August 2025

d2w® 2025 Report

A Scientifically Proven Biodegradable Plastic Technology

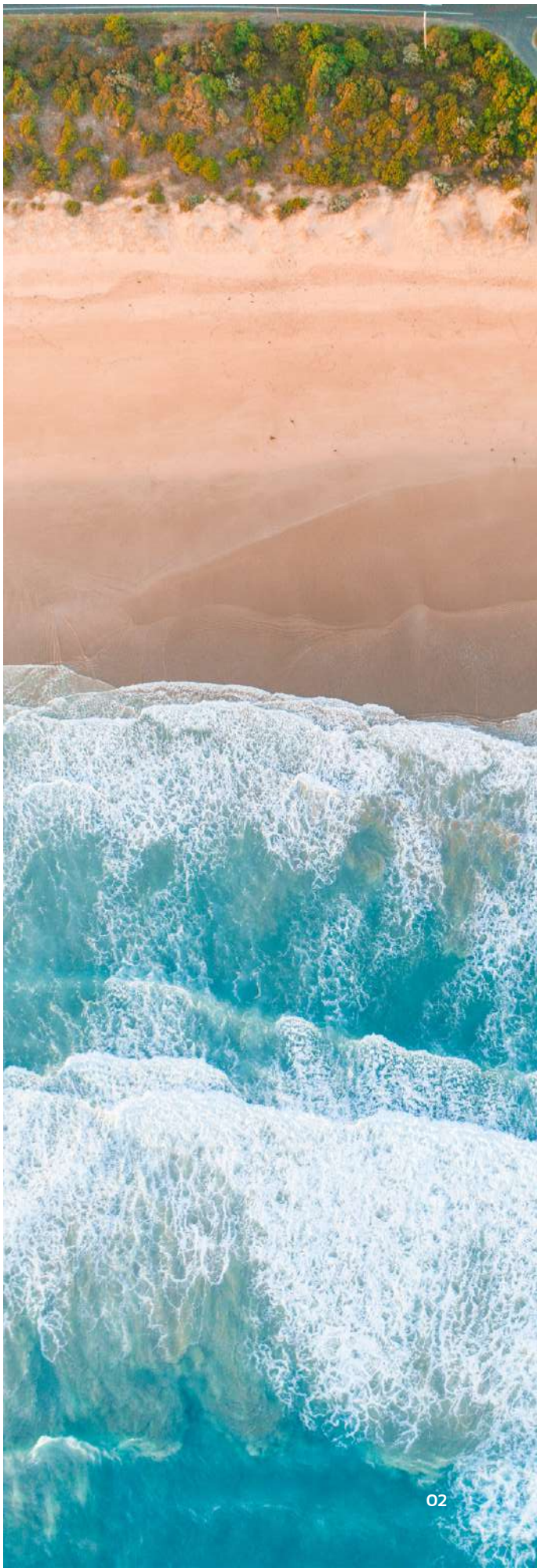
Helping to resolve the issue of plastic pollution

Making Plastic Smarter

Symphony environmental

30 YEARS

Contents



bsi ISO 9001 Quality Management Systems CERTIFIED ISO 14001 Environmental Management CERTIFIED

About us

" World leader in the development and marketing of masterbatches to make plastic products smarter, safer, and more sustainable."

With 30 years' experience in helping our customers to improve their products to the highest environmental standards.

Free technical and marketing support to plastics manufacturers and their customers - adding value to every participant in the chain - right through to the end user.

A Public Listed Company with shares listed on the London Stock Exchange.

The London Stock Exchange Green Badge
This badge helps investors identify businesses that are making substantial contributions to environmental objectives.
Symbol: LON:SYM

What is d_2w?

d_2w is a masterbatch (added at only 1%) which converts ordinary plastic at the end of its useful life, in the presence of oxygen, into a material with a different molecular structure. It is then no longer a plastic and is instead a waxy material which is biodegradable i.e. can be used as a food source by bacteria and fungi in the open environment. The process ends leaving just water, CO_2 and biomass.

- ✓ Looks and feels like conventional plastic
- ✓ Meets the industry standards
- ✓ Can be made in existing plastics factories
- ✓ No need for specialist machinery or to re-train staff
- ✓ Can be used for all the same purposes as conventional plastic
- ✓ Is safe for food contact
- ✓ Can be recycled and made with recyclate
- ✓ Little or no extra cost

d_2w biodegradable plastic technology helps to resolve the issue of microplastics pollution

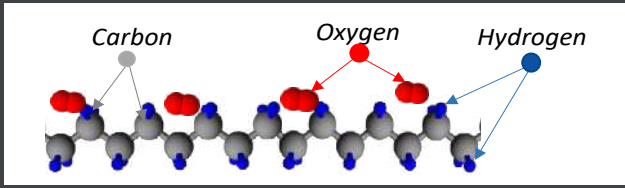
By converting the plastic into biodegradable materials if it gets in to the open environment.

- ✓ Meets standards ASTM D6954, SASO 2879, UAE 5009:2009, AFNOR, AC T51-808 and Mexican Standard NMXE-E-288-NYCE
- ✓ Remains stable in storage conditions for the agreed shelf life
- ✓ Is a drop-in technology

How does it work?

The process is initiated in normal environmental conditions when exposed to oxygen and will be accelerated by exposure to UV light and/or increased temperature. No special conditions are necessary and degradation will continue in the dark - no need to take to a composting facility.

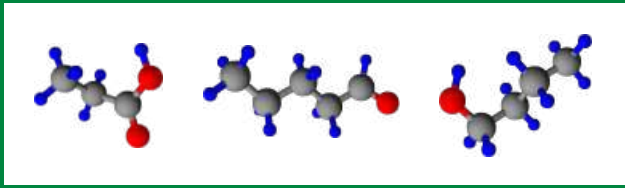
Stage 1



The catalytic effect of the d_2w masterbatch quickly breaks the long molecular chains and generates free radicals.

