



BIOTRANSFORMATION

Next-Gen Biodegradable Solution





POLYMATERIA:

WHO WE ARE?

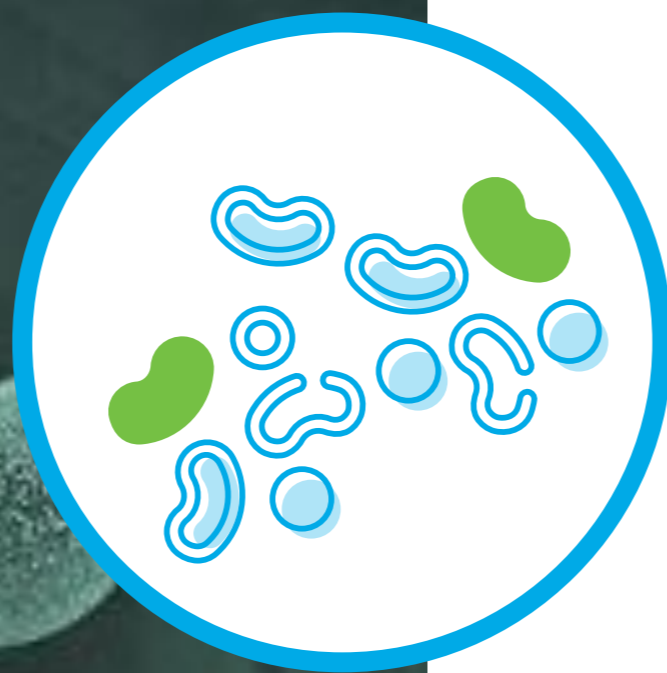
- ① London based privately held Advanced Technology Development Company.
- ① Emerged from the Imperial College London Innovation hub
- ① Focused on new gen environmental solutions for the global plastic value chain.
- ① State-of-the-art R&D facilities at the Imperial College Innovation I-Hub, London, UK.
- ① Highly specialised manufacturing facility (France)
- ① Unique multi-disciplinary approach from a team of researchers and experts in biology, chemistry and polymer science



The problems we solve for our customers:

- ① Concerns about **brand reputation** and loss of customer trust if their packaging were to contribute to plastic pollution
- ② Frustrations over the **complexities & difficulties** for **finding fully scalable alternatives** without making big concession on cost and functional benefits
- ③ Challenges by key stakeholders to **do more to control plastic pollution** ahead of expectations and what is legally required





WHAT SOLUTION DO WE OFFER?

THE ONLY TECHNOLOGY CAPABLE OF DELIVERING FULL MICROBIAL CONVERSION ON PP & PE

- ③ New gen catalytic system able to transform hard crystalline and amorphous structures into **bioavailable wax-like residue** leaving no **microplastic** behind
- ③ **Time controlled process** to allow **optimal use phase** and **recycling recovery**. Empowering end-users with a clear and simple “Recycle by date” marking call to action.
- ③ Tested and certified to **robust international standard for biodegradability of PP and PE** (BSI PAS 9017) underpinned by EN, ASTM, ISO standards (ASTM D5988/ISO 17556)
- ③ Test & Verification performed by **ISO/IEC 17025 accredited independent 3rd party**
- ③ Lab data validated in **real world environmental conditions**

