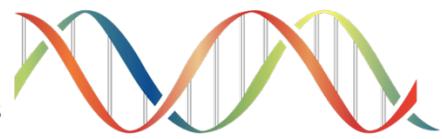




Community BioRefineries
The Epitome of American Innovation



As a Fermented Alcohol-to-Jet (ATJ) Scholar

Scott Hewitt CEO and Vincent James Ph.D. CTO

Alcohol-to-Jet (ATJ): ATJ is a conversion technology that involves transforming alcohols (like ethanol, methanol, or butanol) into synthetic paraffinic kerosene (SPK), which is a type of jet fuel. This process typically includes stages such as dehydration, oligomerization, hydrogenation, and distillation. The resulting jet fuel is then blended with conventional jet fuel to meet aviation standards. ATJ has been recognized as a promising pathway to create sustainable aviation fuel (SAF) due to its ability to utilize various renewable feedstocks.

The Role of Fermented Alcohols in SAF Development

As the aviation industry continues to seek lower carbon, sustainable alternatives to fossil fuels, biofuels have emerged as a critical focus area. Among the biofuels, four fermented alcohols—methanol, ethanol, propanol, and butanol—are often considered as potential candidates for use in various applications. Understanding their properties is essential to evaluating their suitability as aviation fuels:

- **Methanol (CH₃OH):** Also known as wood alcohol, methanol is produced from biomass or synthesized from natural gas. However, its low energy density and high toxicity make it less ideal for aviation fuel;
- **Ethanol (C₂H₅OH):** Commonly used in biofuel production, ethanol is derived from the fermentation of crops like corn and sugarcane. Originally, ethanol began its use as an adjunct to petroleum fuels (gasoline and diesel) as a quick-fix response to the mandates of the Renewable Fuels Act. Despite its widespread use in gasoline, ethanol poses challenges for aviation due to its low energy density, high vapor pressure, and water absorption tendencies (which also prohibits it from transport via the pipeline infrastructure).
- **Propanol (C₃H₇OH):** Available in two forms – 1-propanol and 2-propanol - propanol has intermediate fuel properties but does not meet the stringent requirements for jet engines due to its moderate energy content.
- **Butanol (C₄H₉OH):** Butanol stands out as the most promising candidate among these alcohols. Its higher energy density (around 29.2 MJ/L) and favorable chemical properties make it far more compatible with existing jet fuel infrastructure than the other alcohols. Butanol's ability to blend seamlessly with aviation fuels, coupled with its lower vapor pressure and water tolerance, positions it as a leading choice in the sustainable aviation landscape. (Note: The oil industry has been seeking ways to produce bio-butanol on a commercial scale as a replacement for ethanol (due to its hydrophilic properties) to enable them to transport their biofuels via the existing pipeline system vs. the more expensive rail lines.)

Why Biobutanol Is a Superior Choice for Jet Fuel Over Ethanol

Among these alcohol-based biofuels, biobutanol has proven to be the most suitable for aviation use, primarily due to the following reasons:

- **Higher Energy Density:** With an energy density of approximately 29.2 MJ/L, biobutanol significantly outperforms ethanol's 21.1 MJ/L, making it a more efficient fuel option for aviation where range and energy output are crucial.
- **Chemical Compatibility:** Biobutanol boasts lower vapor pressure, a higher-octane rating, and reduced water absorption compared to ethanol, making it a more stable and safer choice for jet engines. These characteristics help prevent issues like vapor lock and ensure smoother engine performance.
- **Innovative Production Techniques:** Community BioRefineries (CBR) has revolutionized bio-butanol production through its continuous flow process, enhancing both the efficiency and cost-effectiveness of the fuel. By utilizing diverse feedstocks, such as corn, industrial hemp, sweet cane sorghum, soy, and even dairy

cheese waste, CBR has demonstrated the potential of turning underutilized materials into high-value bio-based products.