The polymers then undergo free radical oxidation and their molecular - weight is reduced.

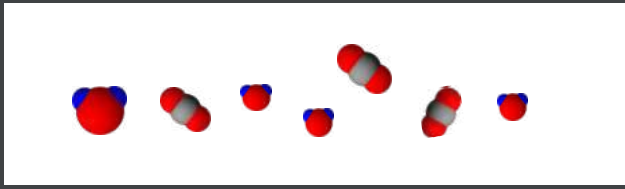
Stage 2



The free radicals combined with the available oxygen atoms create hydro-peroxides.

The material is now hydrophilic and biodegradable.

Stage 3



The resulting oligomers are now available for consumption by microorganisms.

The biodegradation process creates harmless residues (CO_2, H_2O and humus).

Professor Ignacy Jakubowicz of Sweden said of the technology

"The degradation process is not only a fragmentation but 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 bio assimilated."

Watch the process happen here
Intelligent Packaging made with d_2w technology - YouTube

How does it compare to plastic marketed as "compostable" ?

d_2w Biodegradable	vs	Marketed as Compostable
Organic polymer(s) plus a harmless pro-degradant catalyst	**MADE FROM**	Food crops like sugar cane and cornstarch
ASTM D6954 and BS8472 **3 Tier Testing for:** • Degradability • Biodegradability • Non-eco toxicity	**TESTED ACCORDING TO INTERNATIONAL STANDARDS**	ASTM D6400 and EN13432 **Test requirements:** Conversion of 90% of the material into CO_2 gas in 180 days (not into compost).
LOW	**PRODUCTION COSTS**	HIGH
Oxygen	**ACTIVATION**	Moisture and Heat
In the open environment on land or sea – The Catalyst will react with Oxygen to break the molecular bonds to the point where it is no longer a plastic and can be used as a food source by bacteria and fungi, in the same way as nature's wastes	**WHERE?**	Requires collection and transportation to Industrial Composting facilities, where high temperature and moisture can be achieved.
Can be recycled with regular plastic	**RECYCLING**	Cannot be recycled with regular plastic
Low CO_2 emissions	**FINAL STAGE**	High CO_2 emission
Leaves nothing behind – no toxic residues and no microplastics just CO_2, water and humus Minimal impact in landfill	**ENVIRONMENTAL IMPACT?**	Can create microplastics and persist in the environment if littered. Emits methane in landfill

Products are recycled back into nature

Products persist and accumulate in the environment or are wasted by rapid conversion to CO_2

Glossary:

1. **Catalyst:** Substance which speeds up a chemical reaction
2. **Microplastics:** Small pieces of plastic no bigger than 5mm at their longest dimension
3. **Oxidation:** Chemical change caused by the addition of oxygen

Microplastics

d_2w biodegradable plastics consist of a conventional plastic containing a masterbatch.

The masterbatches cause the molecular chains to be dismantled by oxidation so that the material is no longer a plastic and becomes biodegradable. Light and heat will accelerate the process, but it will continue even in dark, cold, conditions. Moisture is not necessary for oxidation and does not prevent it.

- ✓ Ordinary plastic and d_2w biodegradable plastic lose their strength and fall apart at about the same time when exposed sunlight, but fragments of ordinary plastic have a molecular weight which is much too high for biodegradation
- ✓ In summary, if plastic products are made with a d_2w biodegradable masterbatch and get into the open environment intentionally or by accident, the molecular weight of the plastic will reduce much more quickly, and it will become a waxy substance which is no longer a plastic. It will then have become a source of nutrition for naturally occurring microorganisms
- ✓ The European Chemicals Agency (ECH) were asked to study this type of plastic in December 2017. They made a Call for Evidence, and they advised after 10 months that they were not convinced it creates microplastics. We agree with them and have seen no evidence that microplastics from this type of plastic have ever been found in the environment.

Consumer Goods Forum

The Consumer Goods Forum have 10 Golden Design Rules for optimal plastic design, production and recycling.

The second rule is to remove problematic elements from plastic packaging.

Oxo-degradable plastics fragment into microplastics, which contribute to plastic pollution and are therefore considered problematic plastics.

The Consumer Goods FORUM

Rule 2 on page 30 makes it clear that it applies to oxo-degradable plastics, which create microplastics, but not to plastics such as d_2w which biodegrade by oxidative and cell-mediated phenomena either simultaneously or successively.

Microplastics Position Paper

Professional Testimonials from leading organisations

https://www.biodeg.org/subjects-of-interests/microplatics

Professional Testimonial on Scientific Data 2024-2025

https://www.biodeg.org/subjects-of-interests/microplatics/

Lambton College, lambton *Manufacturing Innovation Centre - Degradation of plastics, and microplastics formation*		Lambton College
Jordi Labs a RQM+ Company		Jordi Labs AN RQM+ COMPANY
Instituto Federal Rio Grande do Sul *Campus Porto Alegre* *Professor Telmo Ojeda Statement 2025*		INSTITUTO FEDERAL DE EDUCAÇÃO, CIÊNCIA E TECNOLOGIA Rio Grande do Sul
Fernando Eovfdio da Rosa Figueiredo *Position Regarding Microplastics*		gov.br *Documento assinado digitalmente* **FERNANDO EOVFDIO DA ROSA FIGUEIREDO** *Data: 20/02/2025*
Mr. Claudio Jose Jorge, President of FUNVERDE, *endorses the POSITION DOCUMENT ON POLYETHYLENE (PE) AND POLYPROPYLENE (PP) MIICROPLASTICS.*		FUNVERDE www.funverde.org.br
Dr Hector Ricardo Lopez Gonzales, Liason Director. **Dr Enrique Saldivar Guerrero, Senior Research.** **Dr Ruben Saldivar Guerra, Associate Researcher.**		CIQA CENTRO DE INVESTIGACIÓN EN QUÍMICA APLICADA MEXICO
Symphony Environmental Position Paper on Microplastics *February 2025 - FROM POLYETHYLENE (PE) AND POLYPROPYLENE (PP)*		Making Plastic Smarter Symphony environmental 30 YEARS

Recycling

d_2w biodegradable plastic can be recycled with regular plastic

Scientific studies prove that d_2w biodegradable plastic can be safely recycled without separation.