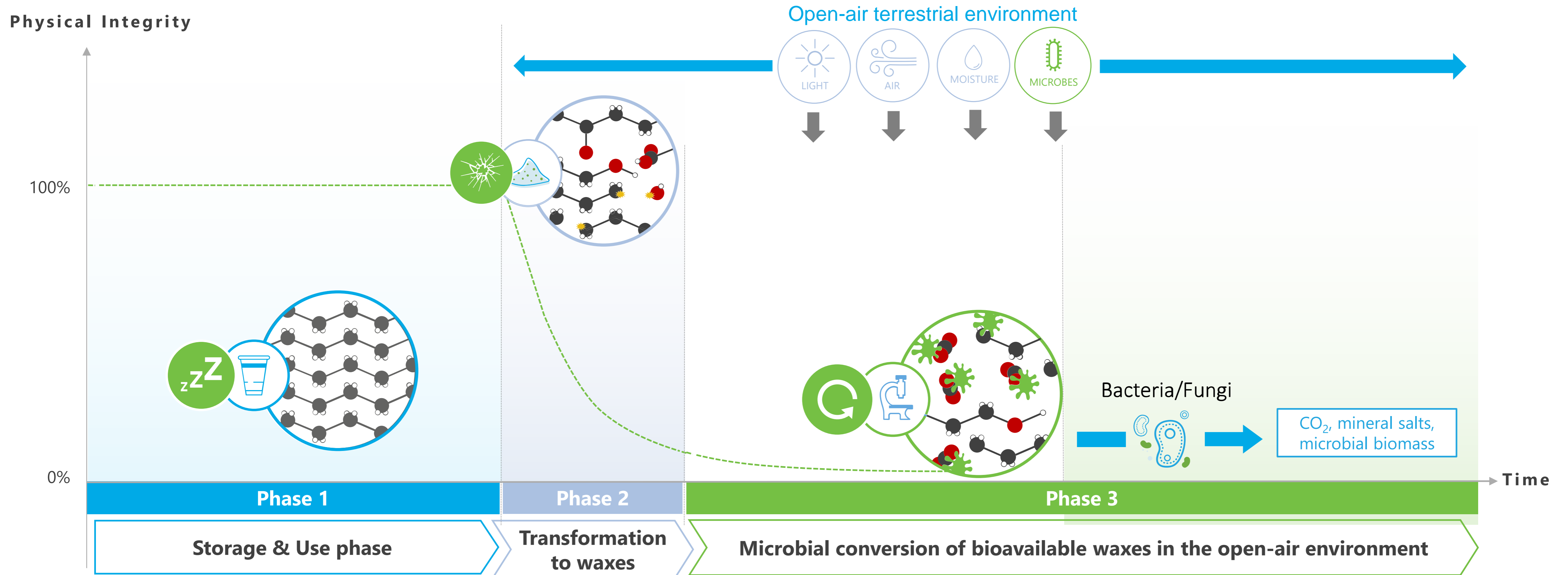
Biodegradable-based solution landscape

MOST SOLUTIONS INVOLVING "BIODEGRADABILITY" HAS NOT DELIVERED ON THEIR PROMISES



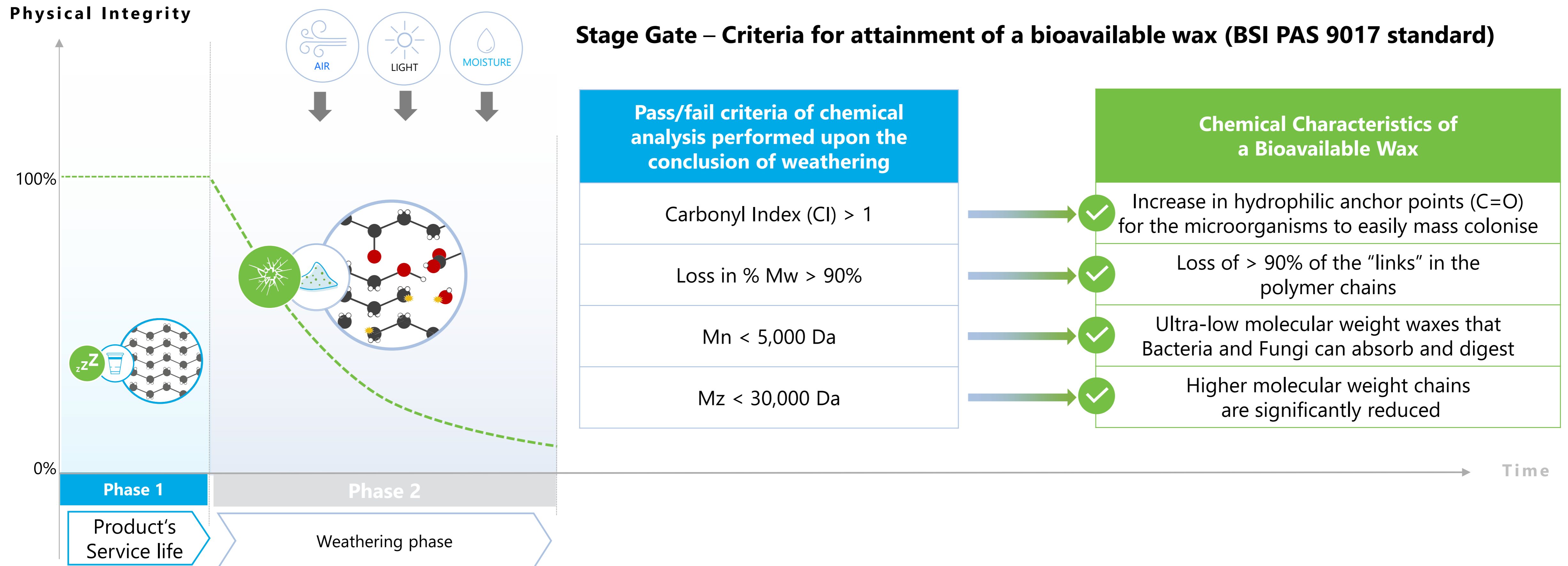
How does it work?

Unique chemical transformation into a bioavailable wax, followed by full microbial conversion into CO₂, mineral salts & microbial biomass



How does it work?

