Compostable plastics – Cause or solution to microplastics in soil?

Bioplastic Conference 2019

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01

Introduction

- Biodegradable polymers in a circular economy
- What are biodegradable polymers?

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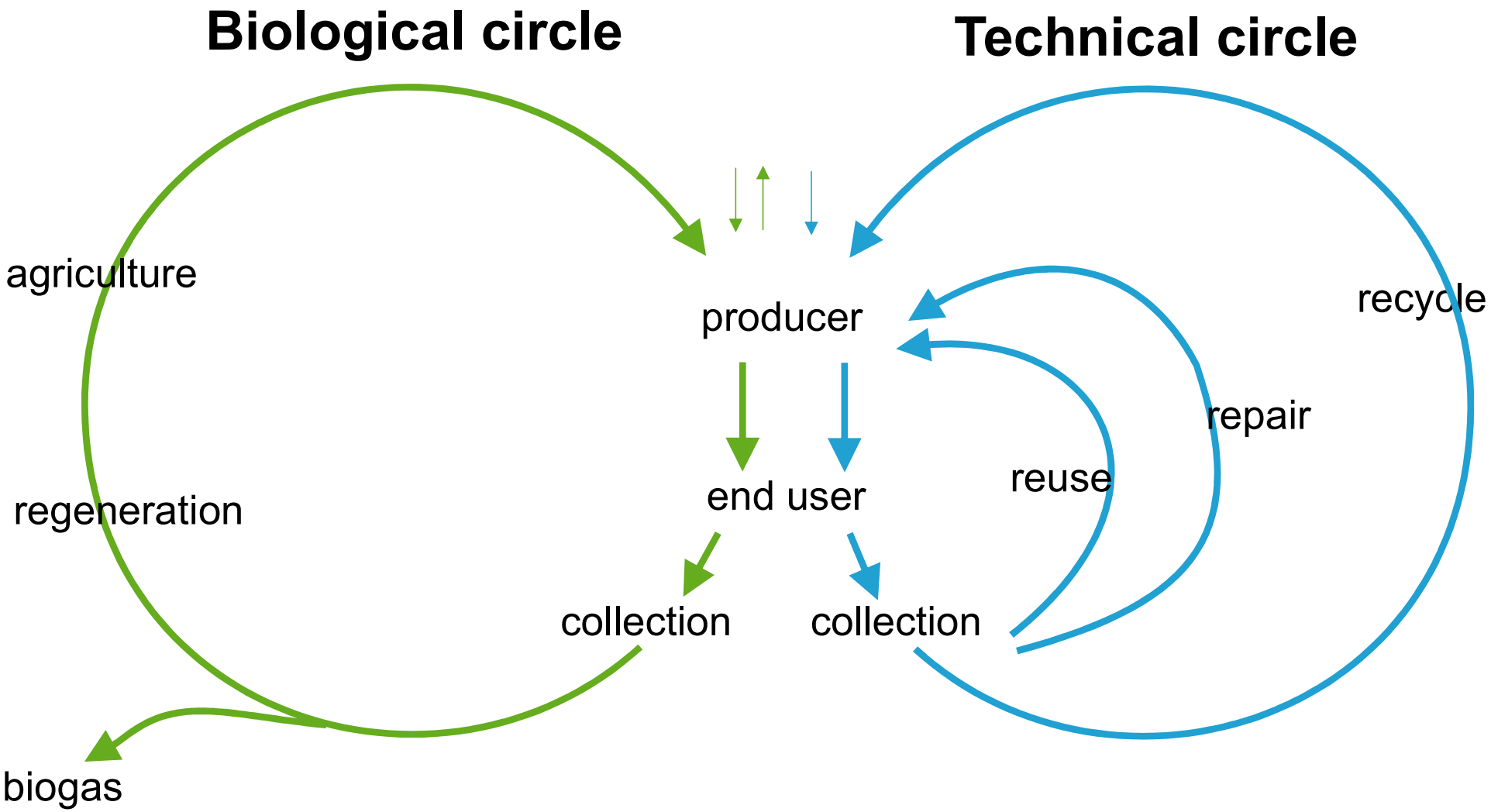
Rethinking Plastics: New plastics economy aligns with circular economy principles



Simplified Graphic based on:

Source: Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment; Drawing from Braungart & McDonough, Cradle to Cradle (C2C).