Recycling of plastics is challenging due to the difficulty of separating different polymer types, contamination of materials, and the low value of certain plastics. Additionally, the processes required for collection, transportation, sorting, and reprocessing make it costly.

As a result, most plastics are not recycled at all or are recycled into mixed plastic for low-grade uses, rather than high-quality products. d_2w biodegradable plastic packaging can be safely recycled without separation and can also be made from recycled materials.

For a detailed review of this subject see: **https://www.biodeg.org/subjects-of-interest/recycling-2/**

Recycling Studies

To view the full report - click on the related article

This report evaluated the recyclability of HDPE bottles made with Symphony's d_2w according to the HDPE-A-01 test protocol devised by the Association of Plastics Recyclers of the United States (APR). This report concluded that no disconformities were detected in any of the samples and all were within the APR benchmarks.

This study proved that where UV stabilisers are included (as is always the case with products for outdoor or long-term use) there will be no negative effects from the inclusion of d_2w biodegradable recyclate.

REPORT 1

This study proved that where UV stabilisers are included (as is always the case with products for outdoor use) there will be no negative effects from the inclusion of d_2w biodegradable recyclate in long-life products.

REPORT 2

This report confirmed that the presence of d_2w biodegradable masterbatch in polyethylene shopping bags is unlikely to prevent compliance of the bags with European Standard 13430-2004 'packaging – Requirement for packaging recoverable by material recycling'.

"More than 500,000 tonnes of d_2w biodegradable plastic have been successfully recycled in the last 5 years!"

International Standards

American Standard ASTM D6954
"Standard Guide for Plastics that Degrade in the Environment by a Combination of Oxidation and Biodegradation" as to which see

https://www.biodeg.org/wp-content/uploads/2021/02/Swift-evidence-to-BEIS.pdf

RENEWED

ASTM D6954 - renewed in January 2024 for another 5 years

Variants of this standard have also been adopted in other countries (see below).

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

French AFNOR Accord T51-808

Plastics – Assessment of polyolefin materials in the form of films. Symphony's d_2w® has been proved to comply with this Accord by CNEP (Centre Nationale d'Evaluation de Photoprotection) which is an independent laboratory at the University Blaise Pascal in France and also by Eurofins Laboratories in Spain.

The standards below were adopted following extensive due diligence by the governments concerned, and based on ASTM 6954.

UAE No 5009/2009
The Emirates Authority for Standards and Metrology (ESMA) has developed, implemented and enforced this Standard as from October 26th, 2009 for Plastic Bags and other Disposable Plastic Objects.

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

https://saso.gov.sa/en/pages/default.aspx

Mexican Standard NMXE-E-288-NYCE
This is a technical standard for validating Symphony's d_2w biodegradable technology.

Other Standards

Armenia
GOST 33747-2-16

Belarus
GOST 33747-2-16

Brazil
ABNT 365:OA

Cameroon
APNC 1747

Dominican Republic
NORDOM 896

Equador
644:2013

Jamaica
JS 355:2022

Jordan
2004-2-12

Kazakhstan
GOST 33747-2-16

Kyrgystan
GOST 33747-2-16

Malta
TS 800-207 (abiotic)

Malaysia
2073-2008

Phillipines
PNS 2104-2-1

Russia
GOST 33747-2-16

Sweden
SPCR 141-2010

Tajikstan
GOST 33747-2-16

Uzbekistan
GOST 33747-2-16

Vietnam
07/2012 BT-BTMNT

ASTM D6954

The ASTM D6954 standard for testing plastics that degrade and biodegrade in the enviornment involves three tiers.

Tier 1 - Abiotic degradation
Tier 2 - Biotic degradaton
Tier 3 - Eco-toxicity

Results of Tier 1 and Tier 2 Testing by Intertek - Abiotic and Biotic Degradation

Analysis of PE film

Molecular Weight (Mw) ASTM 6954 Tier 1	Mw of 327,000 to 2,200 Daltons (Da) with initial thickness of 50 microns
Biodegradation Extent ASTM 6954 Tier 2	Zero % to 94.55%
Microplastics Analysis ISO 24187: 2023 (E)	One particle measuring 8.755 microns and Mw below 2,200 Daltons
50 grams of biomass (Material after Tier 2 Biodegradation)	One single particle of 3.32e-10 grams (0.0000000003316724224 grams
Final Conclusion	One particle found that is **NOT** a plastic material

ZERO Microplastics

Analysis of PP film

Molecular Weight (Mw) ASTM 6954 Tier 1	Mw of 282,000 Daltons (Da) to 4900 (Da) with initial thickness of 50 microns
Biodegradation Extent ASTM 6954 Tier 2	Zero % to 92.76%
Microplastics Analysis ISO 24187: 2023 (E)	Two particles measuring each 8.649 µm, and Mw below 4,900 Da
50 grams of biomass (Material after Tier 2 Biodegradation)	Two particles each at 3.32e-10 grams (0.0000000003316724224 grams)
Final Conclusion	Two particles found that are **NOT** plastic material

ZERO Microplastics

ASTM D6954

Results of Tier 3 Eco-toxicity Testing by Intertek

The following are the latest results of the Eco-toxicity testing for products made with d_2w.

Eco-toxicity testing assesses the ecological impact of the degradation products on the environment ensuring they are environmentally benign.

