Abstract Title: Recent Advances in Enzymatic Plastic Recycling and Upcycling

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Abstract Text:

Growing amounts of plastic waste and its harmful environmental impacts have generated increasing interest in sustainable plastic recycling techniques. Recent biotechnological approaches have emerged as a promising solution for the circular plastic economy, offering a sustainable and efficient alternative to conventional mechanical and chemical recycling methods.

Extensive research spanning over 20 years on microbial polyester hydrolases allowed large-scale bio-based recycling of the prevalent polyester polyethylene terephthalate (PET), commonly utilized in packaging and textiles, through monomer recovery, while significantly enhancing our comprehension of interfacial enzyme-catalyzed depolymerization. Consequently, the present and forthcoming trajectory of PET hydrolase research has evolved from traditional enzyme mining and engineering to encompass broader subtopics, such as material property concerns and the optimization and upscaling of pretreatment and bioreactor processes. Furthermore, the acquired knowledge has advanced the discovery and design of novel enzymes capable of depolymerizing other plastics with hydrolysable backbones, including polyurethanes (PUR) and polyamides (PA, nylon). For plastics comprising solely saturated carbon–carbon bonds in their backbones, such as polyolefins and polystyrene, a chemo-biotechnological process seems to be a feasible approach wherein engineered microorganisms can metabolize small-molecule products derived from (thermo)chemical polymer decomposition to generate value-added products, surpassing the efficacy of the single enzyme-catalyzed approach.

This lecture intends to present an overview of recent advancements in the dynamic research domain of enzymatic and biotechnological plastic recycling and upcycling. This presentation will discuss the challenges and opportunities associated with, e.g., understanding fundamental plastic depolymerization mechanisms and implementing large-scale industrial practices, using examples from our group's recent publications. The bio-based circular plastic economy is envisioned to serve as a long-term strategy for reducing plastic waste, lowering its environmental impact, and facilitating human society's green transition.