Microbial Upcycling of Waste Plastic into Rationally Designed Protein-Based Polymers

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Abstract: For the sustainability of mankind's endeavors, future manufacturing will need to focus on materials with closed-loop lifecycles rather than the traditional linear extract-process-consume-dispose paradigm. Technologies that enable a circular plastics economy are particularly important. The overwhelming majority of plastics used today are derived from petrochemical feedstocks. Even with ideal application of conventional recycling approaches, these plastics can only be recycled a limited number of times before end-of-life disposal by incineration or dumping in landfills, leading ultimately to greenhouse gas emissions, pollution and disruption of natural ecosystems, and loss of feedstock material. Our research aims to develop new technologies that enable a regenerative circular economy for the plastics industry by utilizing protein-based polymers. These polymers are attractive replacements for petrochemical-derived plastics, as they can be completely degraded biologically or chemically into amino acids that are then reintroduced as fundamental building blocks for materials synthesis. Additionally, protein-based polymers can potentially access a wide range of materials properties, as their chemical sequence can be broadly tuned and precisely defined. Our strategy towards introducing protein-based plastics into a circular economy is two-fold. First, we are working to bioengineer bacterial strains that upcycle recalcitrant petrochemical-derived plastic waste into *de novo* designed protein-based polymers. In parallel, we are developing experimental and computational tools to probe sequence-structure-processing-property relationships in protein-based polymers so that materials with targeted properties can be designed at the genetic level. These combined efforts represent a multidisciplinary approach towards solving grandstanding challenges in the biomanufacturing of protein-based polymers for use as sustainable plastics in a circular economy.

Bio: Dr. Helen Zha received her B.Sc. (2007) from MIT and her Ph.D. (2013) from Northwestern University in Materials Science & Engineering. After pursuing postdoctoral research at Eindhoven University of Technology and UC Berkeley, Helen started as a tenure-track assistant professor at Rensselaer Polytechnic Institute in the Department of Chemical & Biological Engineering in 2018. Helen has received an NSF CAREER Award, published 22 peer-reviewed journal articles, and awarded 2 patents to date. Helen also sits on the Advisory Board of Materials Innovation Initiative, a non-profit organization that aims to accelerate the development of next-generation animal free textiles for consumer applications.