These tests help evaluate the environmental degradation of plastics through oxidation and biodegradation processes. The results below were obtained for d_2w testing for exo-toxicity.

Eco-Toxicity Test, Barley Plant

The above study was conducted at 25°C ±4 °C temperature, 65% ±10% humidity and with 16 hours of light. The above results showed that the PE with 1% w/w d_2w showed no negative effect on the plant growth and plant germination.

Control

With d_2w

Eco-toxicity Earth Worms - OECD207

Average weight of earthworms before and after study				
INITIAL				
Particulars	**25%**	**50%**	**25%**	**50%**
Control (g)	0.3215	0.3151	0.3363	0.3287
PE with 1% w/w d_2w Sample (g)	0.3318	0.3524	0.3652	0.4552
FINAL				
Particulars	**25%**	**50%**	**25%**	**50%**
Control (g)	0.3366	0.3325	0.3652	0.3455
PE with 1% w/w d_2w Sample (g)	0.3420	0.3674	0.3895	0.4685

Zero mortality, plus increase in earthworm weight

The mortality rate was found to be 0%.

The average weight of the earthworms increased compared to the control.

Food contact

All grades of d_2w biodegradable plastic are compliant with the following food-contact regulations:

- ✓ **European Union** Regulation (10/2011)
- ✓ **US** - Regulations (21 CFR 175.300, 177:1520, and 178:2010).
- ✓ **Canada** - CFIA Regulation.
- ✓ **Brazil** - All components of d_2w masterbatches are on the 'positive' lists [allowing contact with food] of Resolutions 105 of 19 May 1999 and RDC 17 of 17 March 2008 RDC 326 12/2019, updated and incorporating MERCOSUR Regulation GMC / RES. No. 39/19.

Packaging meat products

ADIV Technical Feasibility Study:
This study demonstrated that d_2w technology can be safely used for the packaging of meat products.

The d_2w plastic packaging was subjected to alimentary (SGS), degradability and non-toxicity tests (OECD 208).

The trays are recyclable if they can be collected, but if they become litter in the open environment.

Climate Change

Studies have demonstrated that one of the benefits of d_2w® biodegradable technology is that the carbon content of the plastic is ultimately recycled back into the ecosystem by living organisms.

Academics agree that substitutes could be vastly worse than plastic. A 40-strong group of academics from Heriot-Watt University in Scotland have said that replacing plastics with other packaging such as glass or metal could double global energy consumption, and could also lead to a tripling of greenhouse gas emissions.

– *BBC News Scotland 20-11-2018.*

Conventional plastic breaks up into fragments under the influence of weathering, and is responsible for the microplastics found in the environment today. They can take many decades to become biodegradable.

Paper and cardboard packaging requires more than four times the energy to manufacture, as well as using more land and water than plastic. It is also heavier and bulkier, which means transportation costs are higher. Manufacturing paper uses land, water, fertiliser and energy resources. Paper is not the best material for protecting food from contamination, especially when wet.

See **https://www.biodeg.org/subjects-of-interest/paper-bags/**

"Compostable" plastics require industrial composting facilities and are required by EN13432 and ASTMD6400 to convert 90% into CO_2 in 180 days. **They therefore contribute to climate-change but do not convert into compost or anything useful for the soil.**

See **https://www.biodeg.org/subjects-of-interest/composting/**

The Alternatives

Bag type	Avg CO_2 equivalent per 1 kg of bags - weight (g)	CO_2 equivalent per 1 kg of bags	CO_2 equivalent per bag (kg)
d_2w vest carrier	8.27	1.750	0.0145
Starch based "compostable" 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
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

Carbon value and footprint

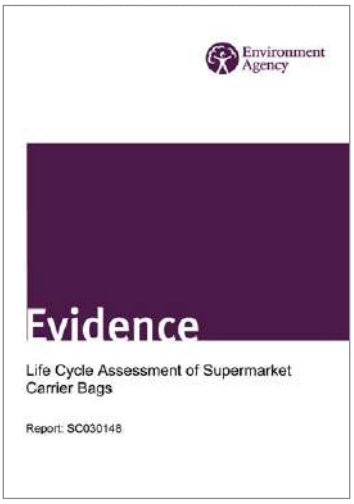
d_2w® has the most beneficial carbon performance of any biodegradable packaging.

Polyethylene used for plastic packaging with d_2w® masterbatch is a by-product of oil and gas, which are extracted for fuels, whether plastics are made or not. The carbon content of hydrocarbons will typically escape to the atmosphere after combustion, but when a d_2w® plastic biodegrades, most of the carbon will be sequestered by plants and other living organisms and is thus recycled back into the ecosystem. (See AFNOR Accord 51-808 ADP/ATP methodology – consumption of degraded material by living organisms.

Life Cycle Assessment (LCA)

Intertek Expert Services - Main features:

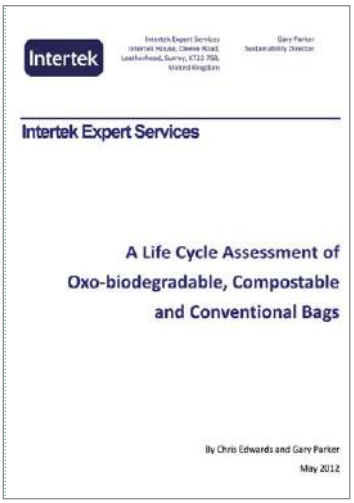
Carbon footprint of plastic bags



This study for the UK Environment Agency by Intertek 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.' The message therefore is **"don't ban plastic bags – upgrade them with d_2w technology."**

Click on the image to the left to access the Intertek report



- ✓ Following the study for the Environment Agency, d_2w® was also 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, minimise the transportation and energy input needed for recycling, and make them d_2w biodegradable.
- ✓ d_2w biodegradable plastic can be recycled with conventional plastic as part of a mixed, post-consumer waste stream without compromising the recycling process, but bio-based "compostable" plastic cannot.
- ✓ The bio-based bag had the worst performance in 10 of the 11 environmental impact categories.

