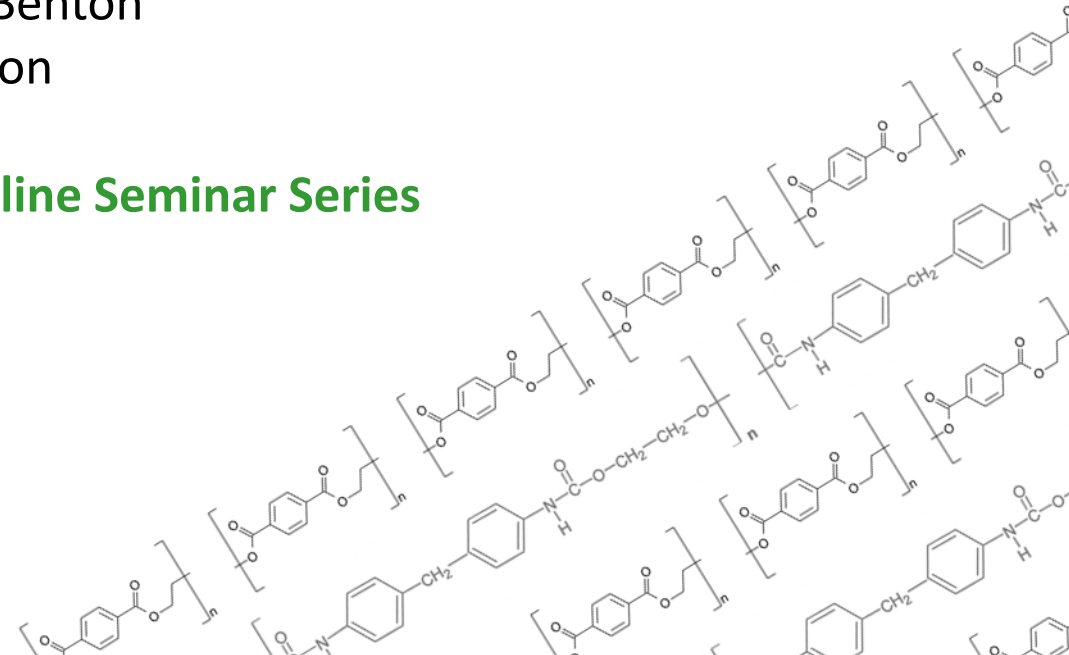


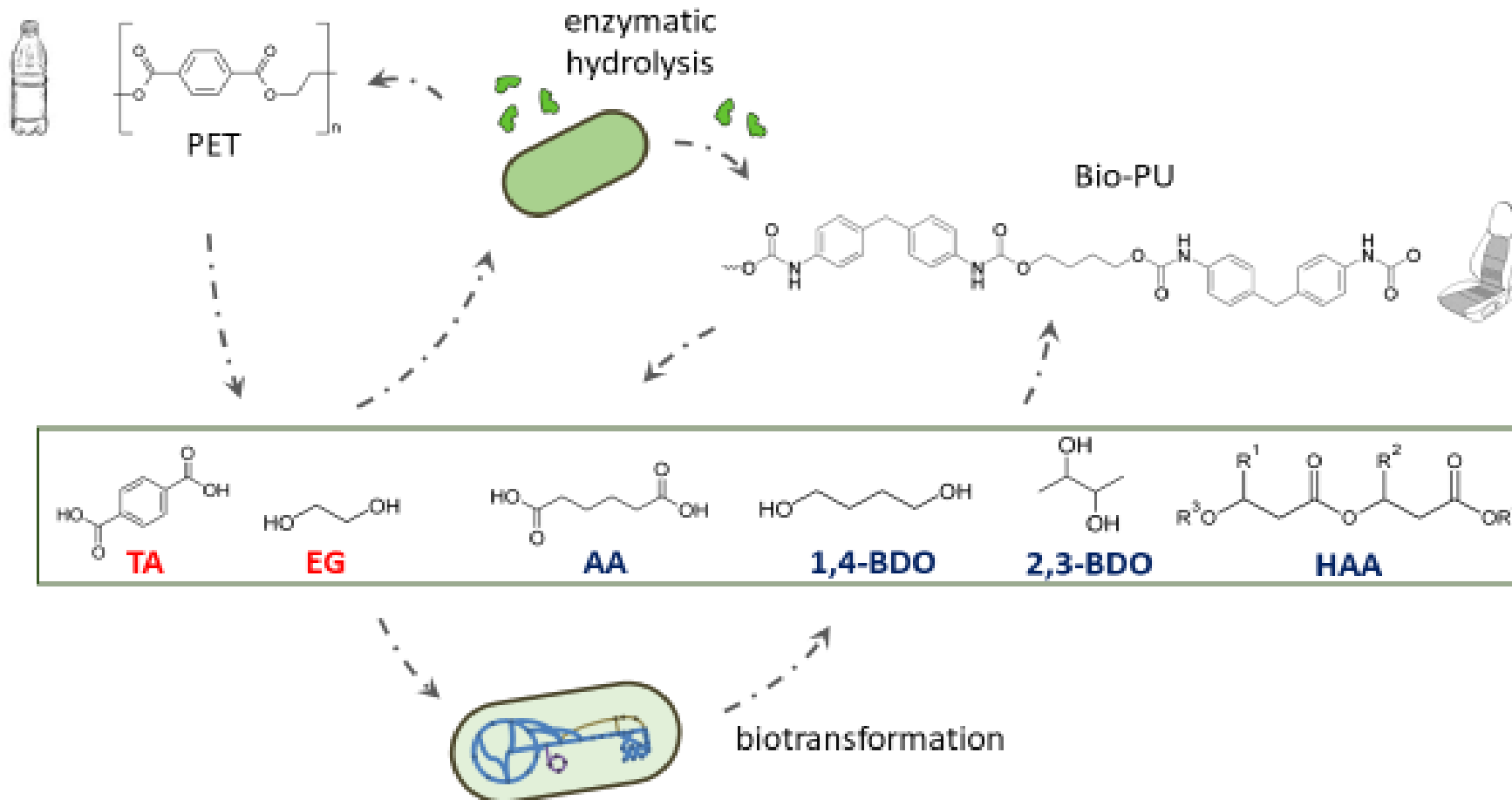
Microbial Integration of Plastics in the Circular Economy (MIPLACE)

