PROJECT SUMMARY FOR PUBLIC RELEASE FILE

Applicant: Battelle Memorial Institute (Battelle), 505 King Avenue, Columbus, Ohio 43201-2696
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Project Title: *Hybrid Approach to Repurpose Plastics Using Novel Engineered Processes*

Objectives of the Project: This project addresses Topic Area 2 of DE-FOA-0002245, aimed at developing novel methods for deconstructing and upcycling existing plastic waste. This work will be conducted to upconvert polyether-polyurethane (PE-PU) foams into regenerated polyols (POs) and diamines as high value end products. The main objectives of the HARNESS program are to: quantitatively benchmark HARNESS technology relative to linear manufacturing by performing technoeconomic and life cycle analysis of PE-PU upcycling, apply biological processing with enzymatic degradation for maximal enzymatic rates, apply chemical and mechanical approaches to improve wetting of the solid PU interface by the aqueous enzyme solution and purify and sort polyol and diamine upcycled products, and to develop market transformation and commercialization plans focused on domestic manufacturing and product distribution.

Description of the Project: To achieve PE-PU degradation and upcycling to target end products with energy savings and recycling goals ranging between 40-80% and 35-70%, respectively, the HARNESS process will employ sequentially coupled technologies. Techno-economic and life-cycle assessments will mitigate risk of thermodynamic inefficiencies. Etching, grinding and mild alkaline hydrolysis coupled with PU degradative enzymes will be used to ensure sufficiently rapid biocatalytic breakdown rate and throughput. Although regenerated POs and nitrogen-containing compounds are expected to separate well with simple liquid-liquid extraction (continuous gravity decanting), distillation will be used as a mitigation approach for low volatility products. The HARNESS technology will be implemented as a scalable operation with minimal facility footprint requirements, in either existing waste treatment or chemical processing plants, and will establish a new upcycling paradigm for PU materials.

Impact of the Project: With an increase in the share of U.S. consumption of trim foam and only 10% of total PU waste being recycled, upcycling technologies that divert PU foams from landfills need to be designed. As degradation and upconversion of PE-PU with hybrid chemical-physical-biological solutions have not been fully developed in the commercial sector HARNESS brings an upconversion process critically needed to divert more PE-PU foam material from landfills and establish at least 40% energy savings. Transition of HARNESS platform will then be made to other plastics and will provide benefit to the domestic economy by integrating local manufacturing facilities into the process and scaling up the PE-PU process. The study is well aligned with the BOTTLE consortium mission to improve energy productivity across the manufacturing/industrial sector through technological innovation and use of secondary waste feedstock.

Major Participants: Battelle will serve as the overall project leader. Our main partners are the National Renewable Energy Laboratory (NREL) which brings decades of research on chemical conversion of molecules for energy generation; Ginkgo Bioworks, a company that employs synthetic biology methods for rapid optimization of biological reactions; and Allonnia, a new venture that supplies the scale up capabilities needed to bring the HARNESS system into the market space. Other participants include polymer operating companies that have vested interests in the project and decades of experience with PU manufacturing: Huntsman, Whirlpool, BASF, Faurecia, and Steelcase. These companies will support the HARNESS platform in validation and testing of regenerated materials and provide technical guidance throughout the project.