Click on the image to the left to access the LCA report

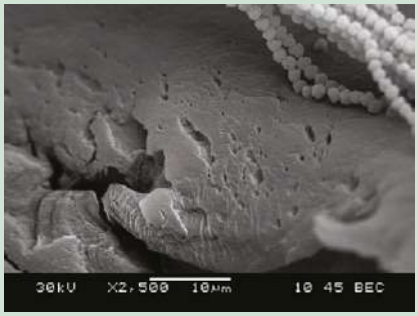
"The d_2w biodegradable bag performed 75% better than the conventional bag when the litter metric is included."

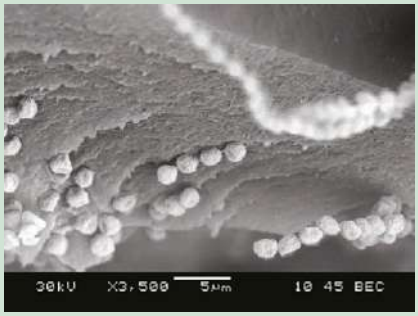
Test Reports and Studies

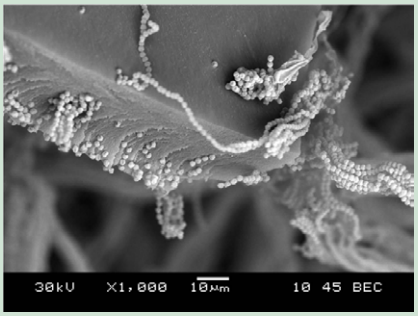
This important study by Queen Mary University, London (QMUL): adds weight to the four decades of scientific research which proves that plastic products containing a d_2w® type masterbatch will become biodegradable much more quickly than ordinary plastic if they get into the open environment at the end of their useful life, and will then be biodegraded by bacteria commonly found in soil and in the marine environment, with no toxicity.

"The use of a prodegradant catalyst such as d_2w® caused a rapid reduction in molecular weight. d_2w biodegradable plastic demonstrated up to 90 times more biodegradation than ordinary plastic when aged for the same period of time."

Bacterial activity is clearly seen on the plastic. See the report **here**.







The study clearly showed that d_2w® plastics are biodegradable and non-toxic on land and in the ocean.

Photographs taken with an electron-microscope show pitting by biotic degradation. The holes in the plastic are roughly the same shape as a single bacterium (1µm).

Intertek has carried out a detailed assessment of samples of polyethylene (PE) and polypropylene (PP) that were subjected to testing by them according to ASTM D6954 Protocol - an international standard for evaluating the environmental degradation of plastics through a combination of oxidation and biodegradation.

See pages 11 and 12 above

This is an excellent result, and shows that plastics upgraded with d_2w technology are very useful in reducing microplastics and reducing the prevalence and accumulation of plastics in the environment.

The Oceans - Oxomar Study

A substantial amount of work has been done over the last 10 years studying the effects of d_2w biodegradable plastics in the aquatic environment (both in salt and fresh water).

Oxomar (First Ever European Study)

A detailed study on plastics in the marine environment has been carried out with the support of the French Government at l'Observatoire Oceanologique de Banyuls sur mer (Lomic). d_2w biodegradable plastic technology has also been studied for many years in France at CNEP (Centre National d'Evaluation de Photoprotection), and the Institut De Chemie de Clermond Ferrand (University Blaise Pascal). **https://anr.fr/Project-ANR-16-CE34-0007**

The study report from Oxomar concluded that plastic made with Symphony's d_2w biodegradable technology will biodegrade in seawater significantly more efficiently than conventional plastic **https://www.biodeg.org/wp-content/uploads/2021/07/Final-report-OXOMAR-10032021.pdf**

"A study sponsored by the French Government found that "plastic made with Symphony's d_2w biodegradable technology will biodegrade in seawater significantly more efficiently than conventional plastic."

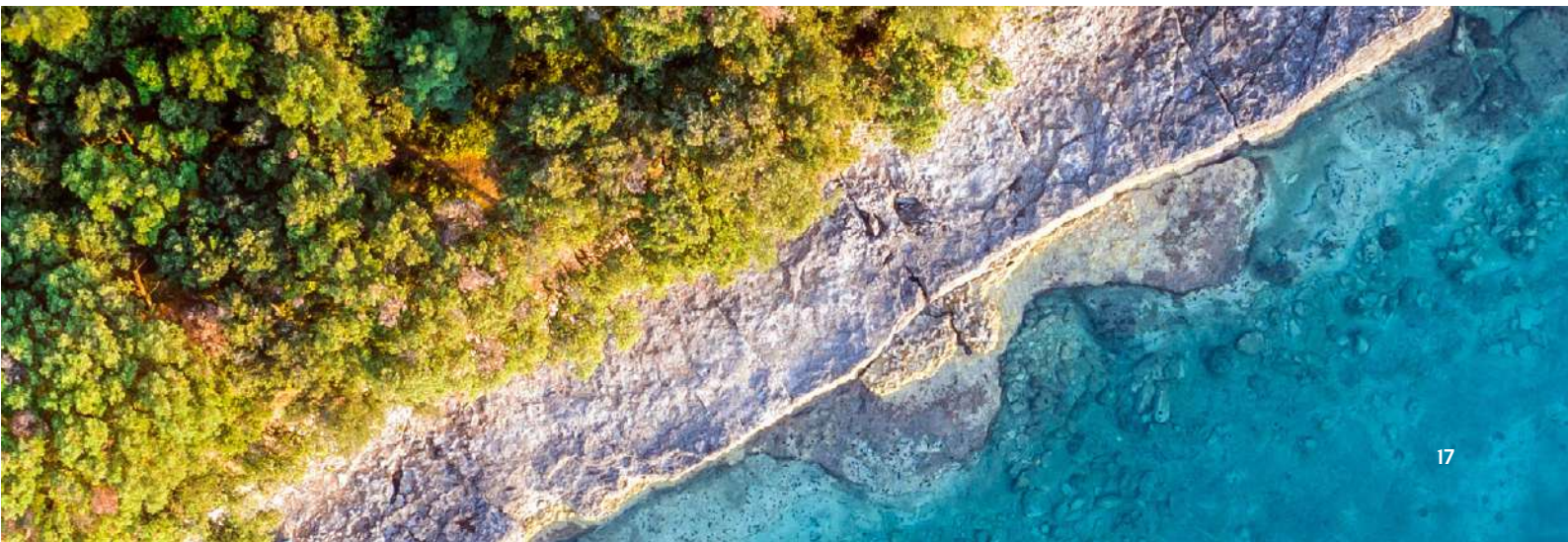
Purpose of the OXOMAR project:

