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Tailoring food waste feedstocks for enhanced biopolymer production for use in soft plastics

Solving two problems with one solution

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RECARB
ARC Research Hub for Carbon Utilisation & Recycling

ARC Research Hub
Value-Added Processing of Carbon Waste

Waste in the 21st Century

Plastic Waste

- >400 million tonnes produced worldwide every year
- >35% used as packaging materials
- Microplastic pollution ~14 million tonnes on the ocean floor
- 2025 APCO targets: 100% reusable, recyclable or compostable packaging.

Food Waste

- 1/3 of the world's food is wasted
- Food waste >5% of Australia's GHG emissions
- Australians waste ~7.6 million tonnes food per year

Cozar et al., Proc. Natl. Acad. Sci., 2014.; H. R. a. M. Roser, [Online], 2022.; C. Z. Barrett et al., Frontiers in Marine Science, 2020.; Australian Government Department of Climate Change, the Environment and Water, [Online], 2022.

Greener packaging must be explored

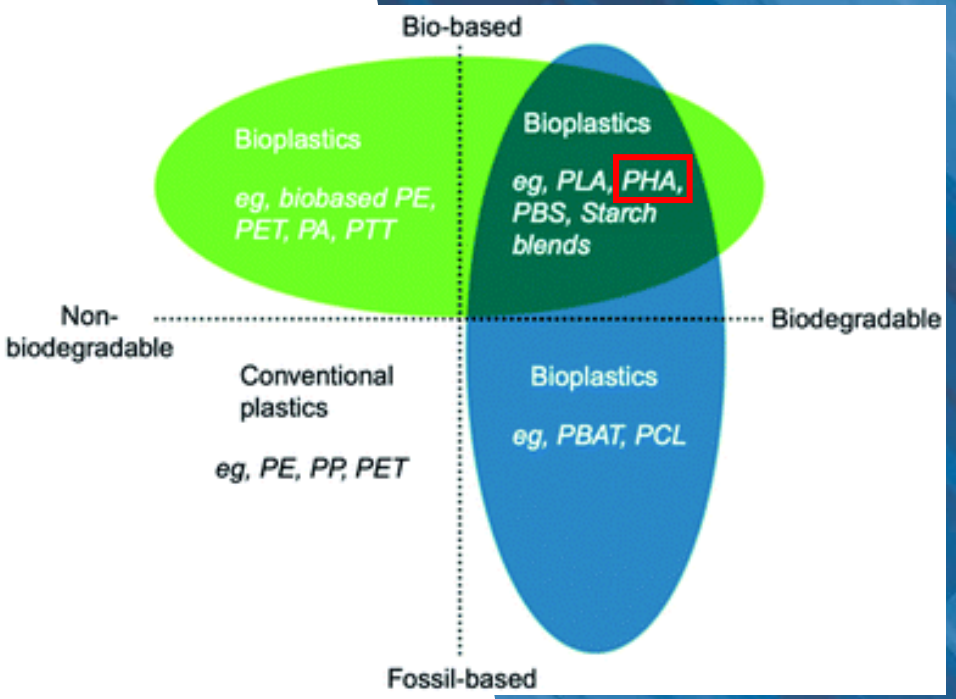
Removing fossil fuel based plastics from the market

Fossil Fuel Based Plastics

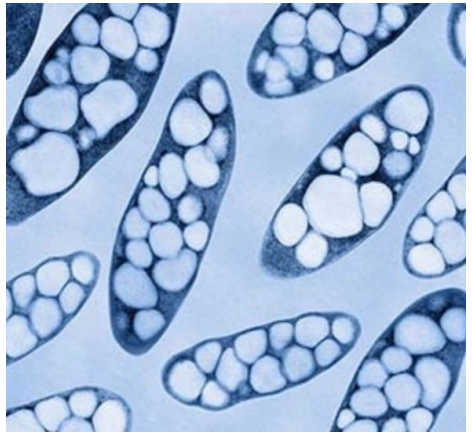
- >99% plastic sourced from fossil fuels
- Low degradation rate
- Plastics manufacturing uses a huge amount of fossil fuels and energy.

Bio-based polymers offer a solution

- Produced from starch, sugars or fatty acids
- Bacteria most widely used
- Store polymers intracellularly as carbon source
- Mechanical polymer properties are key for packaging

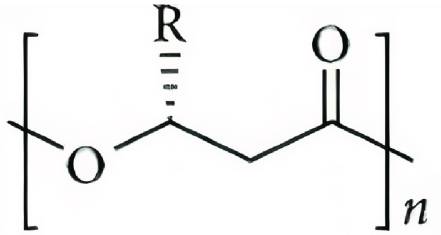


A. Z. Naser et al., RSC Advances, 2021



Key issues PHA commercialisation

Why have PHA's not been widely adopted?



Cost

- Cost of carbon feedstock very expensive, making up at 45-50% of the production cost
- Energy intensive downstream processing (extraction and purification)

Properties

- PHB has poor mechanical properties

Process

- Little research focussing on the whole process, process integration and how it relates to film production

Polymer	Tensile strength (MPa)	Melting point (°C)	Elongation at break (%)
PHB ($R = CH_3$)	40	175	5
mcl-PHA ($R = C_{10}H_{21}$)	**20**	**40–90**	**200**
PBAT*	18	115	20
LDPE**	12	110	400

