel, C., Rabouille, S. and Ghiglione, J. (2018).
Colonization of Non-biodegradable and Biodegradable Plastics by Marine Microorganisms. Frontiers in Microbiology, 9.

Legislation

Many countries have realised that they cannot realistically collect all the plastic and that some of it will inevitably get into the open environment.

The governments of the following countries have decided not to ban plastic, but instead have passed legislation making it mandatory to use oxo-biodegradable or crop-based, or in some cases oxo-biodegradable plastic only.

Legislation in favour of oxo-biodegradable plastic supports the local plastic manufacturing industries in the countries concerned, because the technology can be used with their existing machinery and workforce. It helps to secure the jobs and livelihoods of thousands of people worldwide.

*Oxo-biodegradable Plastic only	**Oxo-biodegradable and Hydro-degradable plastic
Saudi Arabia	Argentina
UAE	Benin
Pakistan	Bosnia & Herzegovina
Kosovo	Burkina Faso
Mauritius	Croatia
Jordan	Democratic Republic of Congo
Brazil (part)	Macedonia
Togo	Montenegro
Yemen	Serbia
Albania	Slovenia
Rwanda	Sudan

*Plastic factories and brand owners cannot export to these countries unless their disposable plastic products contain oxo-biodegradable technology.

**In these countries the legislation specifies either oxo or hydro technology. In practice, oxo-biodegradable is the preferred technology as it is cheaper and more flexible in most applications, and it can be recycled.

d_2w awarded an Eco-Label

The Eco-Label confirms the environmental credentials of the d_2w masterbatch and distinguishes it from other oxo-biodegradable masterbatches on the market. This helps to enhance the green value of the d_2w brand. Therefore your brand, together with d_2w and the Eco-Label represents quality, security of supply and more importantly, trust.

Illustrating product claims

This product was manufactured with d_2w^{TM} technology, which is an oxo-biodegradable plastic additive certified by ABNT under the Environmental Quality – Eco-Label program internationally accredited by INMETRO –Certificate no 365.001/14

The technology d_2w^{TM} is an oxo-biodegradable plastic additive certified by ABNT INMETRO – Certificado no 365.001/14

Suprememe court of Pakistan logo

Pakistan

Oxo-biodegradable plastic is mandatory in the Federal Capital and in several Provinces.

Legislation for use of oxo-biodegradable

Countries in the Middle East are leading the way in legislating for smarter plastic

UAE

The Emirates Authority for Standardization & Metrology (ESMA) is the national Standardization body. A committee of experts appointed by ESMA - conducted a thorough review of the scientific literature and carried out an audit of Symphony's Laboratory and production facilities. They then drafted the UAE 5009/2009 "Standard & Specification for Oxo-biodegradation of Plastic bags and other disposable Plastic objects". This is a Mandatory Standard and consumer plastic products are prohibited in the UAE unless they are oxo-biodegradable. The example of the UAE has been followed in Pakistan, Saudi Arabia and eight other countries.

Jordan

Legislation making oxo-biodegradable plastic mandatory is applied to local manufacturers, importers, distributors, retail traders and all facilities circulating plastic bags.

Legislation in Saudi Arabia

A new law enforced from 14 th April 2017, made it mandatory for all plastic products and / or plastic packaging specified in the regulations to be made using an approved oxo-biodegradable masterbatch, whether they are made in Saudi Arabia or exported to that country.

Products made with polyethylene or polypropylene have to comply with the new regulations and obtain their masterbatch from a supplier authorised by the Saudi Arabian Government.

Symphony Environmental Ltd was the first UK company to be awarded the SASO Quality mark and be granted a licence to supply oxo-biodegradable masterbatch, to comply with the new regulations.

All factories producing the following specified products must demonstrate compliance to SASO rules.

- Carrier Bags
- Courier bags and Parcels
- Mail order bags for periodicals and magazines
- Plastic bags for soil treatment, agricultural/horticultural applications (e.g. banana bags and cultivated soil covers)
- Bubble plastic for wrapping / bubble plastic bags and cover for protection against shocks
- Plastic Flower wrap
- Plastic coves for secondary packaging
- Elastic plastic films ‘rolls’ for goods ‘ packaging
- Clinging plastic films or ‘rolls’ for packaging
- Plastic liners for cardboard boxes
- Polyethylene sheets as table covers
- Personal care products made of plastic, such as gloves, shoe covers and any disposable plastic
- Personal care products
- Bags for bread, nuts sweets and all bakery products
- Plastic bags for saplings
- Heat shrinkable plastic films
- All plastic bags for one-time use, including shopping bags, garbage bags, clothes bags
- One time use food tools like plates, spoons, cups and straws.