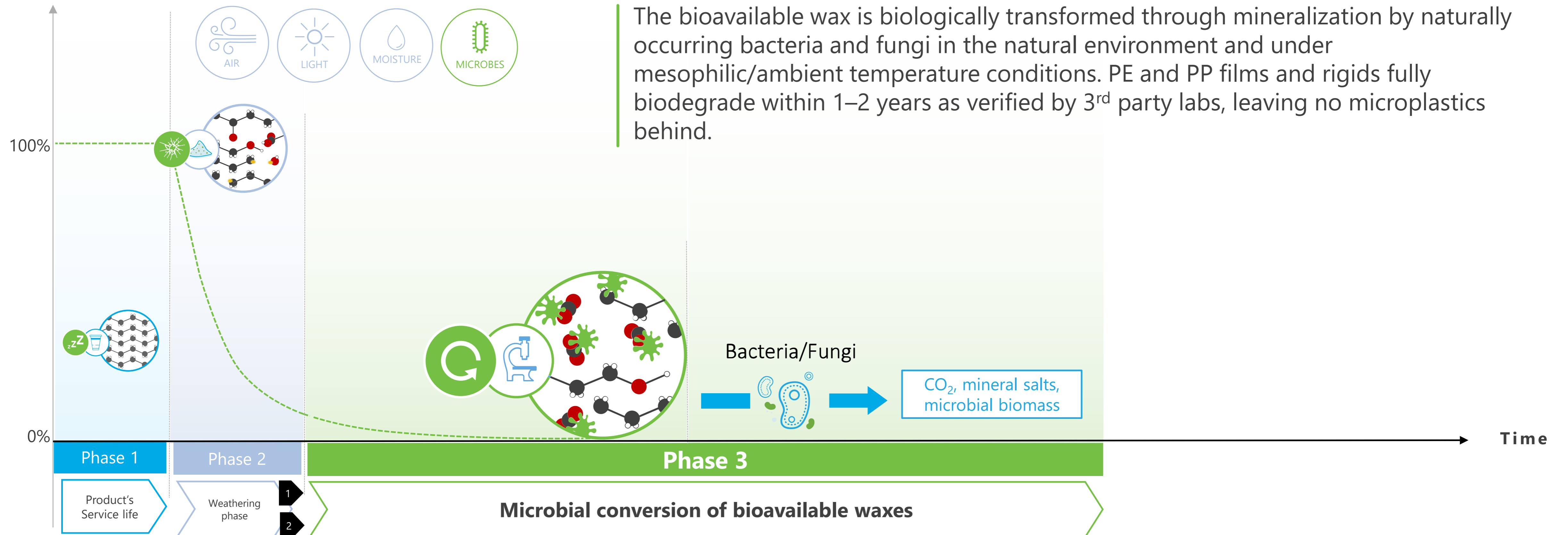
Stringent specification on chemical parameters for an unambiguous quantification of the transformation into microplastic-free bioavailable wax



How does it work?

Microbial conversion of the bioavailable wax > 90% rate must be demonstrated within 2 years timeframe

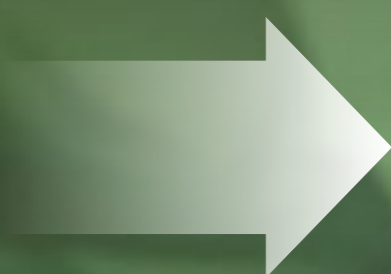
Physical Integrity



HOW IT IS DEPLOYED?

- ① Drop-in Masterbatch (MB) in pellet form
- ① Each MB formulation is tailored to the resin's footprint, application profile and required use life
- ① Compatible with the normal plastic conversion processes
- ① Typical loading rate: 2% weight percentage (wt%)
- ① Commercialised under two brands

NORMAL MANUFACTURING PROCESS



PACKAGING
MANUFACTURING



DROP-IN MB

Cycle+
A Polymateria® Brand

- Long service life (6 months to 3 years)
- Viable recycling option available

DegrAid
A Polymateria® Brand

- Short service life (< 6 months)
- No recycling option



END
PRODUCT



END
CONSUMER



TESTING METHODS AND VERIFICATION PROCESS



Verification & Authentication process

FULL COMPLIANCE WITH THE REQUIREMENTS OF BSI PAS 9017:2020 SPECIFYING BIODEGRADABILITY OF PP AND PE PRODUCT

- ① International standard specification which defines requirements for biodegradability of PP and PE in an open-air terrestrial environment (BSI PAS 9017: 2020).
- ① Robust specification on the degree of chemical transformation (carbonyl index, molecular size), biodegradation rate, environmental safety and timeframe.
- ① Underpinned by relevant EN, ASTM, ISO and OECD standard specifications
- ① Verification and authentication by ISO/IEC 17025 accredited independent third-party testing institutions.