Value proposition of biodegradable polymers: closing the food value chain

Agricultural Input & Outputs

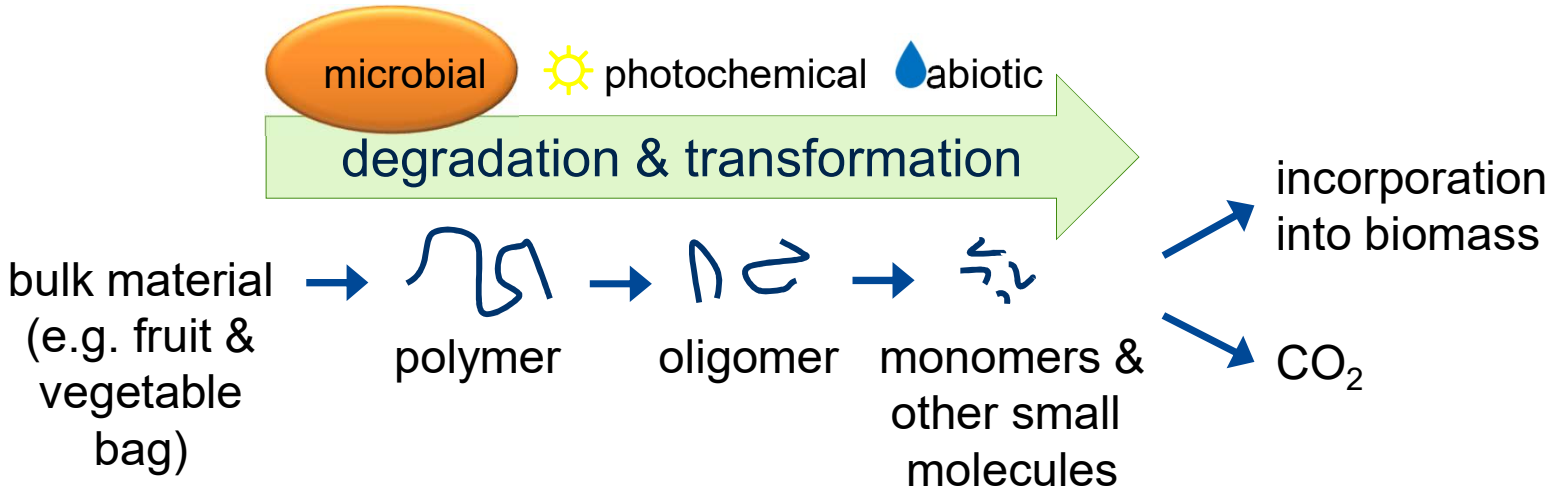
Distribution & Consumption

Compost for Soils

Compost Production

Waste Generation & Collection

Let‘s talk about end of life
Basics



Legend: Microbial: bacteria and fungi Abiotic: e. g temperature, water Photochemical: UV light
Biomass: mass of living biological organisms

- Biodegradation by natural organisms to CO_2 and microbial biomass
- CO_2 is indicator for biodegradability measurement
- 10% of carbon is estimated to go into biomass, 90% of carbon goes in CO_2[1]

[1] OWSnv (2016) EXPERT STATEMENT (BIO)DEGRADABLE MULCHING FILMS. (European Bioplastics e.V., http://www.european-bioplastics.org/news/publications/).

