Project Title: Scale-up of Biodegradable Plastic Product to Enable the Economic Renewable Aviation Fuels

Name of the Applicant: Texas A&M AgriLife Research/ Texas A&M University (TAMU)
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Objectives: The project scales up a platform from a nearly completed BETO project to address challenges in lignocellulosic biorefining (LB) and plastics fate. We will evaluate how the recently developed waste-to-bioplastics platform improves the cost-effectiveness of biomass-based renewable jet fuel from LB. To date, we have developed novel technologies for manufacturing low-cost PHA (Polyhydroxyalkanoates, ~$2.5/kg) from LB waste using engineered microbial strains, improved fractionation, and optimized fermentation. We will integrate this with 1) Danimer Scientific PHA separation and plastic product manufacturing capacity, 2) POET and NREL biomass to jet fuel processing capacity, and 3) Madbouly, Dai, and Yuan team's novel technologies for performance-enhanced bioplastics. Collectively, this will reduce jet fuel net production cost, permit replacing non-degradable plastics with biodegradable ones, broaden bioplastics market access through performance enhancement, and allow production volume matching with LB waste streams. Moreover, technoeconomic analysis indicates the platform could reduce ethanol price to ~$2.5/GGE, and this could translate into opportunities to produce low-cost renewable jet fuel.

Description: In Obj. 1/Task 2, we scale up our lignin-to-PHA platform to half dry-ton/day biomass and 100-hour operation. In Obj. 2/Task 3, we integrate lignin-based PHA production with downstream separation and performance-improved consumer products. In Obj. 3/Task 4, we carry out the conversion of hydrolysate into 2,3-BDO to jet fuel and evaluate economic and environmental impact LB employing TEA, LCA, market analysis, and supply chain optimization.

Impact: The project brings significant innovations, including 1) the integration of biomass-to-2,3-BDO and lignin-to-PHA to potentially reduce jet fuel price, 2) performance-enhanced and cost-effective biodegradable plastic products to broaden the application and market penetration, 3) the flexibility of sugar conversion into jet fuel or bioplastic products to respond to market and maximize LB value output and income, and 4) the synergy with corn ethanol byproducts DDGS to collectively lower jet fuel costs based on high-value contributions of bioplastics. The innovations address major challenges in LB economics and biodegradable plastics with broad impact. First, we will make an improved plastic product by integrating commercial partner PHA separation and Dr. Madbouly and Dai's technologies to use DDGS and nanofillers in improving degradability and structural performance, facilitating the U.S. penetration into the growing biodegradable plastics market. Second, pilot-scale operation enables rigorous TEA, LCA, market potential, and supply chain optimization, allowing industry consideration for commercialization. Third, partnering with the largest U.S. PHA producer will develop commercially ready, low-cost, performance-enhanced PHA-based products. Fourth, coupling team technology with POET-produced DDGS synergizes our LB process with first-generation biofuel products as required in the FOA. Fifth, preliminary TEA analysis indicates that bioplastic revenues could reduce ethanol prices significantly, and similar cost reductions are expected for jet fuel. Sixth, the pathways to biodegradable consumer and industrial plastic products will simultaneously address plastics environmental challenges.