COMPLIANCE FOR APPLICATION IN CONTACT WITH FOOD

FULLY COMPLIANT WITH FDA AND EU REGULATIONS



④ FDA & EU MIGRATION



- Approved food contact for plastic packaging in US market (GRAS statement)
- EU compliance for applications in contact with food (EU regulation 10/2011, including latest amendments)

④ ECO-TOXICITY DECLARATION



- Tested for land acute and chronic effects on earthworms and plants (complies with the requirements of the OECD 207, 222 standards)
- Tested for fresh water acute and chronic toxicity on Daphnia (complies with the requirements of the OECD 202, 211 standards)

RECYCLABILITY DURING PRODUCT'S LIFE-TIME

- ① Test carried out based on RecyClass Recyclability Evaluation Protocol for PE Films and PP Rigid¹
- ① The technology is fully compatible with normal mechanical recycling processes
- ① Tests performed on Pretreatment (grinding, washing, floating, drying), Extrusion (pellet properties) and Converting (plaque properties)

“The findings show that PE flexibles and PP rigids containing Polymateria’s technology with a threshold of up to 50% of the total weight have no impact on the recycling process nor on the resulting recycled material.”

¹ RecyClass, version 1.0, published on 6th September 2018

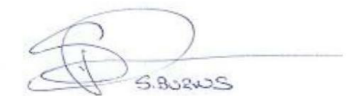


**Scottish Plastic Recycling
Centre of Excellence**

Recyclability Report

RecyClass Recyclability evaluation protocol for PE films

Client: Polymateria
Date: V1: 25/10/2019
V2: 16/12/2019
Report Number: IMP03835-LR-V2
Report Author: Steven Burns



Impact Solutions, 16 Abbotsinch Road, Grangemouth, FK3 9UX
www.scottishplasticrecycling.org


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 **impact solutions**
INDEPENDENT PLASTIC EXPERTS



KEY BENEFITS TO CONVERTERS, RETAILERS AND BRANDS

HOW DO OUR CUSTOMERS BENEFIT?



BENEFITS

- ① Keep the same supply chain as before, minimized changeover and switching cost
- ① Keep the same efficiency gain as before (e.g. filling or packing speed). No impact on operating cost.
- ① Enjoy the same functionality benefits as before (e.g. functional barriers). No trade-off required on shelf-life and quality of goods.
- ① Enjoy intangible benefits such as:
 - ① *Reduced reputational risk. Increased trust and elevated brand*
 - ① *Building goodwill with customers and public at large*
 - ① *Staying ahead of stakeholder's expectations and legal requirements*
 - ① *Staying relevant through differentiation*

COMMUNICATION OF SUSTAINABILITY BENEFITS USING TYPE II ENVIRONMENTAL LABELLING



- ④ Compliance to ISO 14021 specific requirements for self-declared environmental claims
- ④ Specific, accurate, relevant and truthful; no vague or general claims
- ④ Claim substantiated with verification using international standards:
 - Biodegradability: **BSI PAS 9017, ASTM D5988/ISO 17556**
 - Eco-toxicity: **OECD 202, 222, 208 & 211**
- ④ Tested and verified by ISO/IEC 17025 accredited independent third-party
- ④ Evaluation documents retained for information disclosure purpose. Data to be available to all interested parties



Development of a relevant Kitemark marking in progress

HOW DOES THE CUSTOMER JOURNEY AHEAD LOOK LIKE?

- ④ **Introductory session:** Understanding the challenge at hand. Technology intro
- ④ **Follow up session #1:** Technology & product-application fit deep dive, Q&A
- ④ **Follow up session #2:** Mutual Action Plan (MAP) to arrive at proof of concept and decision making for implementation
 - ④ In-depth review of product makeup, technology recommendation
 - ④ Production trial, generation of customer's product prototypes
 - ④ Testing of prototypes by ISO/IEC 17025 accredited independent 3rd party
 - ④ **Go/No-Go sanction by key Decision Makers**
- ④ **Implementation** → Collaborative action plan for market introduction
 - ④ Vendor & Customer set up
 - ④ Content marketing and communication strategy
 - ④ Supply chain & Sales supports





USE CASES:
POLYPROPYLENE (PP) and POLYETHYLENE (PE)

Bags for loose fruits & vegs, textiles & garments or mailing bags

Material: LLDPE, LDPE, HDPE
 Structure: Mono or multi-layer
 Thickness: 15 - 100µm
 Printing: Unprinted, printed
 Printing process: Flexo, rotogravure



Fully proven ready-to-use Polybags, mailing bags, loose bags are commercially available from a range of polybags and flexibles producer partners across, China, Vietnam, Bangladesh or India (e.g., Wing Yip Polybags Ltd, TMV Vina, Avery Dennison, Packman)

PE bags: Biotransformation at work

Abiotic degradation (ASTM D4329/ISO 4892-3)