Visit **www.saso.gov.sa** for more information

Evaluation of Evidence by QC

The credentials of oxo-biodegradable plastic have recently been validated in an independent review conducted by Peter Susman QC, a distinguished barrister and former deputy High Court Judge with over 25 years' experience of adjudicating cases in the Technology and Construction branch of the High Court in England, involving the evaluation of expert evidence.

In his report, dated 2nd November 2018. Mr. Susman found that oxo-biodegradable plastic 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.

Mr. Susman included the January 2018 report of the EU Commission, the Loughborough Report for the UK Government, the Eunomia Report for the EU Commission in 2016, and the Ellen MacArthur reports.

Eunomia

Eunomia Research and Consulting have reported to The European Commission on "the impact of the use of oxo-degradable plastic carrier bags on the environment."

Eunomia concluded the following:

"The debate around the biodegradability of OBP plastic is not finalised, but should move forward from the assertion that OBP plastics merely fragment, towards confirming whether the time-frames observed for total biodegradation are acceptable from an environmental point of view and whether this is likely to take place in natural environments."

"Without exception, the scientific evidence suggests that the conditions present during the abiotic stage (which in most studies is simulated by some form of accelerated pre-treatment) of degradation will have a significant impact on the materials ability to subsequently biodegrade"

"From the information studied, the authors of this report can believe that **it is possible for OBP plastic to fully mineralise in an open environment,** with the prodegradant additives encouraging this action, and thus the polymers and entrained substances can be assimilated into the natural environment"

It is often claimed that biodegradable plastics are likely to encourage littering, but the report says Eunomia also commented on two studies i.e .Station d'essais de Vieillissement Naturel de Bandol and Queen Mary University of London

"During pre-aging under water, OBP plastic is much more susceptible to UV degradation than conventional plastic (as demonstrated by the difference in molecular weight)."

Oxo-biodegradable plastic in the European Union

There are no bans on Oxo-biodegradable products. However the E.U. would like to ban products that damage recycling and that create persistant microplastics. Products made with d_2w are proven to be recyclable and biodegrade and in the open envinronment.

In December 2017 the Commission requested the European Chemicals Agency (ECHA) to prepare a dossier on the grounds that a 'potential' risk to the environment may arise from the use of oxo-plastics… because of their potential to initiate the generation of microplastics. This was not a request for a ban and no ban has been proposed by the Commission.

The Commission's request to ECHA is based on the Commission's 2018 Report which says that oxo-degradable plastic "fragments over time into plastic particles, and finally microplastics, with similar properties to microplastics originating from the fragmentation of conventional plastics". This is true in the case of oxo-degradable plastics but not of oxo-biodegradable plastics.

ECHA were due to report on 17th January 2019, but as at the end of October 2018 ECHA was not convinced that microplastics are formed. ECHA have therefore delayed their report until 19th July 2019. It would be inconceivable for any plastics to be banned unless ECHA finds that there is sufficient reason to do so.

Complies with all the essential requirements of the EU Packaging Waste Directive as amended.

The EU institutions are currently debating a Proposal by the Commission (2018/0172(COD)) for a Directive on "Reduction of the impact of certain plastic products on the environment." The preamble refers to work by ECHA, but does not otherwise mention degradable plastics save to say that the Commission is developing harmonized rules for defining and labelling compostable and biodegradable plastics.

The microplastics being recovered from the oceans are from "oxo-degradable" plastics, which degrade and fragment but do not biodegrade except over a very long period of time. These are conventional plastics which undoubtedly create persistent microplastics, and this is why they have been banned for a wide range of products in Saudi Arabia and 11 other countries, where oxo-biodegradable technology for making these products is now mandatory.

Every year in Europe, 150,000 tonnes of plastic are dumped into the sea. The situation is even more alarming at global level, with 8 million tonnes ending up in the sea each year. If action had been taken years ago to adopt oxo-biodegradable plastic technology there would be no ocean garbage patches of plastic today.

Symphony would therefore have no objection if oxo-degradable plastics were banned in Europe (as the EU Parliament voted to do on 24th October 2017), whilst making it clear that the ban does not apply to oxo-biodegradable plastics.