A. Z. Naser et al., RSC Advances, 2021.; S. A. Ashter, Intro. To Bioplast. Eng. 1st Ed, 2016

**: polymers that are fossil-based but biodegradable.*
***: polymers that are fossil-based and not biodegradable*

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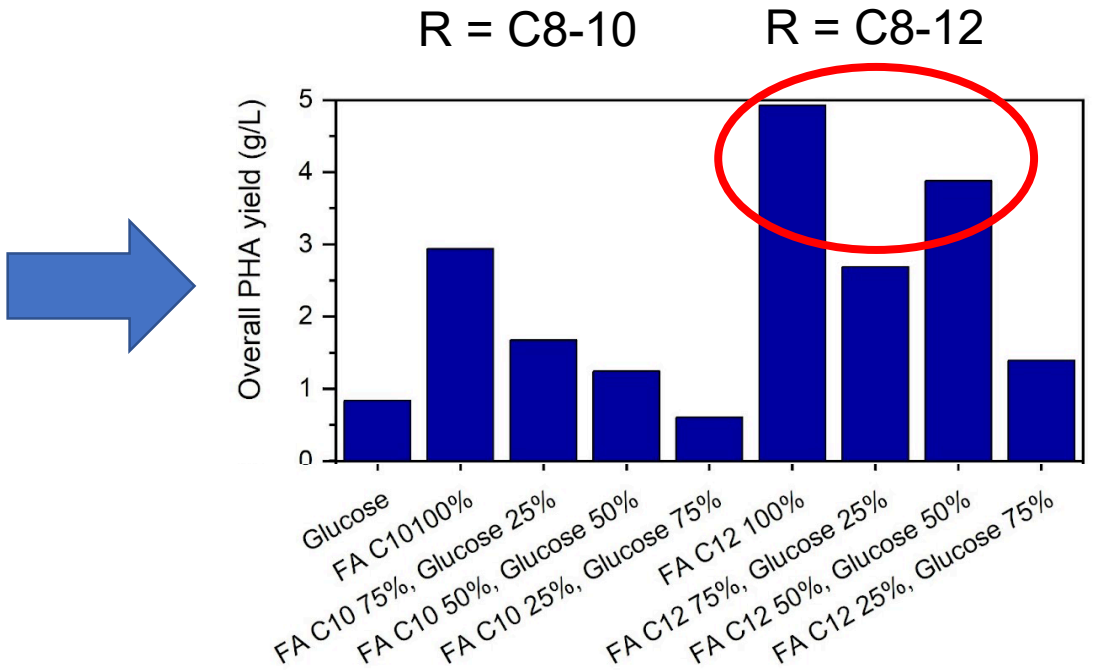
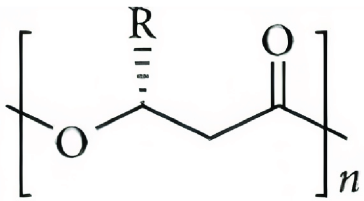
mcl-PHA biosynthesis *Pseudomonas Putida* on mixed feedstocks:

high carbon conversion rate and

properties suitable for packaging applications & drug delivery

sugars from starch + waste oils / fats

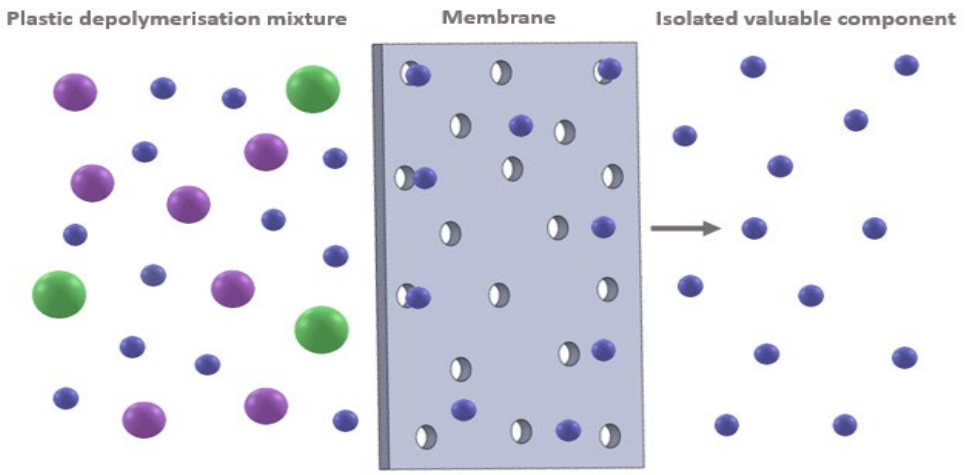




ACS Sustainable Chem. Eng. 2024, https://doi.org/10.1021/acssuschemeng.4c02156

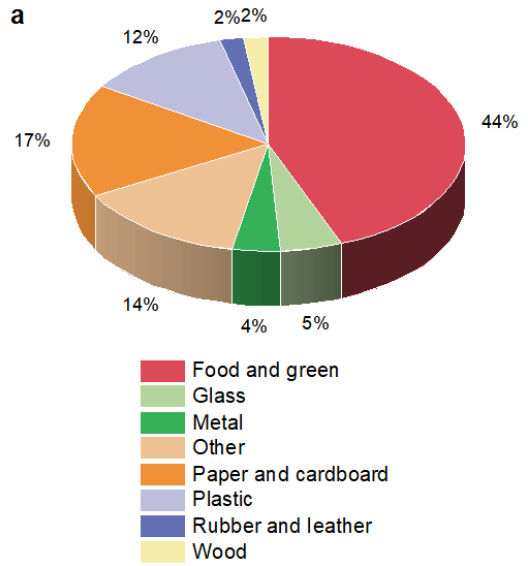
Enhancing plastic waste recycling through:

1) Membrane technologies



CSIRO Ending Plastic Waste

2) Co-valorizing food & plastics



What a Waste 2.0, The World Bank, 2018.

Source: Gemini

Food waste to biopolymers for soft-plastics

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https://www.recarbhub.org/partners

GREAT WRAP

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