Are Biodegradable Plastics the Solution to Plastic Pollution?

- Definition
 - Waste hierarchy
 - Limitations
- Why Biodegradables
- Green washing
- R&D at CSIRO

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Ending Plastic Waste Symposium 2023

What are Biodegradable Plastics?





Biodegradable Plastics as a Waste Management Strategy



Non-degradable single use plastics may be substituted for compostable plastics for certain applications

Recycle or Compost Option?



Limitations of Biodegradable Plastic

Mechanical Properties

- Reduced strength -
- Low flexibility -
- _ resistance

Barrier Properties

Affects food self life

Recycling **Reduced** impact $0_{2} H_{2}0$ Unsuitable for mechanical recycling Thickness Mainly thin films Cost Affects degradation 3-5X conventional plastics rate AS 4724



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Consideration for using Biodegradable Plastics

- Reduced environmental footprint
- Increased consumer demand
- > Evolving legislation for single-use plastic bans



Best Argument for Biodegradable Packaging

Even if waste collection, sorting and recycling were significantly improved, waste management will always be problematic



Littering
Negligence
Incidental exposure
Illegal dumping



Further Challenges for Biodegradable Plastics

> Poor Performance of Compostable Plastics using Citizen Science in the UK

Purkiss et. al. The Big Compost Experiment...., Frontiers in Sustainability, 3, 2022, 1-18

- Home compost study using 9,701 citizens
- 60% of certified home compostable did not meet performance targets
- Concluded that compostable plastics are not effective

Why?

- Packaging is engineered to maximise mechanical performance limited to an ideal compost environment
 - Temperature, airflow, nutrients, moisture, microbe loading e.t.c.
 - Changes to certification targets may be necessary?

BIOPLASTICS







Consumer Choices....

Green Washing – value proposition, misconception or deception?

1. Oxo-degradable

- ✓ Disintegrates
- Reduced Animal Threat
- Persistent microplastics
- 🗵 Nonrecyclable
- 2. Non-degradable Bioplastic
- ☑ Uses less petrochemicals
- Recyclable
- Non-degradable, environmental pollution





antbotti

X

3. Uncontrolled 'Green' Plastics

Petrochemical blends – polyethylene + PLA or starch

- Uses less petrochemicals
- Carbon capture (if non-degradable)
- Problematic recycling
- Non-degradable, environmental pollution
- Unverified Compostable Plastic -Excessive degradation period?
- Environmental/animal hazard
 - Accumulates in compost bin
- Produces methane in landfill



OLASTIC



....are biodegradable plastics the solution to plastic pollution?



- Depends on value proposition and tolerance to limitations
- Only recommended for certain applications (see APCO)
- Technology is evolving and essential to address limitations

R&D Needs and Challenges

- Degradation rate and Mechanical Performance
- Recycling (Upcycling)
- Oxygen/moisture barrier performance
- Clear end-of-life Labelling for Consumers
- Banning green washed products







R&D Activities at CSIRO

- Biodegradable composites to improve mechanical properties
- nanocellulose incorporation into biodegradable polyesters
- Kingshuk Dahli, PhD student RMIT
- > Assisting start-up Uluu with their PHA polymers
- materials evaluation
- material processing





R&D Activities at CSIRO

Enzyme incorporation into polyesters for enhanced degradation rates -> thicker, stronger home compostable plastics





- Contract R&D for Enzide Technologies[™] (form. Earthpak)
- Enzyme engineering for targeted activity and thermal stability (Biocatalysis and Synthetic Biology Team)
- MOFs enzyme encapsulation technology (Licence from CSIRO)





Thank you

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** Extra slides **



Biodegradable Plastics Classification Based on Degradation Environment

			<u>Relative</u>	<u>Microbial</u>		
	<u>Application</u>	<u>Temperature</u>	Degradation Rate	Mineralisation	<u>Hydrolysis</u>	<u>Product</u>
4	Oxo-degradable	ambient	Variable	some	via catalysis	micro plastic + CO_2 + H_2O
	Industrial Compostable	60°C	Fast	Yes	Yes	$CO_2 + H_2O$
	Home Compostable	ambient	Moderate	Yes	Yes	$CO_2 + H_2O$
	Biodegradable - soil	ambient	Slow	yes–moderate	Yes	$CO_2 + H_2O$
	Biodegradable - marine	ambient	V. Slow	yes–slowly	Yes	$CO_2 + H_2O$
	Biodegradable - water	ambient	V. Slow	yes-slowly	Yes	$CO_2 + H_2O$

Mechanical performance

Oxo-biodegradable films – e.g. oxo-polyethylene





Contains 1-2% Mn or Fe salts which catalyse chain scission

Microbial biodegradation to CO₂





Compostable Polyester Films



Industrial @ >60°C, e.g. PLA Home @ <30°C, e.g. all other biodegradable plastics (excluding PLA)



Compostable Polyester Films





Compostable Polyester Films