1. To investigate whether the catalysed polyolefin will fully biodegrade in a reasonable time in the marine environment
2. To investigate whether biodegraded polyolefin or its by-products create any toxicity in the marine environment
3. To provide solid scientific data on the future of catalysed polyolefins at sea

The participants included:

- 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)
- Symphony Environmental Ltd (Expertise in d_2w biodegradable technology)

This study of d_2w biodegradable plastic in the marine environment was completed in 2021. This 3 year study, led by Dr Jean-Francois Ghiglione at the LOMIC Laboratory, and was a Euro 750,000 project to create new scientific knowledge.



The Oceans - Oxomar Study cont...

Oxomar scientists have published several papers, during the work, including the following:

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

https://www.biodeg.org/wp-content/uploads/2021/07/Final-report-OXOMAR-10032021.pdf

Explanation to the Oxomar Report - (See link above)

The Oxomar scientists have said (on page 3 of the above report) that 'The lack of knowledge about this product has led to recent measures banning the marketing of oxo-degradable plastic (Oxo) in Europe, being defined by the CEN in TR15351 as 'degradation identified as resulting from oxidative cleavage of macromolecules'.

Our objective was to provide solid scientific data on the fate of plastic defined by the CEN in TR15351 as 'degradation resulting from oxidative and cell-mediated phenomena, either simultaneously or successively'. The basis of the project rested on 3 axes to assess (1) abiotic degradation, (2) biodegradation and (3) possible toxicity when thrown into the sea.

On page 4 they say 'we tested the biodegradability of the various d_2w films using either a pure strain known to degrade PE (Rhodococcus rhodochrous), or a complex bacterial inoculum from the marine environment. Biodegradatoin has been characterized from the point of view of:

Physics: Atomic Force Microscopy (AFM)

Chemistry: Nuclear magnetic resonance (1H NMR), High resolution Mass Spectrometry coupled with Liquid Chromatography (LC-HRMS) and Fourier Transform Infrared Spectroscopy (FTIR)

Microbiology: Confocal and epifluoresence microscopy, flow cytometry, high throughput DNA sequencing, respirometry (O2 and CO2)

On P11 they say 'We have obtained congruent results from our multidisciplinary approach that clearly shows that d_2w type biodegradable plastics biodegrade in seawater and do so with a significantly higher efficiency than conventional plastics. The oxidation level obtained due to the d_2w prodegradant catalyst was found to be of crucial importance in the degradation process. Out of the that six-formulations tested, the Mn/Fe pro-oxidant was the most efficient, with no toxic effects under our experimental conditions.

Biodegradability was demonstrated either by using the culture bacteria Rhodococcus rhodochrous or by a complex natural marine community of microorganisms. The project ended with significant advances in the understanding of the biodegradation and non-toxicity of d_2w-type biodegradable plastics in the marine environment.

We confirm that accelerated artificial aging (UV, temperature) which was perfectly mastered in this project, is a tool of choice which is particularly well suited to the study of the fate these plastics in the marine environment (task 1). Accelerated artificial aging does not invalidate the results'.

"Accelerated artificial aging does not invalidate the results."

Bandol Study - Natural ageing in sea water

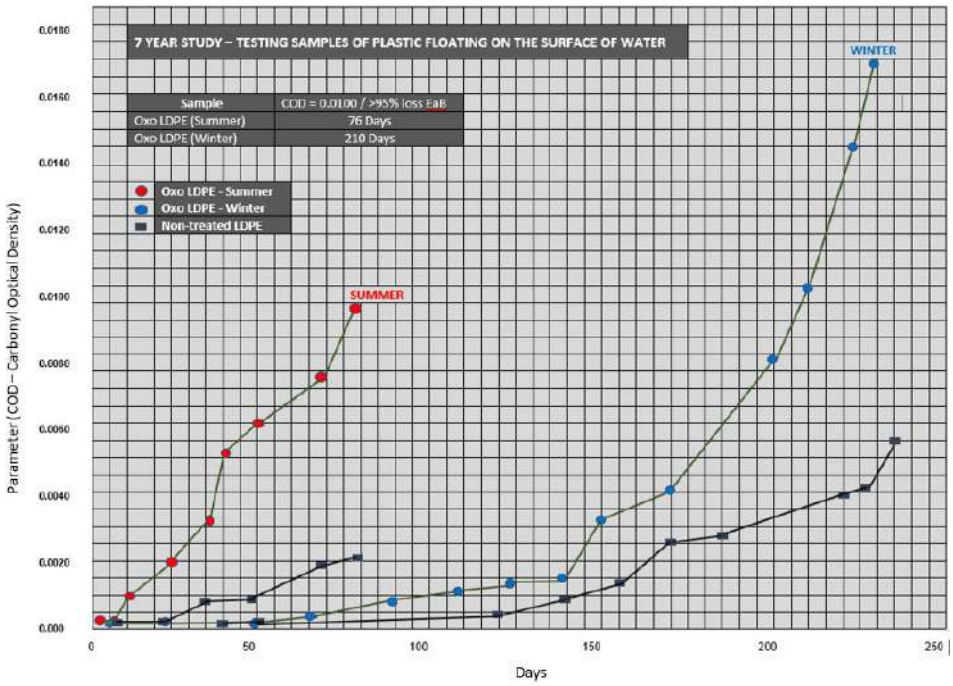
Station d'essais de Vieillissement Naturel de Bandol on the Mediterranean coast of France.