RRI and stakeholder engagement

Jose Jiménez and Joanne Benton
Imperial College London

European Biotechnology & Society Online Seminar Series
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PET: polyethylene terephthalate
(commonly used for single-use plastics especially in the beverage industry)

PU: polyurethane (foams) used in insulation panels, carpet underlay, furniture

EG = ethylene glycol; TA = terephthalic acid; AA = adipic acid; 1,4-BDO = 1,4-butanediol; 2,3-BDO = 2,3-butanediol; HAA = hydroxyalkanoyloxy-alkanoic acid

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“RRI implies that societal actors (such as researchers, policymakers, business, charities, industry etc.) work together during the research and innovation process in order to better align both the process and its outcomes with the values, needs and expectations of society”

“...a collective responsibility... a collective process of all the different stakeholders linked in some way to the research and innovation...”



‘bio-processes for the optimized, integrated production of butyl esters from sustainable resources’

Implementing RRI: integrating life cycle analysis & stakeholder engagement

Eva Sevigné-Itoiz, Lorenzo Di Lucia, Onesmus Mwabonje and Jeremy Woods
Centre for Environmental Policy (Imperial College London)

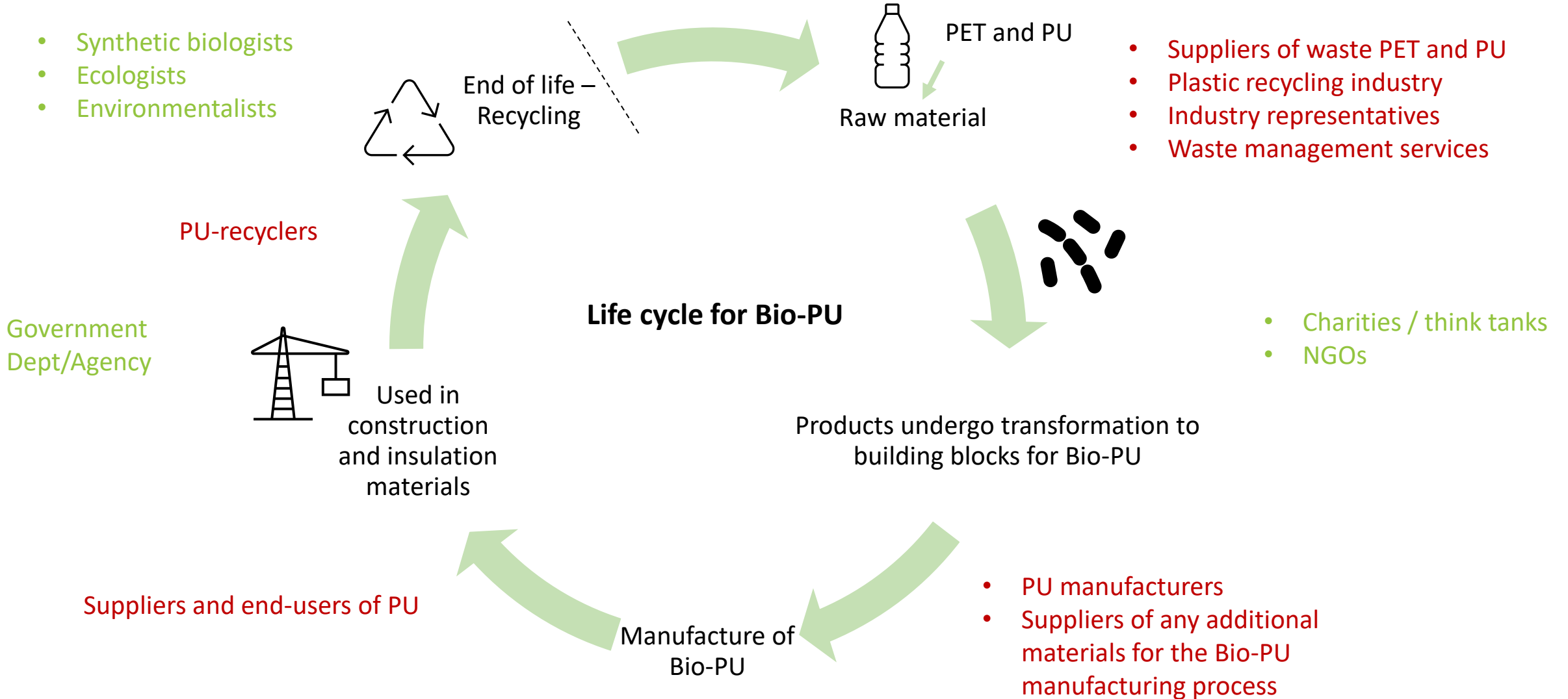
Goals:

- i) to conduct a cradle to gate Life Cycle Analysis (LCA) (based on ISO 14040-14044) of the MIPLACE project,
- ii) to evaluate and interpret the environmental impacts under different scenarios,
- iii) to provide suggestions for improvement if necessary.

Primary data collected from MIPLACE and secondary data from databases and literature.

LCA can help identify stakeholders along the supply chain and stakeholder feedback informs the design of the LCA.

Life cycle for Bio-PU and stakeholder engagement



1. Stakeholder engagement: semi-structured interviews



- Resemble a flowing conversation