02

Biodegradability

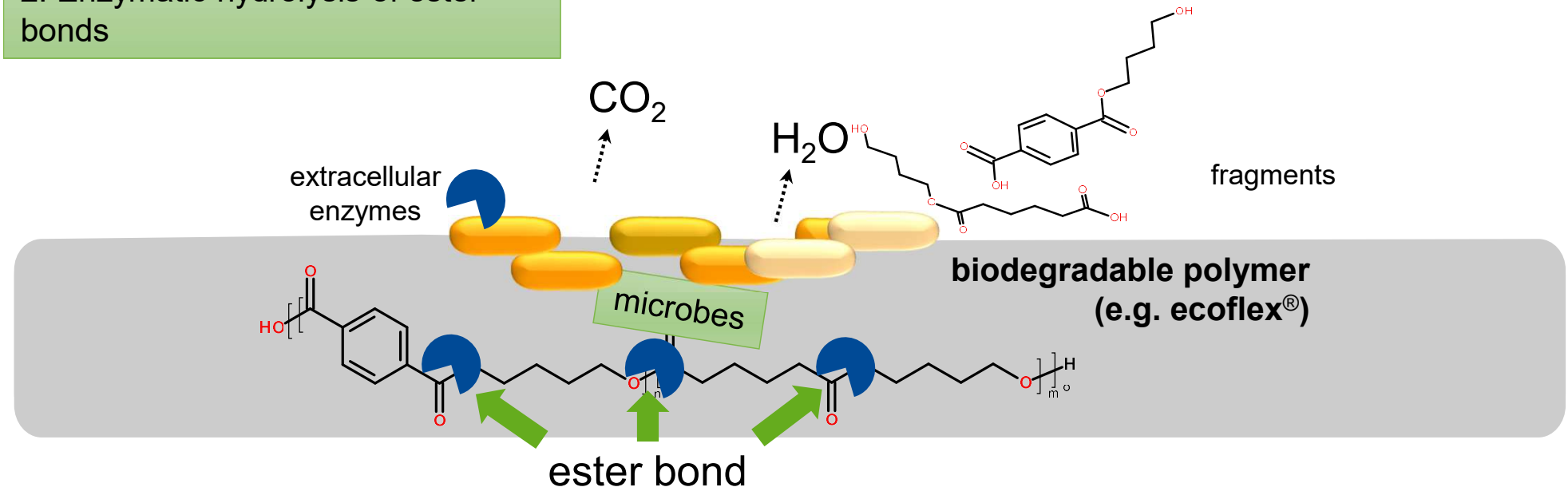
Process of biodegradation of biodegradable polyesters

1. Microbial colonization of the surface and excretion of enzymes (e.g. cutinases)

2. Enzymatic hydrolysis of ester bonds

3. Release of short fragments

4. Uptake and metabolization by microbes



Legend: Hydrolysis: Cleavage of molecules in presence of water

Compost EN13432

Mineralization	• 90% converted to CO_2 at 58°C in mature compost in 6 month
Disintegration	• Less then 10% of the material is bigger than 2 mm particle size
Control of constituents	• regulated metals, regulated substances
Field behavior	• No negative effect on composting process
Ecotoxicology	• No harm for plant growth

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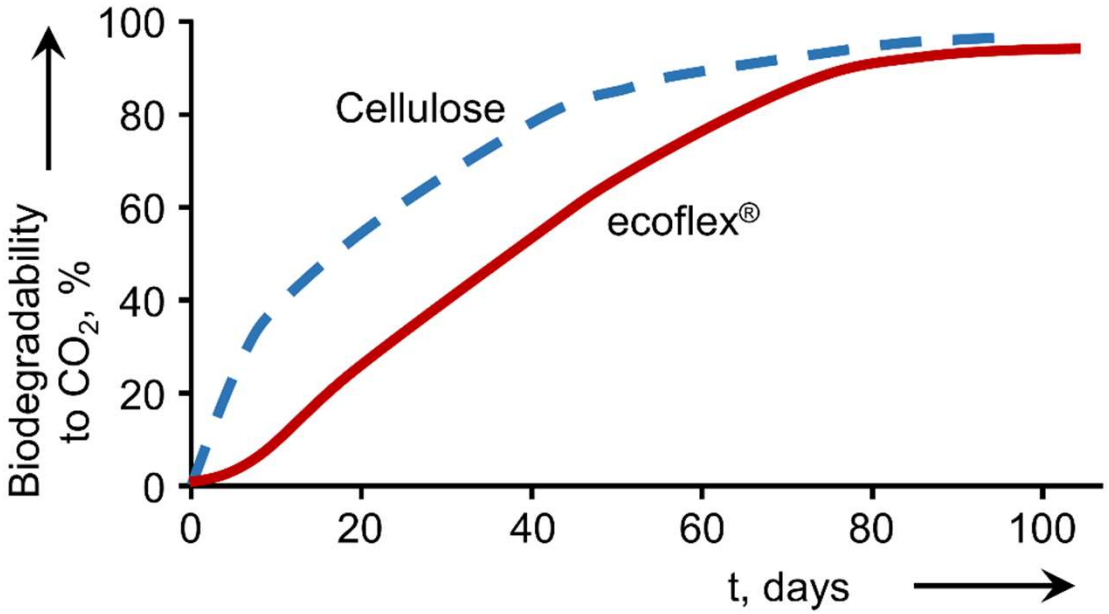
Biodegradation of ecoflex® in compost
Mineralisation