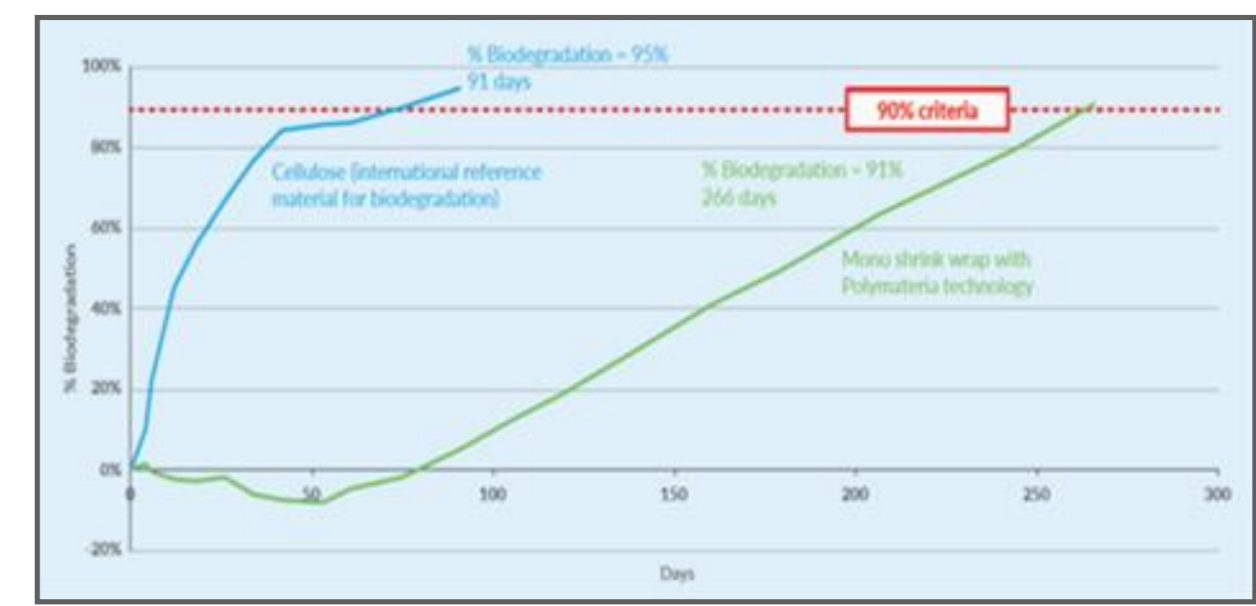
After end-use, under the action of UV, air and moisture, the polybag is transformed into bioavailable waxes typically within 3-5 months.

	PAS 9017 specification	PE film benchmark*	LDPE polybag +2% PLM
Carbonyl Index (CI)	> 1	1.9	1.6
% loss of Mw	> 90%	98%	98%
Mn	< 5,000Da	507Da	768Da
Mz	< 30,000Da	19,333Da	10,762Da



Biodegradation on soil (ASTM D5988/ISO 17566)*

The waxes are safely reabsorbed into the natural environment as CO2, mineral salts and microbial biomass through (on soil) microbial conversion over 90% rate typically in less than a 1 year (266 days)



* Benchmark: LLDPE/LDPE film 87µm + 2% PLM MB

Collation Shrink Wrap & Stretch Films

Material: LLDPE, LDPE, HDPE
Structure: Mono or multi-layer
Thickness: 15 - 100µm
Printing: Unprinted, printed
Printing process: Flexo, rotogravure



Fully proven ready-to-use shrink and stretch films for multi-packing and pallet wrapping are commercially available from a range of leading shrink and stretch film producer partners in Europe and LATAM (ValGroup, Polimur, Coveris, Polivouga, Manupackaging)