- Interview should be guided but allow for other relevant themes to develop



- To include a series of open-ended questions
- Questions can be adapted depending on the stakeholder



- Interview until themes become repetitive

2. Stakeholder engagement: developing a storyboard



Microbial Integration of Plastics in the Circular Economy (MIPLACE)
The upcycling of plastic waste

Website: www.miplacebio.com
Twitter: @miplacebio
MIPLACE: a multidisciplinary project funded within the framework of the ERA-CoBioTech programme of the European Union (www.cobiotech.eu)

MIPLACE ERA CoBioTech



Plastic waste: A global crisis

- 400 million tonnes of plastic produced globally each year*
- Estimated 25% is incinerated and 56% going to landfill*
- Global average recycling rates are 14-18%*
- Plastic pollution poses environmental and health risks
- Use of fossil fuels for virgin plastics contributes to climate crisis

*Source: Plastics, the Circular Economy and Global Trade World Economic Forum (2020)

MIPLACE ERA CoBioTech

2. Stakeholder engagement: developing a storyboard

Current recycling technologies

- **Mechanical recycling:** after sorting, washing and grinding, the materials are recovered by remelting and regranulating. These recyclates can then be converted into the same or similar plastic products.
- This method can also result in plastic 'downcycling' as high temperatures and shear forces during processing often reduce the quality of plastic polymers. Consequently, the recycled materials may be used in lower value applications.
- **Chemical recycling:** used to recycle plastics that are mixed with other materials or different types of plastics. Plastics are broken down by chemical transformation into monomers which can be used to form new plastics or higher value chemicals.
- The process can be costly as it can be resource and energy intensive and uses chemical catalysts. Therefore, it may have economic and sustainability challenges.