- ecoflex® is fully biodegraded after 90 days
- Comparable biodegradability to cellulose

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How does the disintegration look like in field tests?

- Under industrial composting conditions– high temperature, defined water, oxygen and nutrient supply – the degradation takes only a few weeks

Degerdation of a compostable film in the first week…

… in the second week…

… in the forth week

Quelle: Müll & Abfall, 2013/05, Georg Kosak

Independent certification according to EN13432 secures full industrial compostability!

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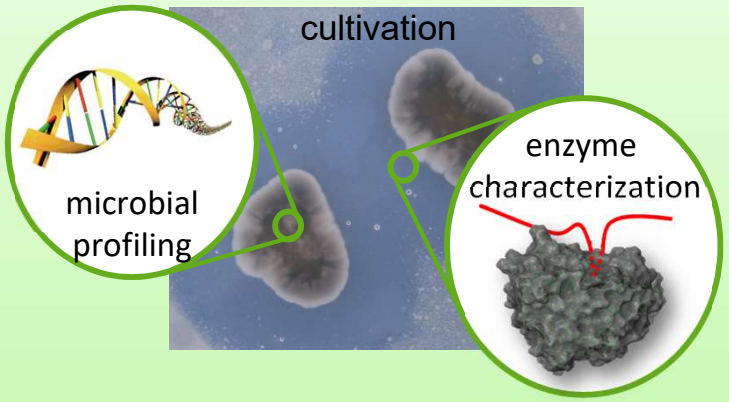
Basic understanding and field evaluation are both needed to understand biodegradability

Fundamental understanding

Understanding structure-biodegradability relationship



Polymer characteristics

⇕

Microorganisms and enzymes

⇕

Abiotic factors

Field evaluation

Assessing product performance in field trials

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Cooperation ETH Zürich and BASF on biodegradation in soil

Rebekka Baumgartner[1], Michael T. Zumstein[1], Taylor Nelson[1], Melissa Maurer-Jones[1], Hans-Peter Kohler[2], Kristopher McNeill[1], Michael Sander[1]

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2. Swiss Federal Institute of Aquatic Science and Technology (Eawag), **Environmental Biochemistry**, Dübendorf, Switzerland
3. Advanced Materials & Systems Research – Biopolymers, BASF, Ludwigshafen, Germany

→ **Landmarking cooperation for sustainable chemistry**

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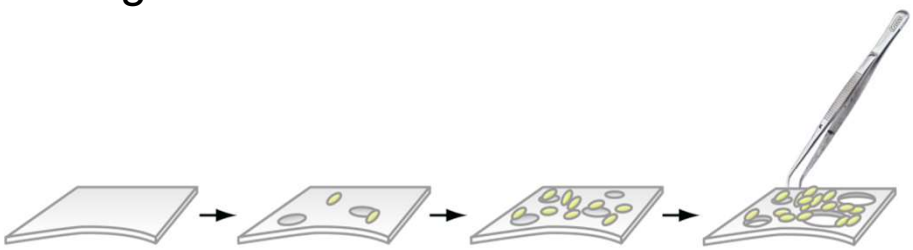
Microbial characterization
Microflora is a dominating factor

➔**Who is eating our product?**

Isolation of microorganisms directly from partial degraded polymer films
(→ more than 400 isolates, esp. fungi)

