Applicant: North Carolina State University (NCSU)

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Other Key Participants: Barry Freel and Geoff Hopkins (Ensyn), Zachary Combs (Birla Carbon), James Fleetwood (Battery Innovation Center), Adam Whalley (Zeton Inc.), Evan Hyde (Refinery Community), Yuan Yao (Yale University), Stephen Kelley and Hasan Jameel (NCSU), Sang-Don Han and Abhijit Dutta (NREL).

Project Title: Scaling Up Biocrude Derived Anode Material (BDAM)

Project Objective: The objective of this project is to scale up the key process ("delayed coker") for converting biocrude pyrolysis oil into high-quality graphite and hard carbon that are economically and environmentally preferred as anode materials in lithium and sodium ion batteries.

Project Description: Previous lab-scale work at NCSU and NREL has shown that a fraction of biocrude oils from fast pyrolysis of woody biomass can be converted into graphite and hard carbon, which perform as well as commercial anode materials in lithium and sodium ion batteries. The remaining biocrude is preferred for biofuels production. This project will reduce commercialization risks by scaling the initial critical carbonization process, so-called "delayed coker", which is common in most petroleum refineries. Experimental data collected in this project will be used to design, build, and operate a pilot-scale delayed coker. The reactor will be demonstrated for more than 500 hours with fast pyrolysis biocrude. The intermediate carbons produced in the pilot-scale delayed coker will be further processed into graphite and hard carbon, and their electrochemical performances will be evaluated for battery applications. Techno-economic analysis (TEA) and life cycle analysis (LCA) will be conducted to identify and improve the specific process steps that have the greatest impact on costs and sustainability, respectively.

Methods to be Employed: The team will conduct laboratory experiments to determine scale up parameters for graphite and/or hard carbon production, and conduct initial economic analysis to guide the experimental details. Zeton and Refinery Community will help with designing the pilot-scale delayed coker, and Zeton will construct the reactor. Ensyn will run the delayed coker for 500 hours using a standard pyrolysis oil, and then the reactor will be transferred to NREL where catalytic fast pyrolysis oils will be evaluated. With the help of Birla Carbon, graphite and hard carbon will be produced from laboratory- and pilot-scale intermediate carbons. Battery performance tests will be conducted at NREL and the Battery Innovation Center. The full-scale TEA modeling will be conducted at NREL and NCSU, while the LCA work will be conducted at Yale.

Potential Project Impact: The most common type of battery-grade graphite is imported from other countries, where it is mined and upgraded using energy- and chemical-intensive processes with severe environmental burdens. Development of a less-severe, cost-effective process for producing anode materials for battery applications from domestically sourced biocrude has the potential to impact the market for electric vehicles and grid electrical storage, thereby boosting the US bioeconomy. The markets for these batteries are growing by more than 20% per year, and are fundamental for electric vehicles and large-scale deployment of solar and wind power. In addition, the successful production of value-added co-products is critical to biorefinery commercialization by lowering the production costs of renewable liquid transportation fuels.