Testing shows that d_2w biodegradable plastic will degrade to low molecular-weight materials under natural conditions floating on water.

7 Year Study

FTIR analysis demonstrated the capability of LDPE film to degrade quickly in marine environments when containing 1% d_2w® additive.

A weathering test on the sea water surface was performed to show the behaviour of samples containing d_2w® masterbatch in aquatic environments (films and bags accidentally released into oceans, rivers or lakes), which has provided positive results.



"FTIR analysis demonstrated the capability of LDPE film to degrade quickly in marine environments when containing 1% d_2w® additive."

d_2w Biodegradable Plastic is endocrine safe

A new scientific study has demonstrated that biodegradable oligomers, created by the oxidation of polymer containing Symphony's d_2w biodegradable masterbatch have no effect on the endocrine system.

d_2w biodegradable film was exposed to accelerated ageing and oligomers were extracted into water by Institut De Chimie de lermont-Ferrand (ICCF) in France. Polymer oxidation was confirmed by FT-IR spectroscopy; and dissolved oligomer content was confirmed by nuclear magnetic resonance (NMR) spectroscopy and mass spectrometry (MS).

The resulting solution of dissolved organic carbon was submitted to Laboratoire Watchfrog in France for investigation of any endocrine disruption effects, including thyroid, estrogenic and adrogenic effects.

No effects were observed up to the maximum concentration of 100 mg C-L-1 which is substantially higher than is likely to be experienced by any creature in nature.

Other independent studies

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

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 and biodegradation and to prove non-toxicity of polyethylene films containing d_2w biodegradable masterbatch, according to the US standard ASTM D6954. This Standard establishes a procedure in which the samples are subjected to consecutive steps of oxidation, biodegradation and ecotoxicity assessment.

The study concluded that the presence of the biodegradable masterbatch in polyethylene samples increased the biodegradability, as evidenced by their higher mineralisation compared to conventional polyethylene. None of the samples liberated metals at higher levels than those permitted. Also, biodegradation of these plastics did not generate toxic metabolites affecting the rate of germination in plants.

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[3]Instituto de Ciencias Fisicas, Universidad Nacional Autónoma de Mexico, Cuernvaca, Morelos, México

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Colonization of Non-biodegradable and Biodegradable Plastics by Marine Microorganisms. Frontiers in Microbiology, 9.

Legislation for use of d_2w type biodegradable plastic

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

The governments of the following countries know that their citizens find plastic essential, and have therefore decided not to ban plastic, but instead have legislated to make it mandatory to use the d_2w type of biodegradable plastic*.

Legislation in favour of d_2w biodegradable plastic supports the local plastic manufacturing industries in the countries concerned, because the technology can be used with their existing machinery and workforce, securing the jobs and livelihoods of thousands of people worldwide, and allowing the population to continue to use plastic to protect their food and water from contamination without the associated environmental problem.

- Albania
- Brazil (part)
- Colombia
- Jordan
- Mexico (Jalisco)
- Pakistan
- Serbia (Parts)
- Saudi Arabia
- Somalia
- Togo
- UAE
- Yemen

*Plastics factories and brand owners cannot export to these countries unless their disposable plastic products contain an approved biodegradable technology such as d_2w.

European Union

Single-use Plastics Directive 2019/904

On 20th June 2025 Symphony Environmental Technologies Plc received confirmation as follows from the Environmental Protection Agency of the Republic of Ireland - a member-state of the European Union:

"Following a thorough review of the submitted documentation and relevant scientific studies, we can confirm that d_2w products do not fall within the scope of Directive (EU) 2019/904, which prohibits the use of certain plastic materials due to their contribution to microplastic pollution."

"The d_2w technology has been scientifically demonstrated to undergo full biodegradation without leaving behind persistent microplastics or toxic residues. This conclusion is supported by independent studies and aligns with the objectives of the Directive to reduce plastic pollution and promote sustainable alternatives."

"Furthermore, we have reviewed the Commission Notice (2021/C 216/01) published in the Official Journal of the European Union on 7 June 2021, which provides guidelines on the implementation of Directive (EU) 2019/904. Based on the evidence submitted, we are satisfied that d_2w products are not subject to the restrictions outlined in the Directive or its accompanying guidelines."

It is important to note that the scientific evidence submitted to the EPA of Ireland related to d_2w only, and their approval therefore relates only to d_2w and to no other biodegradable plastic.

This decision by the EPA of Ireland accords with written advice received by Symphony from Joshua Holmes KC, a specialist in EU law, that Symphony's d_2w biodegradable plastic is not subject to the Article 5 Prohibition.

Peru

It's official: The Government in Peru confirm that d_2w is not an oxo-degradable plastic, and does not generate microplastics.

Following legal action by Symphony's distributor in Peru, a clear distinction has been acknowledged, and it has been officially confirmed that d_2w biodegradable plastic technology does not leave microplastics behind.

A legal action against the Ministry of Production was heard before INDECOPI (Public National Institute for Free Competition and Protection of Intellectual Property) who resolved, and the Ministry admitted, that there is no bureaucratic barrier against d_2w-biodegradable technology, because the prohibition in the 2021 Decree regulating degradable plastic bags was against oxo-degradable plastic and not against d_2w biodegradable plastic.