➔ Fungi have been identified to be the most potent but not exclusively degrading microorganisms in soil



Exemplary soil organisms (not necessarily ecovio degraders)

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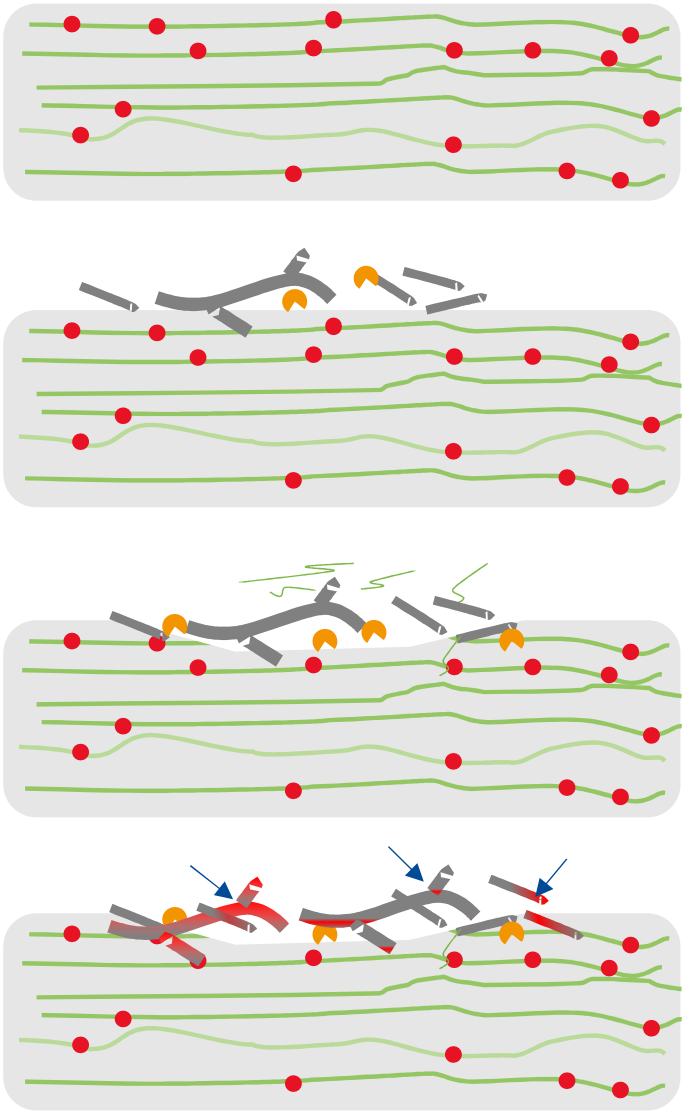
Microbial metabolism
How to show the biomass formation?



1. Microbes colonize the surface and excrete enzymes (e.g. cutinases)

2. + 3. Enzymes break down the polymer and release of water-soluble fragments

4. Microbes digest the fragments and grow
➔Formation of biomass from labelled carbon

Labelled carbon

Polymer with labelled carbon

Fungal hypha and bacteria

Water soluble fragment with labelled carbon

Enzyme

Fungal hypha and bacteria with labelled biomass

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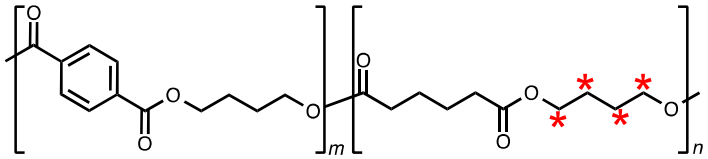
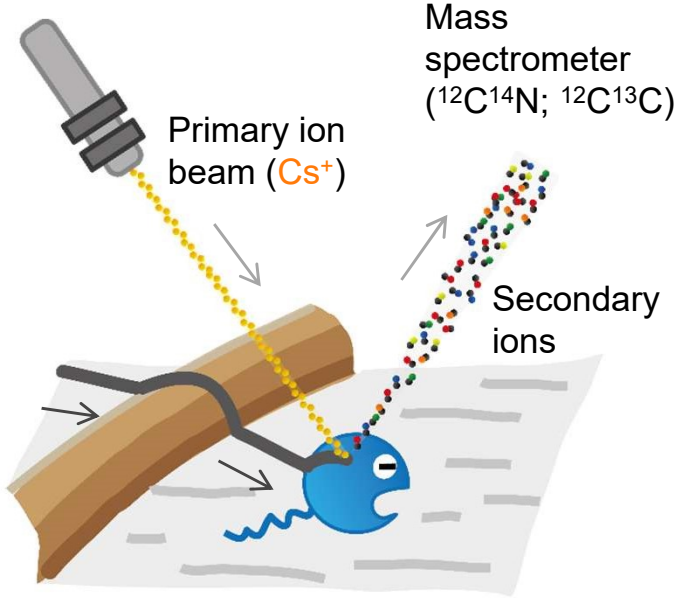
Microbial metabolism
Conversion into microbial biomass

