Summary

Conversion of 2,3-Butanediol to Biojet Fuel: Scale-up and Technoeconomic Analysis of Energy-Efficient Separations and Fermentative Diol Production

Applicant: Georgia Institute of Technology (GT)
Partners: National Renewable Energy Laboratory (NREL)
Oak Ridge National Laboratory (ORNL)
ExxonMobil Research & Engineering (EMRE)
Principal Investigator: Sankar Nair
Co-Investigators: Matthew Realff, Carsten Sievers, Richard Elander, Eric Karp, Michael Hu, Christine Elia, Benjamin McCool

This project targets key process scale-up, modeling, detailed evaluation, and TEA/LCA issues in the conversion of 2,3-butanediol ("BDO") to kerosenic biojet fuel blendstocks for commercial aviation. The overall objectives are to: **(1)** Accomplish critical and "next logical level" scale-up steps of novel, specialized technologies developed by us for fermentative production of BDO and its separation from aqueous phase by adsorptive and membrane processes, **(2)** Incorporate above technologies to modify the technoeconomic and life cycle analysis of a BDO-to-hydrocarbon fuel process, and **(3)** Perform laboratory-scale conversion of highly enriched BDO to biojet fuel by known catalytic pathways, in order to conduct ASTM blendstock specification testing and establish relationships between catalytic conditions and fuel properties.

These objectives will be achieved by collaborative advancement of five project elements. **(1)** We will demonstrate scale-up of BDO enrichment to 85+wt% from clarified fermentation broths by a cyclic or continuous adsorption pilot plant to produce 100 kg BDO at > 1 kg/day. **(2)** We will demonstrate construction and operation of a multitubular pervaporation membrane module to pre-concentrate the BDO broth. Each of these scaled-up systems will be operated for 500 h cumulative and 100 h continuous on-stream time. **(3)** To support the above two objectives, we will demonstrate scale-up of fermentative BDO production at 1000 L scale, to obtain at least 100 kg BDO with at least 100 g/L concentration early in the project. **(4)** Laboratory-scale catalytic conversion work will carefully evaluate and optimize catalyst properties and conditions for enriched BDO feeds, and produce biojet fuel samples that meet ASTM biojet blendstock standards by project-end. **(5)** The entire project will be tied together by a process modeling, TEA, and LCA framework that will produce accurate, well-parametrized separation process models validated during our scale-up work, and integrate them with an overall process TEA to meet (modeled) throughput, minimum fuel selling price (MFSP), and CO_2 emissions reductions.

Many reports document the attractive market for jet fuel, and large CO_2 reductions that would be enabled by a shift to biojet fuel. A key technology challenge for further driving the MFSP below $2.5/GGE is to reduce the cost and increase the quality of BDO feedstock to the catalytic conversion process. In this context, our tightly-integrated approach has clear potential for deeply driving down the MFSP and CO_2 emissions of biojet fuel. Our initial separation process model and TEA estimate a net-present-value (NPV) benefit of more than $0.15/GGE for the proposed process over the SOT for 10-year biojet production, with high potential for further process improvements. This would be a very significant and transformative impact of this work. The separation and fermentation technologies scale-up levels will be 100X and 1000X respectively from present bench scale, and would constitute the highest scale-up for BDO production to date.