Synergistic Thermo-Microbial-Electrochemical (T-MEC) Approach for Drop-In Fuel Production from Wet Waste

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Project Description:

This project aims to address the wet waste disposal and valorization challenges at community scales with much higher efficiency and lower cost. We propose to develop a synergistic approach to enable a total conversion of food waste to high quality jet fuel blendstocks while also solving its aqueous phase problem. Hydrothermal liquefaction (HTL) can effectively convert wet waste to biocrude oil that can be further upgraded into transportation fuel. However, the post-HTL wastewater (PHW) has become a major bottleneck and carbon sink on its application. On the other hand, hydrotreating and hydrocracking HTL biocrude requires a large amount of H_2 (currently generated via steam reforming of natural gas), which is a significant cost item and barrier of biomass-to-jet fuel efforts.

In this project we will develop a synergistic thermo-microbial-electrochemical (T-MEC) process that converts food waste to jet fuel blendstocks and simultaneously treats aqueous wastewater and recovers H_2 and nutrients. Specifically, we will partner with SnapShop Energy to collect food waste mixes for HTL conversion to biocrude oil. The biocrude oil will then be distilled into distillate fractions and catalytically upgraded to bio-kerosene (jet fuel). New catalysts and processes will be developed, and the kerosene products will be tested using ASTM standards. In the meantime, the PHW will be directed to integrated microbial electrochemical cells (MEC) and thermal electrocatalysis (TEC) reactors to convert the liquid waste to H_2, CO_2, NH_3, and clean water. Electroactive membrane electrodes will be developed to extract NH_3 and H_2 with high efficiency. The TEC process concurrently generates H_2 and reduces CO_2 to form clean tunable syngas, which will be converted into transportation fuels via an established system at PNNL. The PHW valorization process closes the carbon and energy loops by providing sufficient H_2 for biocrude upgrading and capturing the previously lost aqueous carbon and nutrients.

We will develop and demonstrate on site a pilot T-MEC system that continuously treats 1-ton/day food waste and generated PHW for hundreds of hours. System-level analyses including technoeconomic analysis (TEA) and life cycle assessment (LCA) will be performed, and it is estimated that system carbon efficiency will be increased from anaerobic digestion baseline of 35-45% to >75%, and the disposal costs will be reduced by >25%, attribute to reduced waste and high-value products recovery.

Project Impacts:

This project enables the integrated valorization of food waste by generating ASTM-quality drop-in fuels and reducing cost and increasing carbon efficiency via wastewater resource recovery. This approach carries great promise to sustainably manage and valorize ~15 million dry tons of food waste (potentially ~77 million dry tons wet waste) and generate hundreds of millions to billions of dollars in revenue each year. With this development, the national bioeconomy portfolio will be expanded, the local economy and job markets will be boosted, and national energy security will be improved.