Reduction and Recycling

The Commission proposes various measures for reducing the quantity of plastic goods being produced, and measures for encouraging collection for recycling. We support those measures, but plastic waste will still escape into the open environment for the foreseeable future in unacceptable quantities, and the Commission has not addressed this part of the problem.

As the Ries report says "Every year in Europe, 150,000 tonnes of plastic are dumped into the sea. The situation is even more alarming at global level, with 8 million tonnes ending up in the sea each year." If action had been taken years ago to adopt oxo-biodegradable plastic technology there would be no plastic ocean garbage patches today.

Packaging Waste Directive

Oxo-biodegradable plastic complies with the EU Packaging Waste Directive because it complies with Annex II sections 1, 2, and 3(a) (b) and (d). Oxo-biodegradable plastic does not contain any of the hazardous substances listed in Art 11 of the Directive, and oxo-biodegradable plastics are tested according to the same eco-toxicity tests prescribed by EN13432 for plastics intended for composting.

Mexico - Summary of the present situation regarding legislation on plastics at City, State and National Levels as of March 2018

Since the mid 90´s there have been initiatives by elected members to regulate at the three levels of government, the use and final disposal of synthetic materials.

This follows a growing global trend to solve the increasingly important issue of environmental degradation due to the uncontrolled presence of plastics in the earth´s ecosystems.

Mexican authorities and members of Congress are introducing measures to reduce the use of plastics in general, and plastic bags in particular.

On 8th October 2003, a General Law for the Prevention and Integral Management of Residues (LGPGIR) was approved. It is the legislation that oversees and controls the management of urban solid waste, as well as hazardous waste. It also includes a third type of waste, identified as "Wastes for special management". This LGPGIR was last amended on the 22nd of May 2015.

On 19th August 2010 in Mexico City, a law was approved to prohibit the free hand-out of plastic bags by supermarkets and stores in general. This law has not been enforceable as it is impractical.

On 13th April 2017, the representatives of Movimiento Ciudadano introduced a law that promotes (through subsidies), the use of Polyethylene terephthalate bottles that have a "plant origin" (Bio-bottles). However, it has not been yet brought to the plenum of the House, where it will be seen that those bottles are not biodegradable. Nor do they save fossil-resources.

The ruling PRI party together with the left-wing PRD introduced an initiative on 28th June 2017, "to establish the basis for the transition to the use of biodegradable materials".

It has not yet been brought to the floor. Furthermore, on 15th December 2017, the City of Querétaro passed a law that bans plastic bags in all commercial stores, but biodegradable bags are exempt from this regulation. The law establishes sanctions on the stores, not on the consumers. Sanctions will vary from confiscation of the bags to the refusal to renew the operating license of the store. This law took effect on 1st April 2018.


CERTIFICADO DE CONFORMIDADE
Conformity Certificate
Nº 365.001/14
RES Brasil Ltda
Aditivos Plásticos com função Oxibiodegradável - Marca d2w
Hubron International Limited
PE-308.01
ABNT NBR ISO 14020:2002
ABNT NBR ISO 14024:2004
12/12/2017 a 12/12/2020

Above: Official Certificate of conformity, presented to RES Brasil Ltda.

Brazil

There are some states and cities in Brazil where the use of oxo-biodegradable shopping bags and sometimes even garbage bags is mandatory. In addition to the above, there was a proposal in 2017 for a national law designating that only biodegradable plastic (including oxo-biodegradable) would have to be used in all packaging. It is still under discussion in the Senate.

Testing was carried out according to the requirements of ASTM 6954 and OECD 207. It was demonstrated that earthworms exposed to soil with non-degraded and degraded oxo-biodegradable films did not demonstrate evidence of ecotoxic effects for the duration of the test, up to 21 days. Earthworms did demonstrate an increase in weight during these tests.

EcoSigma®

Integrated Solutions in Environmental Management Ltda.

Leadership Team

Our objective is not only to produce a first class product but also to communicate with consumers and industry organisations, parliamentary commissions, NGOs and government agencies with the aim of explaining the merits of oxo-biodegradable plastic and d_2w in particular.

Nirj Deva DL, MEP

Chairman of Symphony Environmental

Member of the European Parliament. Nirj is also Advisor to the Prime Minister of Sri Lanka and Deputy Lord Lieutenant to HM Queen Elizabeth II.

Michael Stephen

Deputy Chairman of Symphony Environmental Technologies PLC and Chairman of Symphony Environmental Ltd.

