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PNNL-SA- 166047

# Microchannel Reactor for Ethanol to Butene

## CRADA 503

September 2021

*Robert Dagle*

LanzaTech, Inc.

Oregon State University

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
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Abstract

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## Abstract

A key challenge facing most bioprocessing operations is that multiple unit operations are required, thereby resulting in complex, energy-intensive, and expensive processes. Further, biomass transportation costs drive the need for smaller, distributed processing plants. To incorporate the smaller scales desirable for biomass, novel processes must be developed with reduced capital costs. With over 20 years of experience in the development and commercialization of microchannel reactor technology, Oregon State University will partner with Pacific Northwest National Laboratory to demonstrate a microchannel reactor with lower capital costs for an alcohol-to-jet (ATJ) process technology that is currently being commercialized by LanzaTech. Ethanol can be produced from biomass feedstocks such as LanzaTech's proprietary biochemical process using carbon from a number of possible feedstocks; syngas generated from biomass resources (e.g., MSW, organic industrial waste, agriculture waste) or reformed biogas, or from other biomass feedstocks such as corn kernel fiber. Ethanol then undergoes catalytic dehydration to form ethylene followed by a two-step oligomerization, hydrogenation, and fractionation to control the hydrocarbon product slate to the jet-range. Successful process development aided by a market pull for low carbon aviation fuel has spurred scale-up and commercial demonstration. However, Sustainable Aviation Fuel is a very price sensitive market and improved economics through process intensification will make the current ATJ process even more attractive. Recent efforts at PNNL have culminated in the development of a new catalyst technology for the conversion of ethanol to n-butene-rich olefins. A greater than 90% conversion, total olefin selectivity of 80-90% (n-butene selectivity ~60%), and good stability over a 100 hour test duration has been demonstrated at the bench scale. Producing butene-rich olefins directly from ethanol with high yield is new and impactful because the higher olefins can be selectively oligomerized to distillate-range hydrocarbons, thus eliminating one process step from the current ATJ process. Further, coupling the severely endothermic ethanol dehydration with exothermic C-C bond formation results in more energy efficient processing. Additional intensification and energy savings will stem from incorporating this new ethanol to n-butene catalyst technology within the ATJ process implemented using a microchannel reactor platform. Due to recent advances in microchannel manufacturing methods and associated cost reductions we believe the time is right to adapt this technology toward new commercial bioconversion applications.

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