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PROJECT SUMMARY
Scale-Up of the Primary Conversion Reactor to Generate a Lignin-Derived Cyclohexane Jet Fuel

Applicant: University of North Dakota
Principal Investigator: Wayne Seames with co-PIs: Alena Kubatova and Bethany Klemetsrud

Subcontractor: Washington State University, co-PI: Bin Yang
FFRDC Subcontractors: DOE/NREL's National Bioenergy Center, co-PI: Xiaowen Chen and DOE/INL's Energy & Environmental Science & Technology Division, co-PI: Allison Ray
Industrial Partner: Advanced Refining Technologies, Lead: Darryl Klein

In this project, the University of North Dakota (UND) in collaboration with Washington State University (WSU), DOE/INL's Energy & Environmental Science & Technology Division, and DOE/NREL's National Bioenergy Center will design, build, and test an engineering scale version of the key reaction step for a process to convert reactive lignin into a cyclohexane-rich kerosene/jet fuel. These data will then be used in techno-economic and sustainability analyses to define the commercial potential of the technology. Also included are catalyst improvements to increase reaction conversion yield and/or selectivity to the target cyclohexanes and/or decrease catalyst costs by replacing REEs with more common metals in the catalyst formulation. Improved reaction production characterization method development is also provided.

Corn stover will be preprocessed by INL and shipped to NREL where it will be converted using NREL's dilute alkali deacetylation and mechanical refining process into a 10 wt% reactive lignin in a 10 pH NaOH/water solution. This reactive lignin slurry will be shipped to UND where it will be reacted with H_2 over an innovative bi-functional catalyst to directly generate alkylmono-cyclohexanes and/or alkyl dicyclohexane derivatives using the aqueous catalytic hydrodeoxygenation process developed at WSU. These will be produced by the catalytic depolymerization of lignin into monomers and dimers (cleaving C–O–C bonds without disrupting C–C linkages) followed by catalytic hydrodeoxygenation using a bifunctional catalyst. The C_{12}-C_{18} cyclic structure hydrocarbons will then be isolated from other reaction products with a projected yield of at least 30 wt% of the inlet carbon.

WSU with assistance from ART will generate pelletized forms of their existing catalyst. Then, a bench-scale continuous system will be used to translate the current batch, lab-scale reaction and optimize conditions for continuous operation with a pelletized form of the catalyst. Using the design parameters generated, an engineering scale reactor system will be designed, built, and commissioned capable of processing 8L/hr of the lignin solution (corresponding to 50 tons/hr of corn stover) into the cyclohexane-rich intermediate product solution. The improved analytical methods will be used to fully characterize the reaction products. After commissioning, the engineering scale catalytic hydrodeoxygenation system will be operated for at least 100 continuous hours and for at least 500 total hours using the original catalyst formulation. Then the system will be used to test the improved catalyst formulation developed during the project. The rest of the process will be simulated so that a techno-economic analysis can be performed. Lifecycle analysis will also be conducted to quantify the reduction in greenhouse gas (GHG) emissions for the enhanced jet fuels.