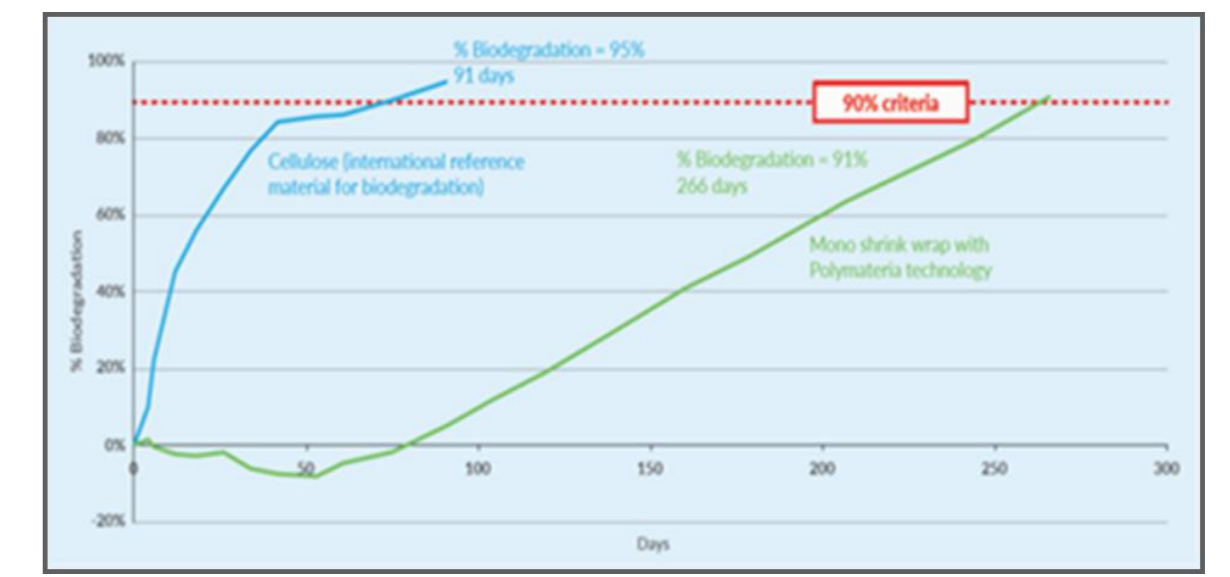
PE collation shrink and stretch film - Biotransformation at work -

- Abiotic degradation (ASTM D4329/ISO 4892-3)**
 - At the end of its use life, under the action of UV, air and moisture, the film is chemically transformed to bioavailable waxes within 3-5 months leaving no microplastics behind.

	PAS 9017 specification	PE shrink film benchmark*	PE stretch film +2% PLM
Carbonyl Index (CI)	> 1	1.9	1.3
% loss of Mw	> 90%	98%	95%
Mn	< 5,000Da	507Da	2,300Da
Mz	< 30,000Da	19,333Da	13,333Da



- Biodegradation on soil (ASTM D5988/ISO 17566)***
 - Waxes are safely reabsorbed into the natural environment as CO2, mineral salts and microbial biomass through microbial conversion over 90% rate typically in < 1 year (266 days)



* Benchmark: PE shrink film 87µm +2% PLM MB

Bakery bags made from PP or LDPE/LDPE

Material: PP, LDPE, LLDPE
Process: blown cast film
Thickness: 10-70µm
Aspect: Clear or coloured
Printing: Flexo, rotogravure



Fully proven ready to use biodegradable bread bags are commercially available from a range of leading European packaging converter partners (e.g., Valle Plastic, Palamy, Flexpak).

PP, PE bakery bags - Biotransformation at work -

Abiotic degradation (ASTM D4329/ISO 4892-3)

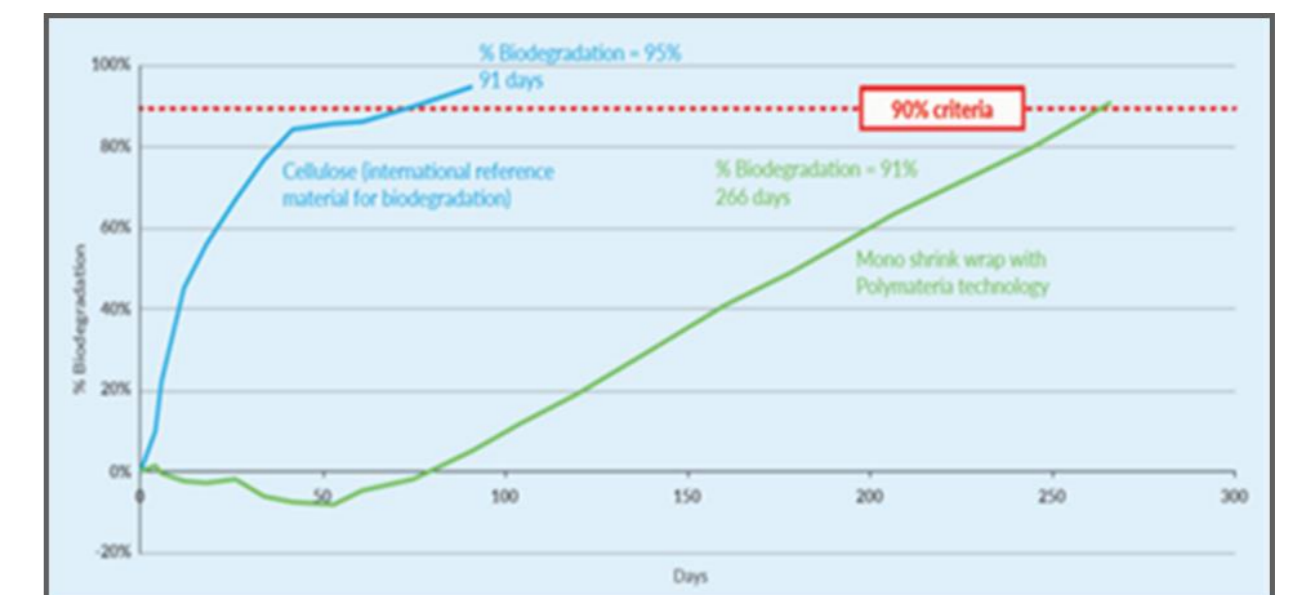
- Under the action of UV, air and moisture, the bread bag is chemically transformed into bioavailable waxes within 3-5 months leaving no microplastics behind.