Sources: European Bioplastics: Mechanical recycling (July 2020); Zhu et al (2022) Enzyme discovery and engineering for sustainable plastic recycling. Trends in Biotechnology; Plastics, the Circular Economy and Global Trade. World Economic Forum (2020); Plastic pollution: How chemical recycling technology could help fix it. The Conversation (2022)

The MIPLACE approach for upcycling PET and PU plastic waste

- MIPLACE aims to develop an efficient **bio-based process** that uses plastic waste as a feedstock.
- Microbial communities will enzymatically degrade PET and PU plastic waste into their constituent monomers. These can be transformed into building blocks for Bio-PU, a more environmentally friendly construction and insulation material.



- ✓ Degradation and conversion of plastic waste by microbes can be achieved with lower energy inputs which influences carbon footprint.
- ✓ Enzyme biocatalysis.
- ✓ Plastic waste is converted into molecules with added value that can be upcycled into new products.

PET: polyethylene terephthalate commonly used for single-use plastics especially in the beverage industry
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2. Stakeholder engagement: developing a storyboard

Techniques in a nutshell

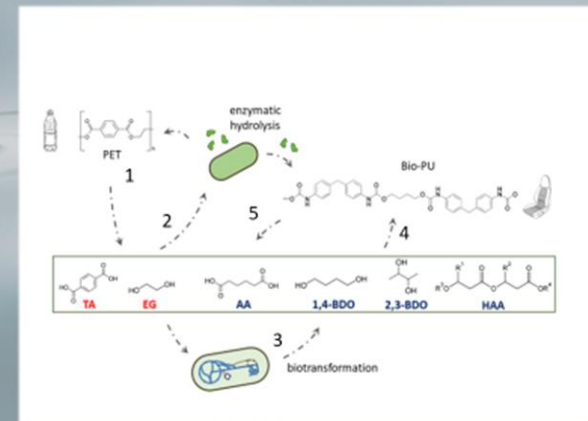
- **Synthetic biology:** employing engineering techniques to redesign organisms for beneficial applications such as solving problems within agriculture and the environment.
- Pieces of DNA from an organism, or novel DNA, are inserted into another organism's genome thus changing the genetic code and the activities of the recipient organism.
- **Adapted laboratory evolution (ALE):** the continuous culturing of individual strains or communities on PET or PU as the sole carbon source.
- As a result of such selection pressures, better plastic degraders will emerge.



<https://www.genome.gov/about-genomics/policy-issues/Synthetic-Biology>



The MIPLACE approach for upcycling PET and PU plastic waste: a more detailed look



Microbes will perform enzymatic hydrolysis of PET and PU plastic waste to produce monomers (1). These monomers support microbial growth (2) but also undergo biotransformation (3) into other monomers that are used to synthesize Bio-PU (4) so achieving the upcycling of plastic waste.

Bio-PU is used as a construction and insulation material and can be recycled (5) at the end of its life demonstrating a circular approach for tackling PET and PU waste.

PET = polyethylene terephthalate; PU = polyurethane; EG = ethylene glycol; TA = terephthalic acid; AA = adipic acid; 1,4-BDO = 1,4-butanediol; 2,3-BDO = 2,3-butanediol; HAA = hydroxyalkanoxy-alkanoic acid

3. Stakeholder engagement: example interview questions

- What are your overall thoughts on the MIPLACE approach for tackling plastic waste?
 - Are there any aspects of this research that you would like to know more about?
 - Should the technology do anything else?
 - Is the technology socially desirable and in the public interest?
 - What do you consider the best platform for providing access to scientific information?
 - Does terminology influence how you think about the research? ('GMO' vs 'engineered organisms')
-
- *We welcome your feedback on our approach to stakeholder engagement – what else could we do?*
 - *We invite you to comment on the above questions!*

4. Stakeholder engagement: what next?

- Have identified different stakeholder groups but need to identify potential interviewees
- To look for emerging themes in stakeholder feedback following interviews
- To report feedback to project partners
- To use stakeholder feedback to inform the design of the LCA
- How to engage with the general public?

We would like to thank:

Eva Sevigné-Itoiz, Onesmus Mwabonje and Lorenzo Di Lucia (Centre for Environmental Policy, Imperial College London)

Thank you for listening!

