Applicant: North Carolina State University (NCSU)

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Project Title: Catalytic Upgrading of Carbohydrates in Waste Streams to Hydrocarbons

Project Objectives: The primary objective is to develop a process for converting the carbohydrates in paper sludge, a wet organic waste stream, into a hydrocarbon (HC) product that can be blended into jet or diesel fuel, both economically and sustainably.

Project Description: Previous work performed at NREL, NCSU, and other laboratories, starting with pure sugars and some biomass feedstocks, has shown it is possible to convert carbohydrates into HC products, but none has been performed with the proposed waste feedstock. Other proposed work within the project will be performed to assess and overcome any negative effects due to non-carbohydrate components, such as inorganic ash, and the potentially higher level of variability in the paper sludge compared to pure sugars and biomass. A further objective is to show that the process is economic and environmentally sustainable through techno-economic analysis (TEA) and life cycle assessment (LCA) of the process, and show that there is the potential for a minimum 25% reduction in the net levelized cost of disposal of the paper sludge. A final objective is to validate the process at a relevant scale and produce sufficient HC product for fuel property analyses to demonstrate its blendability into jet or diesel fuel.

Methods to be Employed: The project will be accomplished by 1) removing ash from paper sludge, 2) enzymatically hydrolyzing carbohydrates in paper sludge to monomeric sugars, 3) dehydrating both pentoses and hexoses to furfural and 5-hydroxymethylfurfural, 4) condensing furans with ketones via an aldol condensation to produce intermediates containing molecules with 14 to 16 carbons, 5) catalytic hydrodeoxygenation of the intermediates to paraffins that have excellent properties for blending into jet or diesel fuel, 6) executing robust TEA and LCA to focus research on developing cost-effective routes to produce advanced biofuels, address key cost barriers, and ensure the sustainability of the process.

Potential Project Impact: Hydrocarbon biofuel production is a key component of DOE's strategy to research and develop the optimal transformation of biomass resources into high performance biofuels, supported through public and private partnerships. This is to be accomplished by conducting research and development in advanced biotechnological processes capable of increasing energy production from domestic lignocellulosic feedstocks, with emphasis on reducing U.S. dependence on imported fossil fuels and enable development of price-effective advanced biofuels and coproducts. In the U.S., more than 8 million wet tons of paper sludge (50% moisture) are generated annually. Almost all is landfilled at an approximate cost of $200 million per year, including trucking and landfilling costs. Approximately 40 locations produce 100 dry tpd of paper sludge or more. The carbohydrates in paper sludge could be converted to 0.15 billion gallons of diesel fuel, showing that this project is precisely aligned with DOE's strategy for production of high performance biofuels.

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