	PAS 9017 specification	PE shrink film benchmark*	PE bread bag +2% PLM
Carbonyl Index (CI)	> 1	1.9	1.8
% loss of Mw	> 90%	98%	97%
Mn	< 5,000Da	507Da	1,315Da
Mz	< 30,000Da	19,333Da	5,473Da



Biodegradation on soil (ASTM D5988/ISO 17566)*

- The waxes are safely reabsorbed into the natural environment as CO₂, mineral salts and microbial biomass through microbial conversion on soil over 90% rate typically in < 1 year (266 days)



* Benchmark: PE shrink film 87µm + 2% PLM MB

BOPP-based flow wrappers & overwraps

Film: clear, white, matt or cavitated
 Structure: 3 or 5 layer
 Thickness: 15-60µm
 Printing: Unprinted, printed
 Printing process: Flexo, rotogravure



Fully proven ready-to-use OPP films are commercially available from a range of leading OPP producer partners in Europe, Middle East and India. (Poligal, Polivouga, Gulf Packaging, MSFL)

BOPP films

- Biotransformation at work -

Abiotic degradation (ASTM D4329/ISO 4892-3)

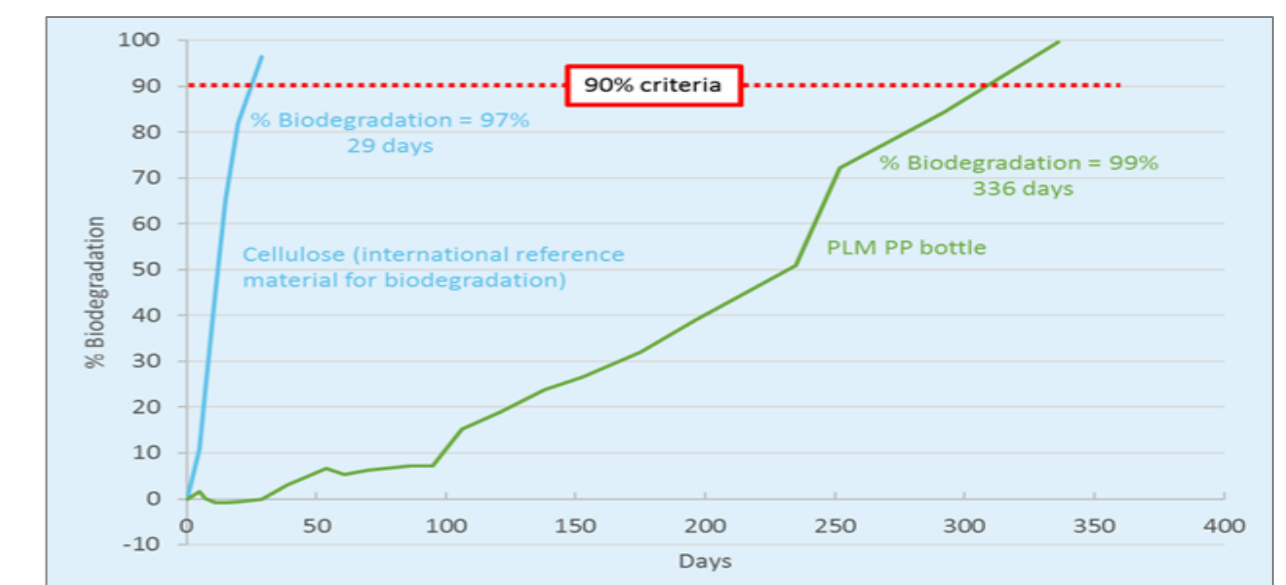
- At the end of its use-life, under the action of UV, air and moisture, the film is chemically transformed into bioavailable waxes within 3-5 months leaving no microplastics behind.

