Innovative Polyhydroxyalkanoates (PHA) Production with Microbial Electrochemical Technology (MET) Incorporation for Community-Scale Valorization

This project will increase the value and carbon conversion of food waste and mixed organic waste through bioplastics (polyhydroxyalkanoates [PHA]) formation to provide an economical solution for community-scale waste treatment in lieu of landfilling food waste or traditional anaerobic digestion (AD). Bioplastics will better valorize community-scale, mixed waste systems by generating a bioplastic product that is significantly more valuable than biogas generation. The novel process will improve the carbon conversion efficiency by more than 50%, while reducing the waste disposal costs by at least 25%. The proposed project "Innovative Polyhydroxyalkanoates (PHA) Production with Microbial Electrochemical Technology (MET) Incorporation for Community-Scale Valorization" is led by the University of Maryland (Lansing, Hassanein), with collaborators at Virginia Tech (Wang), Idaho National Laboratory (Adhikari, Hu, Wahlen), Naval Research Laboratory (Tender, Yates), quasar energy group (Li, Ge), Hampton Roads Sanitation District (Wilson), and Maryland Environmental Services (Tomczewski).

A major innovation for bioplastic production is the use of a salt-loving (halophilic) microorganism, *Haloferax mediterranei (HM)*, to address critical barriers in the bioplastic market through: 1) elimination of expensive feedstock concentration steps and harmful product extraction steps that require toxic solvents, thereby decreasing capital expenditures, 2) increased quantities of specific high-value bioplastics (poly(3-hydroxybutyrate) (PHB) and poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV)), and 3) the ability of *HM* to create bioplastic from unrefined, simple organics produced during dark fermentation of food waste. To provide the simple organics for PHA production, we will combine technologies, such as thermohydrolysis pretreatment (THP) to improve waste digestibility, dark fermentation (DF) to break apart the waste, microbial electrochemical technologies (METs) to improve carbon conversion efficiency, and novel separation techniques to purify the PHA product and recover salt used in the process. We will incorporate a comprehensive, iterative life cycle assessment (LCA) and techno-economic analysis (TEA) models to guide the development of each step to most sustainable and profitable process.

The project outcome will be marketable bio-based plastics, with reduced waste volume and disposal costs. Our work will achieve at least a 50% increase over existing carbon conversion efficiency in AD (30%) and at least a 25% reduction from existing food waste disposal costs ($75/dry ton), which will enable quasar energy group, our committed entrepreneur partner and leading bioenergy business experts, to take the process from pilot-scale to commercialization.

This project will accomplish five project tasks: 1) initial verification of our baseline metrics, 2) maximize production of an optimized feedstock for bioplastics production (volatile fatty acids) using THP, DF, and MET, while arresting methane production (an unwanted byproduct), 3) increased production of bioplastics, specifically higher level bioplastics (PHBVs) using pure cultures of the halophilic organism, *HM*, with enhanced PHA separation allowing production from all food waste, including high salinity food processing and aquaculture wastewater, which are difficult to treat, 4) incorporation of TEA and LCA into each process step; and 5) operation of a continuous flow reactor system (50 L) with enhanced PHA product formation for at least 100 hours under realistic conditions. Our team includes industrial partners to ensure that we have access to real waste streams while also receiving input directly from industry at every level of the project to ensure that the work directly impacts the envisioned end users. The proposed project here will enable the economical treatment of waste streams at the community scale with increased carbon conversion efficiency and decreased disposal costs.