United Arab Emirates

The UAE were concerned about the accumulation of plastic in their environment. They did not wish to ban plastic products which are very useful to their people, so they sent experts to investigate Symphony's d_2w biodegradable plastic technology.

They concluded that plastic made with this technology would safely biodegrade if it escaped into the open environment, and they legislated in 2019 to prohibit the manufacture or import of a wide range of plastic products unless made with a masterbatch technology tested for degradation, biodegradation, and non-toxicity in accordance with UAE Standard 5009/2009. Symphony's d_2w biodegradable plastic has been certified in accordance with that Standard.

Saudi Arabia

A law enforced as from 14 April 2017, made it mandatory for all plastic products and / or plastic packaging listed in the regulations to be made using an approved biodegradable masterbatch, whether they are made in Saudi Arabia or imported into that country.

Products made with polyethylene or polypropylene have to comply with the regulations and to contain masterbatch from a supplier authorised by the Saudi Arabian Government. Symphony Environmental Ltd was the first company to be awarded the SASO Quality mark and be granted a licence to supply masterbatch which complies with the regulations.

All factories producing the following specified products must demonstrate compliance with SASO rules which are being introduced and enforced in 3 phases. For more information click here.

Phase 1

Shopping bags, garbage bags, clothes bags, disposable sheet rolls (table covers), cups, forks, spoons and woven barley bags.

Phase 2

(TBA) Bubble wrap, postal bags, courier and security bags, mail order and magazine bags/ wraps, disposable tableware (plates, spoons etc.) flower wraps, stretch films for packaging, overwraps i.e. plastic wrapping for clothing and plastic covers used for secondary packaging, shrink wrap films, cling films, packaging cling films and food bags and packaging bags used for bread, nuts, sweets and all bakery items.

Phase 3

(TBA) Diaper wraps, plastic liners (used for cartons) personal care products (i.e. shoe covers, gloves, disposable personal care products), plastic bags used in soil remediation, agriculture, horticulture applications such as banana bags and mulch films, plastic bags used for seedlings, food packaging bags, woven plastic bags.

الهيئة السعودية للمواصفات والمقاييس و الجودة
Saudi Standards,Metrology and Quality Org.
SASO
قابل للتحلل
OXO-BIODEGRADABLE

Please visit
https://saso.gov.sa/en/pages/default.aspx
or **here** for more information.

Yemen

On 13th September 2023, the Republic of Yemen announced that it would be enforcing legislation mandating the use of d_2w technology. See https://www.youtube.com/watch?v=OG17MhWWP-Q

Manufacturers were informed by the Environment Authority that with immediate effect they will be allowed to produce only d_2w biodegradable plastic bags, and their operating licence will not be renewed if they are found to be non-compliant. The customs authorities will ensure that only d_2w biodegradable plastic bags are imported, and letters have been issued to commercial banks, shopping malls and other commercial enterprises warning them not to purchase or use non d_2w biodegradable plastic bags.

A team of inspectors will be deployed to ensure compliance, and they will be using Symphony's d_2Detector in this effort.

Credentials and Endorsements

Africa - d_2w® was the first biodegradable technology to be approved in Ghana, Rwanda and Togo. In the Middle East - d_2w® was the first biodegradable technology to be approved (by ESMA in the UAE) and SASO in Saudi Arabia.

- ✓ Symphony is accredited to ISO 9001 for quality management and to ISO14001 for environmental quality.
- ✓ Certified Biodegradable - Biodegradability of d_2w biodegradable polymers has been studied and certified at laboratories worldwide, including: Eurofins (Spain); RAPRA (UK); SPI (Sweden); Blaise Pascal University - CNEP (France); University of Pisa (Italy); Euro Laboratoire (Spain), Universita Autonoma Metropolitana (Mexico), and Intertek(India).
- ✓ Certified Non-Ecotoxic and free of restricted chemicals. Tested according to OECD 207, 208 and Annex E of EN13432 by independent laboratories RAPRA (UK) Applus, Eurofins (Spain) and OWS (Belgium).
- ✓ Symphony is certified by the Biodegradable Plastic Association ("BPA") **www.biodeg.org** as qualified for membership.

Singapore Green Label

A green label has been awarded by the Singapore Environment Council (SEC) for carrier bags containing Symphony's d_2w® masterbatch. The Green Label establishes grading criteria on environmental, health and performance for plastic products that biodegrade in the open environment owing to the inclusion of a pro-degradant catalyst during manufacture.

The Singapore Green Label is an endorsement of environmentally friendly claims, to prevent greenwashing.

ANSI American National Standards Institute

Using biodegradable plastic technology such as d_2w, tested according to ASTM D6954-24, (Standard Guide for Exposing and Testing Plastics that Degrade in the Environment by a Combination of Oxidation and Biodegradation) can prevent future contributions to the accumulation of plastic waste that has escaped into the environment.

Read more at https://blog.ansi.org/?p=178809

Eco II Manufacturing Inc is a leading manufacturer of LDPE products in Canada. The company has been producing a full range of biodegradable garbage bags using Symphony's d_2w prodegradant masterbatch since 2006.

FUJAIRAH PLASTIC FACTORIES GROUP

Fujairah is a major plastics manufacturer who have been supplying both garbage and shopping bags containing d_2w to customers in the Arabian Gulf and elsewhere in the world for over 20 years.

Symphony's d_2w biodegradable plastic technology was awarded the Green Apple Award – Crystal Status, which is the highest award for environmental best practice.

The Millenium Product Award by the Design Council and sponsored by the UK Department of Trade and Industry. Symphony's d_2w was awarded Millenium Product status

Symphony Environmental USA have won the Best of Jacksonville Award in the Environmental Program category for the 5th time, having won also in 2019, 20, 21, 22, 23 and 24.

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