Barrister and Former Member of the UK Parliament. Member of the Environment Committee of the Parliament.

Michael Laurier

Chief Executive Officer of Symphony Environmental Ltd.

Michael's career began with his long established family packaging business. Brentwood Sack and Bag Co. Limited.

Bob Wigley

Non-Executive Director of Symphony Environmental Technologies PLC.

Special Advisor to the CEO of Symphony. He was Chairman of Merrill Lynch EMEA and Ambassador for UK Business for the Prime Minister.

Symphony Marketing Team

Natalie Jenkins
Head of Marketing

Gokhan Demirci
Graphic Designer

Paula Hickford
Marketing Executive

Ben Stanford
Media and Communications Executive

@ Symphony Environmental Technologies

Access to Overseas Businesses

As well as providing guidance, market research and customer insight. H M Government has hosted receptions for Symphony at British Embassies/High Commission in Mexico, India and Russia. In addition to the above, they also provide access to overseas buyers.

HM Government

PRBN

The Responsible Business Map identifies the key issues businesses need to address to achieve long-term financial value, enabling both society and the planet to thrive.

BUSINESS IN THE COMMUNITY

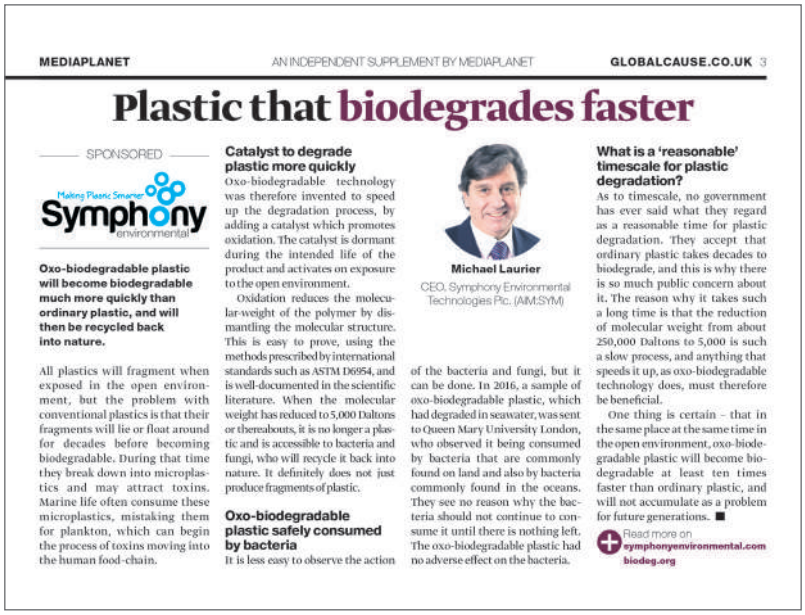
The Prince's Responsible Business Network

HRH THE PRINCE OF WALES ROYAL FOUNDING PATRON

New Scientist: Future of Plastic

Supplement 'Future of Plastic' 9th June 2018

An article by Michael Laurier appeared in the New Scientist weekly magazine (Issue date 9th June 2018). The article was in a prominent position inside the special supplement entitled 'Future of Plastic'



The content inside the supplement included contributions from Sir David Attenborough, The Ellen MacArthur Foundation, the Plastic Pollution Coalition; UNEP and Dr. Lisa Emelia Svensson, Global Director for Ocean at the UN Environment Programme; UNESCO; the Ocean Foundation's Mark Spalding, President of Ocean Foundation and the Marine Conservation Society. The Special Supplement was distributed s follows:

Print Distribution:

- **New Scientist:** Stitched within the centrefold of every edition from 7th to 14th June 2018 to coincide with World Oceans Day
- **4-8 June** International Symposium on the Effects of Climate Change on the World's Oceans (Washington, D.C., United States)
- **3 - 6 July** Executive Council of the Intergovernmental Oceanographic Commission (Paris, France)
- **10-11 September** International scientific conference on Ocean, Climate and Biodiversity (Paris, France)
- **October 29 - October 30** Our Ocean 2018 Conference (Bali, Indonesia)

Social Media Distribution included the following:

UNESCO - en.unesco.org
Facebook: 639K likes - Twitter: 3.03M followers

The Ellen MacArthur Foundation
www.ellenmacarthurfoundation.org
Facebook: 18,035 likes - Twitter: 363,000 followers