The Challenges of Ethanol in Jet Fuel Applications

Despite its popularity in ground-based biofuel applications, ethanol faces significant hurdles when it comes to aviation fuel:

- **Low Energy Density:** Ethanol's energy density is considerably lower than that of Jet-A1 fuel, making it inefficient for aviation use as a larger volume of ethanol would be needed to achieve the same energy output.
- **High Vapor Pressure and Water Absorption:** Ethanol's tendency to evaporate easily and absorb water can lead to issues such as phase separation and ice formation, which are particularly detrimental to aircraft performance and safety.
- **Incompatibility with Jet Engine Systems:** The chemical structure of ethanol is not suited to the specific requirements of jet engines, potentially leading to poor combustion, reduced engine efficiency, and increased wear on engine components.
- **Biochemical drawback:** Ethanol is naturally corrosive to metallic surfaces, which is why the entire fuel systems of gasoline powered autos had to be re-engineered to accept gasoline with any amount of ethanol present. (This also extended to all smaller gasoline engines for uses such as lawn mowers, snow blowers, and even the smaller 2-cycle engines.)

To re-engineer the fuel and combustion elements of a jet engine, given the extreme operational pressures and temperatures involved, presents a monumental cost to 1) every entity which currently uses jet engines for any purpose, requiring a total replacement, or, a complete "re-hab" of their current engines, and/or 2) all jet engine manufacturers will have to re-design their engines and produce the "updated" versions at a huge cost to those companies.

- **Regulatory Limitations:** Ethanol fails to meet the strict standards set by aviation authorities, making it difficult to certify ethanol-blended fuels for commercial jet use.

The Strategic Role of the Minnesota SAF Hub in Scaling SAF Production

The establishment of the Minnesota SAF Hub through the GREATER MSP Partnership, supported by leaders like Delta Air Lines, Bank of America, Ecolab, and Xcel Energy, is a significant stride toward creating a comprehensive SAF value chain aimed at decarbonizing the aviation sector. The multi-phase approach to integrating SAF into Minnesota, alongside future advancements in regenerative agriculture, aligns perfectly with the innovative strategies employed by Community BioRefineries, LLC (CBR).

While the SAF Hub's efforts to scale sustainable fuel production are commendable, CBR and its partnership with Burnett Dairy represent a true game-changer in this field. Their use of multiple feedstocks – to include dairy cheese waste, corn, industrial hemp, and perhaps sweet cane sorghum - not only enhances the sustainability of biobutanol production but also demonstrates a commitment to maximizing the potential of every molecule in these resources.

As we conclude this journey into Fermented Alcohol-to-Jet (ATJ) fuel technology, the words of Antoine de Saint-Exupéry come to mind:

"As for the future, your task is not to foresee it, but to enable it."

Saint-Exupéry, a celebrated aviator and author of *The Little Prince*, was not only a pioneer of early aviation but also an innovative thinker whose contributions helped shape the spirit of flight during the 20th century. His experience as a pilot during the dawn of aviation led him to explore the limits of aircraft capabilities, directly influencing advancements in flight technology. Though he did not directly contribute to jet fuel technology, his advocacy for innovation and his philosophical outlook on pushing boundaries laid the foundation for future developments in aviation fuel and design, including the sustainable advances we are witnessing today.

CBR and its partnership with Burnett Dairy are true game-changers in this mission, leading the charge by transforming agricultural by-products into sustainable aviation fuel. Their innovative use of diverse feedstocks marks a significant shift from traditional methods, turning what was once seen as waste into a powerful driver of progress. These efforts exemplify the proactive spirit that aviation pioneers like Saint-Exupéry once championed—a commitment to not just adapt to the future but to actively create it.

As we face the limitations of ethanol and the increasing need for more efficient biofuels, biobutanol stands out not only as a superior choice but as a testament to our ability to reshape the aviation industry. In this pursuit, CBR and Burnett Dairy's vision highlights that true innovation lies not in predicting the future but in building it—fueling our skies with solutions that honor both our past achievements and our responsibility to the planet.

Burnett and CBR accomplish all this by applying what had previously been waste disposal challenges and turning them into a means for truly innovative green solutions.

Vincent James has been a science and technology driver for Community BioRefineries for many years. His doctoral work focused on organic Zymology (fermentation science).