	PAS 9017 specification	PP benchmark*	BOPP film +2% PLM MB
Carbonyl Index (CI)	> 1	3.2	1.2
% loss of Mw	> 90%	96%	98%
Mn	< 5,000Da	1,910Da	3,850 Da
Mz	< 30,000Da	9,250Da	15,000Da



Biodegradation on soil (ASTM D5988/ISO 17566)*

- Waxes are safely reabsorbed into the natural environment as CO₂, mineral salts and biomass through microbial conversion over 90% rate in typically < 1 year (336 days)





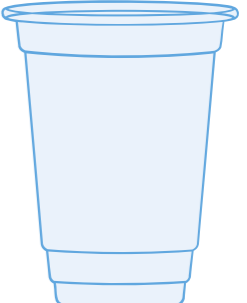
* Benchmark: PP bottle + 2% PLM MB

CASE STUDY

NEXT-GEN SUSTAINABLE DRINKING CUPS



RANGE OF CUPS INCLUDES (BUT NOT LIMITED TO)

	P/F CRITERIA	 0.2-0.3L CUP	 0.5L CUP	 0.5L CUP
Thickness	Microns	200	300	500
Manufacturing process		Thermoformed	Thermoformed	Injection Moulding
Pigments/Additives		None	None	None
CI	>1	1.03	1.22	2.04
Reduction in MW (%)	>90%	98.3%	97.7%	93.2%
Mn (Da)	<5000 Da	2770 Da	2267 Da	2680 Da

Thin Wall Containers: ice cream tubs, deli containers, takeaway containers, pots

Material: food grade PP
 Process: IM and Thermoforming
 Thickness: ≤ 1mm
 Aspect: clear, coloured



Fully proven ready-to-use biodegradable TWC, deli containers, pots are commercially available from a range of leading OPP producer partners in Europe, USA and Asia.

Thin Wall PP Container - Biotransformation at work -

Abiotic degradation (ASTM D4329/ISO 4892-3)

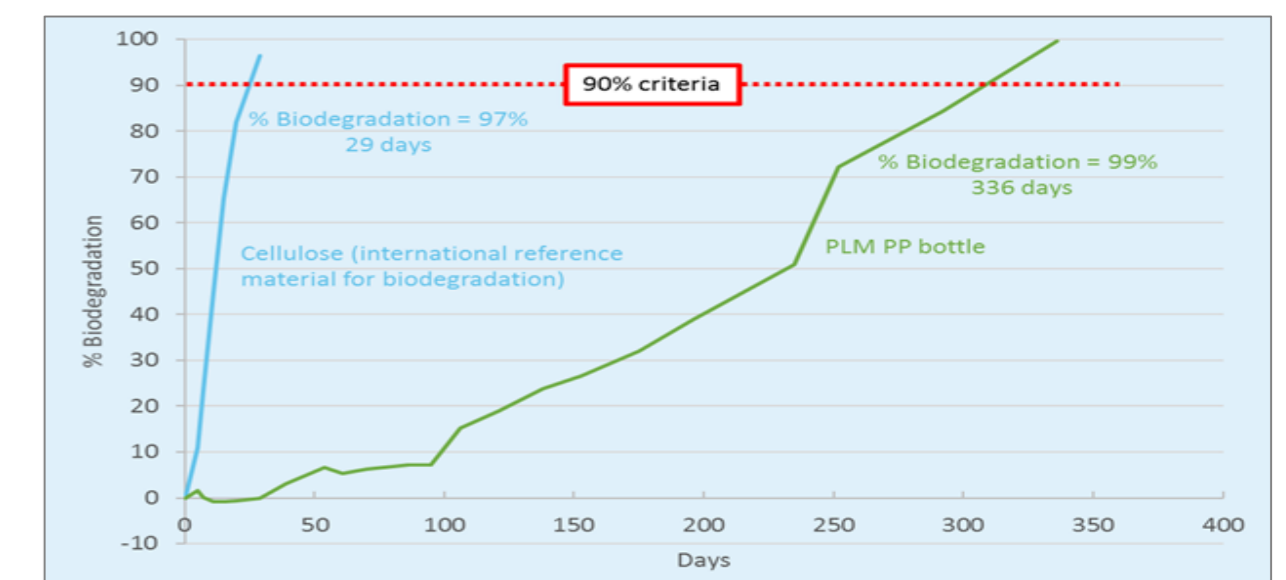
- The product is chemically transformed into bioavailable waxes within 3-5 months from the end of its useful life under accumulated exposure to UV, air, heat, and moisture.

	PAS 9017 specification	PP benchmark*	PP noodle pot +2% PLM MB
Carbonyl Index (CI)	> 1	3.2	1.9
% loss of Mw	> 90%	96%	98%
Mn	< 5,000Da	1,910Da	1,253Da
Mz	< 30,000Da	9,250Da	7,000Da



Biodegradation on soil (ASTM D5988/ISO 17566)*

- Bioavailable waxes are safely reabsorbed into the natural environment as CO₂, mineral salts and biomass through microbial conversion over 90% rate typically in < 1 year (336 days)



* PP bottle 1mm thickness



WE ARE ENGAGING
WITH GLOBAL BRANDS,
WHO DON'T WANT TO
SEE THEIR PRODUCTS
HERE





Thank You!

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