Higher energy-content jet blending components derived from ethanol

Area of Interest: 5 Optimization of Bio-Derived Jet Fuel Blends
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Team Member Organizations

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Bioenergy Technologies Office (BETO) efforts in generating sustainable aviation fuels (SAF) have helped establish the production of synthetic isoparaffinic jet fuels with favorable properties, such as high energy density, excellent thermal stability, and favorable cold flow performance. When blended with isoparaffins, <u>cycloalkanes carry the potential of further fuel performance improvement</u> with at least a 4% net increase in energy content. PNNL and LanzaTech have already demonstrated a sustainable, non-petroleum, route to isoalkanes. However, economically attractive cycloalkane production from waste and biomass is challenged by large hydrogen requirements, preferential selectivity to aromatic compounds and low yields to jet fuel range components. Many gaps in understanding cycloalkane properties and performance in complex jet fuel mixtures remain. Purdue University has teamed with LanzaTech and PNNL to fill these knowledge gaps by analyzing fuel samples generated using a novel cyclization chemistry, providing a feedback loop to inform that chemistry based on properties that are proxies for performance and operability, followed by an examination of economic, ecological, and societal pressures associated with deployment of the technology in the U.S. The close tie and integration of Purdue's fuel property analysis, with PNNL's process development, can lead to an economically attractive process.

The overarching strategy of the Purdue-LanzaTech-PNNL team's work proposed here targets the understanding of current and new cycloalkanes for use as a jet fuel. Through catalyst development, this work will provide a route to control the cycloalkane/n-alkane/iso alkane content of a next-generation fuel with minimal or no aromatic content. Combining n-alkane and iso-alkane streams (high specific energy, MJ/kg) with cycloalkanes (higher energy density, MJ/L), is expected to enable at least a 4% net increase in combined (specific (MJ/kg) and volumetric (MJ/L)) energy content without impacting 'drop-in' fuel requirements, such as seal swelling.

This project will result in a selective low-cost route to high performance renewable blendstock fuels. The team will develop a novel process and catalyst system for building cyclic alkanes in the jet fuel range with minimal hydrogen consumption, processing requirements, and carbon intensity. This cycloalkane-rich fuel can be blended with n-alkanes and iso-alkanes (based on performance testing data from Purdue) from the previously developed LanzaTech/PNNL Alcohol-to-Jet process, to provide a fuel with ideal performance attributes. The fuel analysis and testing by Purdue will enable a robust understanding of the properties and behavior of the cycloalkanes produced to inform process development. Additionally, seal-swelling analysis will quantify the ability of fuel blends with zero or minimal aromatics content to satisfy the seal swell requirement of O rings. Lastly, Purdue's system-level analysis will lead to the development of a roadmap for deployment in key regions that takes into account system pressures such as hydrogen, water, energy efficiency, and ease of infrastructure access.