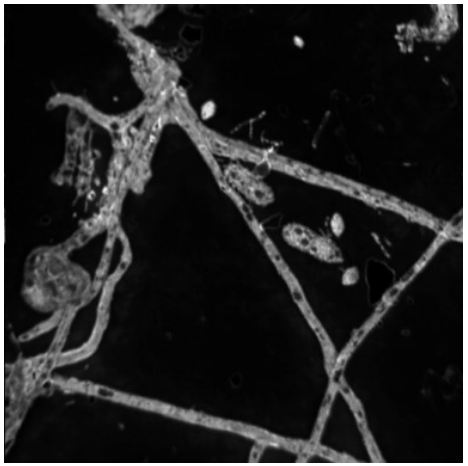


poly(butylene adipate-co-terephthalate)
PBAT: labeled in adipate

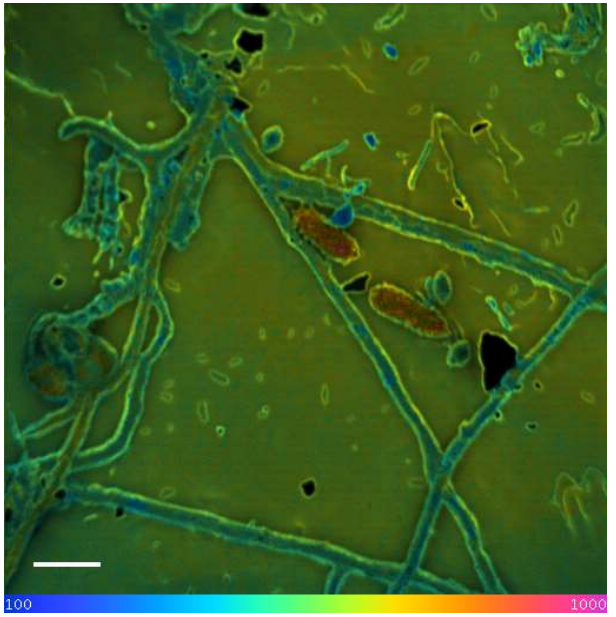
Nanoscale secondary ion mass spectrometry (NanoSIMS)



$^{12}C^{14}N$ - ions



^{13}C atom percent
^{13}C / (^{12}C + ^{13}C) (%)



at%: 0.99

at%: 4

Zumstein et al., Science Advances, **Biodegradation of synthetic polymers in soils: Tracking carbon into CO_2 and microbial biomass,** 2018

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03

Conclusion

European legislation on certified compostable bags

Examples

Italy

- Mandatory compostability for light and very light bags (EN13432)
- Mandatory bio based content: 40% in 2018; 50% in 2020; 60% in 2021

Spain

- From 2020: Mandatory compostability for light and very light bags (EN13432)

Austria

- Legislation draft for 2020: Mandatory compostability for light and very light bags

France

- Mandatory compostability for light and very light bags (home compostability)
- Mandatory bio based content: 40% in 2018, 50% in 2020, 60% in 2025

Ban of oxo-degradable mulch film in 2020

Belgium

- Walloon: Mandatory compostability for light and very light bags (home compostability)
- Mandatory bio based content: 40%

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