Enzymatic Degradation of PBAT: Toward a Sustainable Strategy for Polyester Waste Recycling

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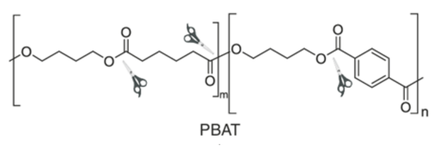
The plastic threat

Polymers have become indispensable in modern life and the global economy due to their low cost, high performance and ease of processing. However, poor end-of-life management has led to widespread plastic pollution and significant resource loss. In agriculture, PBAT-based mulch films are frequently employed to improve soil quality and crop yield. While PBAT is classified as a compostable polyester and is structurally more susceptible to enzymatic degradation than polymers with carbon-carbon backbones, its natural degradation rate in the environment remains relatively slow. Bio-based degradation using renewable biological agents such as enzymes or microorganisms presents a sustainable and environmentally friendly strategy to reduce and recycle plastic waste [1]

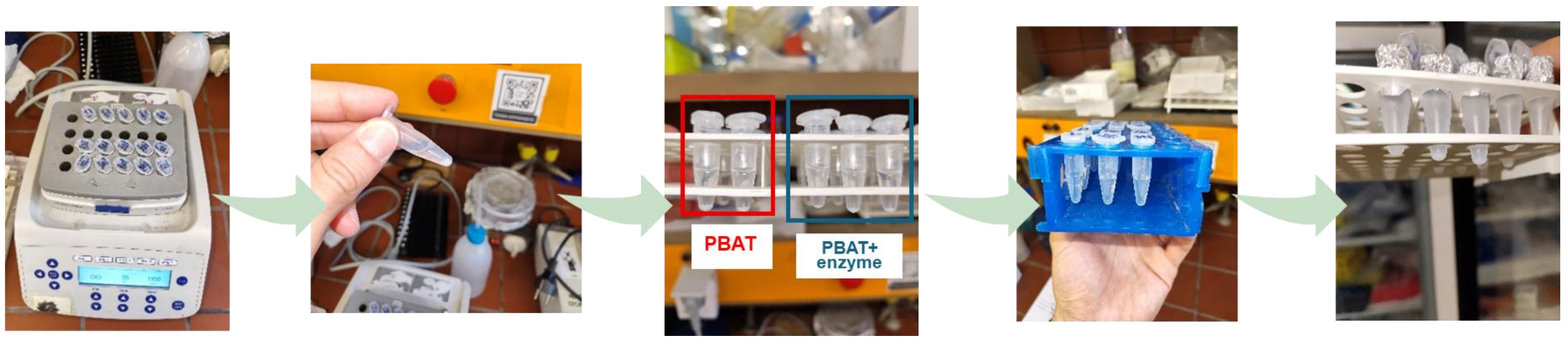
Research objective

Enzymatic degradation of a commercial powdered PBAT using the following enzymes [2]:

- **HiC** cutinase from *Humicola insolens*
- Leaf-branch compost *cutinase* (**LCC**) enzyme
- **DmPETase** cutinase-like enzyme from *Deinococcus maricopensis*
- **Se1JFR** from a bacterium belonging to a distinct phylum (*Actinomycetota*)
- **FoCut** cutinase from *Fusarium oxysporum*



Methodology



Experimental set-up
- 5 mg PBAT
- 450 µL PBS solution
- 1 mg/mL final concentration
- T = 55 °C
- t = 24h
- Oscillator set = 1350 rpm

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- 0.5 µL HCl
- 5% v/v DMSO *vs.* total H_2O

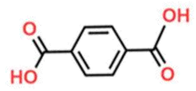
- Centrifugation (1100 rpm, 6 min)

- Solid residue (washed with 1 mL Millipore water) and supernatant collected and stored frozen

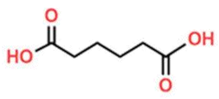
Ability of enzymes to degrade PBAT

HPLC analysis to evaluate the monomers concentration

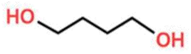
Terephthalic acid (TPA)



