Near-critical Fluids Treatment for Liquefaction and Extraction of Bio-Fuels

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Category 1a: Scale-up of Biotechnologies – Pre-pilot for Biofuels and Bioproducts
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Executive Summary

We propose to develop liquefaction of biomass and biowaste feedstocks in the presence of near-critical fluids such as supercritical CO_2 (sCO2) and subcritical water (SW) to form oil-products and subsequently extract hydro-treating-suitable bio-crude to produce liquid-biofuels and valuable chemicals. The proposed process will build on the emerging hydrothermal liquefaction (HTL) process for bio-crude products by utilizing the synergistic solvent properties of sCO_2 and SW to improve the quality of bio-crude and provide robust operation and fuel extraction. Low viscosity and high density of these near-critical fluids will improve the process operation while tunability in solvent properties with temperature and pressure will provide efficient product extraction to remove water, metal, and O-content of bio-crude. This improved bio-crude composition will provide improved ageing stability, carbon content, heating value and compatibility to industrially established hydro-treating processes to obtain transportation fuels compared to the baseline of HTL. In addition, near-critical fluids mitigate the energy intensive moisture control requirements in feedstocks and thus also allow for conversion of diverse moisture grades of biomass into liquid fuels. This improvement in bio-crude quality, yield, efficient dewatering, and product extraction will provide us with lowered GHG emissions to beyond 70% reduction compared to petroleum-based alternatives. Integration of dewatering, liquefaction, and sCO_2-extraction can be achieved for efficient operation and potentially lowered capital costs.

For this research, process components, mainly sCO_2-feedstock-dewatering, near-critical liquefaction, and sCO_2-bio-crude extraction, will be developed for continuous mode operation and investigated to build predictive models of their operation. These reactor studies will be carried out at FOA-relevant scale to gain design knowledge of the operational requirements for demonstrated process output. Different real feedstock samples will be examined each from different classes including lignocellulosic, algal, wet biomass, and sorted municipal solid wastes. The influence of operational parameters such as temperature, pressure, solvent/feedstock ratio, feedstock loading, residence time, and solvent requirement on process output such as energy input, GHG impact, water and CO_2 recyclability, product quality and yield, and by-products will be achieved from these tests. Bio-crude and sCO_2-extracted crude components' quality will be judged in terms of parameters such as O/C, H/C, composition, viscosity, ageing stability, water content, density, and heating value. The goal will be to obtain bio-crude with capabilities to be incorporated into hydro-treating plants of petroleum-crude which yield transportation fuels. This will be demonstrated based on ASTM standard characterization of the extracted-bio-crude and its similarity with petroleum-crude. Predictive process models will be developed accordingly, which will be used further for life-cycle and techno-economic analysis of integrating these components. These analyses will be utilized to determine the economic, GHG and fuel cost impact of the integrated process along with optimal conditions and process integration needed for maximizing these benefits.