The Plastic Pollution Coalition
www.plasticpollutioncoalition.org
Facebook: 190,088 likes - Twitter: 34,000 followers

UN Environment Programme - www.unenvironment.org
Facebook: 641,375 likes - Twitter: 726,000 followers

The Ocean Foundation - www.oceanfdn.org
Facebook: 11,379 likes - Twitter: 42,000 followers

Marine Conservation Society - www.mcsuk.org
Facebook: 118,086 likes - Twitter: 32,300 followers

The World's Top Scientists

The OPA is a not-for-profit organisation, registered with the European Parliament (186930701-1291-26)

In September 2017, the OPA published a report entitled "Rethinking the future of plastics" **http://www.biodeg.org/wp-content/uploads/2018/07/rethinking-plastics-march-2018-21-5-18-no-endorsements.pdf** as part of an overall strategy to improve the environment, which is fully consistent with the principles of **"Reduce" "Re-use" "Redesign" and "Recycle."** In addition to this comprehensive report, the OPA has recently issued a summary of the document inviting representatives of Governments, NGOs, Scientists and companies who support the technology to endorse the document. They intend to get as many signatories as possible. To date four of the worlds leading scientists in the field of Oxo-biodegradable technology have endorsed the document along with other leading people and organisations.

Prof. Emo Chiellini
Professor of Chemistry, University of Pisa, Italy

"As Professor of Chemistry at the University of Pisa (Italy) and Chairman of the LMPE Srl Laboratory of Lucca (Italy) I have studied oxo-biodegradable plastics technology for more than thirty years.

I have read the attached document published by the Oxo-biodegradable Plastics Association and I agree with it. I have no doubt that oxo-biodegradable technology can mitigate the environmental burden of plastics in the open environment."

Prof. Telmo Ojeda
Environmental Sciences, Instituto Federal de Educação, Ciência e Tecnologia, Campus Porto Alegre – RS - Brazil

I endorse all statements made by the OPA in this document.

I have been testing oxo-biodegradable products (Symphony) since my doctorate in biodegradability of polymer materials in 2003. Since then, I have never encountered any negative results for these products. I consider the oxo-bio products as an adequate environmental solution for littering, associated with excellent results for the life cycle assessment and at low additional cost.

Prof. Jacques Lemaire
Research Branch at CNEP

Dr. Dominique Fromageot
Scientific Advisor, Research Branch at CNEP

Luis Manuel Guerra
President - Institute of Assistance in Ecological Research, AC (INAINE)

Consumer Survey

UK - 16th April 2018

Symphony commissioned YouGov in the UK to carry out a survey designed to understand the public's awareness, knowledge and desire to take action against plastic pollution which is a global issue.

88%

would support the UK government legislating to make the use of oxo-biodegradable plastics a legal requirement, as other governments have done

90%

of UK adults would support treating everyday plastic items (e.g. shopping bags, plastic packaging, etc.) with oxo-biodegradable technology

86%

of UK adults would be happy to use oxo-biodegradable plastic instead of their usual plastic

The survey was designed to understand the public's awareness, knowledge and desire to take action against plastic litter - which is a global issue. 2,170 people were surveyed across all demographics) The results were published on Monday 16th April 2018.

Mexico - 31st May 2018

The survey was designed to find out what people in Mexico know about oxo-biodegradable plastic technology and how they feel about replacing conventional plastic items with oxo-biodegradable plastic. The poll surveyed a representative sample of 1,000 people across urban Mexico. The results were as follows:

95%

of urban Mexican adults would be happy to use oxo-biodegradable plastic instead of their usual plastic

97%

of urban Mexican adults would support treating everyday plastic items (e.g. shopping bags, plastic packaging, etc.) with oxo-biodegradable technology.

98%

of urban Mexican adults would support the Mexican government legislating to make the use of oxo-biodegradable plastics a legal requirement, as other governments have done.

d_2w oxo-biodegradable plastic (OBP) is fully biodegradable and should be considered as part of an overall strategy to improve the environment.

It is fully consistent with the principles of the circular economy and sustainability and fits perfectly with the idea of products and materials being used and re-used for as long as possible.

OBP represents an insurance policy - it promises that if plastic litter escapes into the open environment, it will degrade and biodegrade until there is nothing left, no toxic residues and no microplastics.

A scientifically proven technology

www.symphonyenvironmental.com

info@d2w.net

@ Symphony Environmental Technologies