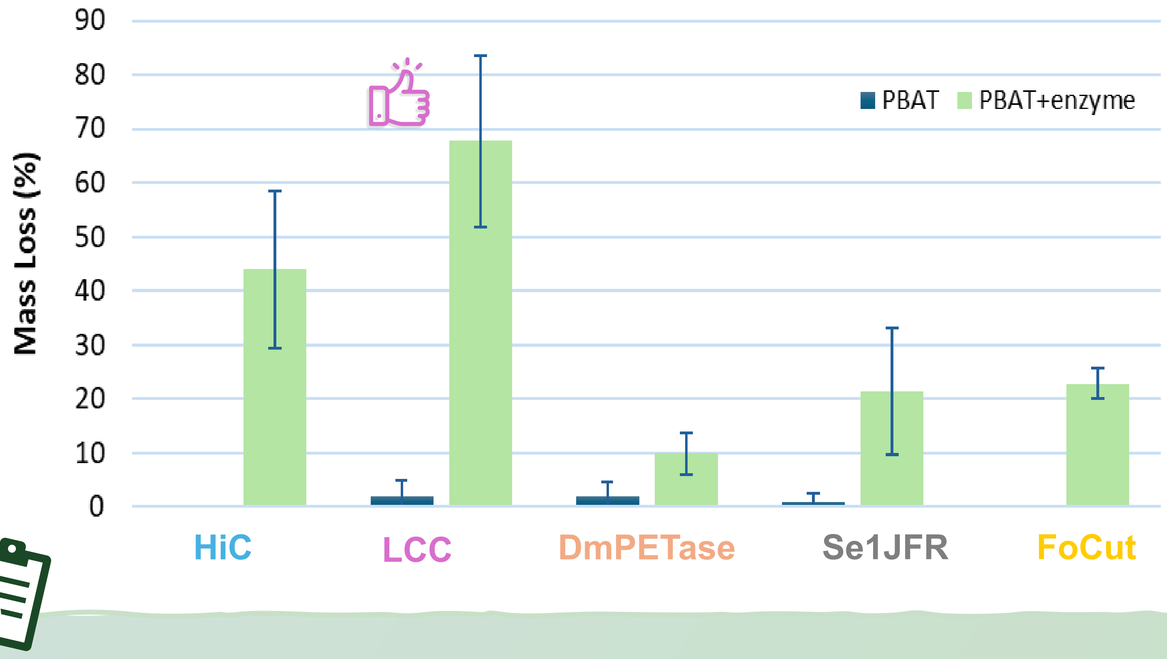
Adipic acid (AA)



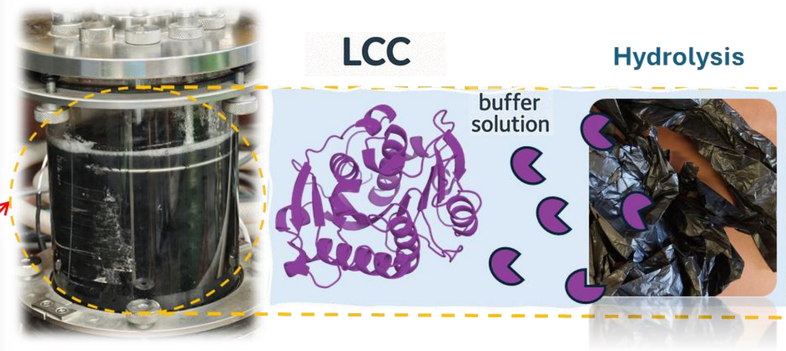
1,4-butanediol (BDO)



Mass Loss (%)



Work in progress



- ❑ Scale-up on high solid loading of a commercial PBAT-based mulch film by using the best-performing enzyme (LCC)

Conclusive remarks

- LCC enzyme showed the best performance (in terms of mass loss and TPA monomer formation) on PBAT degradation
- BDO and AA formation was monitored to study occurrence ester bond cleavage mechanism

References

[1] K. Makryniotis, E. Nikolaivits, C. Gkountela, S. Vouyiouka, E.Topakas, *J. of Haz. Mat.* **455**, (2023) 131574

[2] K. Makryniotis, E. Nikolaivits, G. Taxeidis, J. Nikodinovic-Runic, E. Topakas, *Bio. J.* **19** (2024) 2400053

Acknowledgments

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