Alcohol to Jet - Isobutanol

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Vice President Regulatory Affairs
Gevo Inc.

Session 3 – Next in the Production Line: What to Expect for Future Development and Production of Aviation Alternative Fuels
Alcohol to Hydrocarbons

- Biocatalyst (yeast)
- Gevo integrated fermentation technology (GIFT®)
- Isobutanol
- Alcohol to Jet (ATJ)
• Sugar to Isobutanol fermentation facility owned by Gevo and producing renewable isobutanol.

• Location – Luverne, MN

• Creating the feedstock for our demonstration scale ATJ process in Silsbee, Texas
• Proprietary processing based on standard unit operations in a typical petroleum refinery.
• Gevo has been producing jet fuel since 2011 with over 5 years of process performance data on process capability and feedstock, including QA/QC process control charts to 6 SIGMA.
• Process yields have been shown at 98% of theoretical.

Process Flow
ASTM D7566 Annex 5

Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons

A5. ALCOHOL-TO-JET SYNTHETIC PARAFFINIC KEROSENE (ATJ-SPK)
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Freezing Point (ASTM D2386)</td>
<td>-40°C max Jet A -47°C max Jet A-1</td>
<td>- 50°C</td>
<td>&lt;-80°C</td>
</tr>
<tr>
<td>Flash Point (ASTM D3828)</td>
<td>38°C min</td>
<td>48°C</td>
<td>48°C</td>
</tr>
<tr>
<td>Energy Density (Net Heat of Combustion) (ASTM D3338)</td>
<td>42.8 MJ/kg min</td>
<td>42.9 MJ/kg</td>
<td>43.2 MJ/kg</td>
</tr>
<tr>
<td>Thermal Oxidation Stability (JFTOT) (ASTM D3241)</td>
<td>pass</td>
<td>pass</td>
<td>pass</td>
</tr>
<tr>
<td>Total Sulfur Content (ASTM D2622)</td>
<td>0.3% max</td>
<td>0.05%</td>
<td>&lt;0.01%</td>
</tr>
</tbody>
</table>
• Extensive Quality Control Process of each lot which includes requirements from ASTM, Joint Inspection Group (JIG), DEFSTAN 91-91 and others.

• Analytical testing completed by Third Party per ASTM D7566 Annex 5 requirements.

• Chain of custody requirements on container cleaning procedures, transfer documents, etc. built in to Gevo standard SOPs.
• True carbon reduction comes from using renewable carbon and not emitting petroleum carbon back into the atmosphere

• Through ASTM D6866 carbon 14 analysis we show our customers that our product is 100% renewable carbon and does not contain petroleum derived carbon.

<table>
<thead>
<tr>
<th>Submitter</th>
<th>Beta Analytic, Inc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
<td>Miami, FL 33195 USA</td>
</tr>
<tr>
<td>Date Received</td>
<td>December 22, 2016</td>
</tr>
<tr>
<td>Date Reported</td>
<td>December 22, 2016</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent Biogenic Carbon</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory Number</td>
<td>4064215</td>
</tr>
<tr>
<td>Testing Method</td>
<td>D6866-15 (Method B145)</td>
</tr>
<tr>
<td>Percent modern carbon (MMC)</td>
<td>152.4 +/- 0.3</td>
</tr>
<tr>
<td>Atmospheric adjustment factor</td>
<td>121.6 x [ppmc]</td>
</tr>
</tbody>
</table>

1. The work was done at Beta Analytic in their chemistry lab and AMS. No non-renewable carbon was used.
2. Beta chemistry laboratory and AMS do not need or measure artificial C14 used in terrestrial and environmental AMS testing.
3. Validating quality assurance is verified with a Quality Assurance report posted securely to the web library containing the PDF members-only copy of this report.

ASTM D6866-15 gives precision on Percent Biogenic Carbon as +/- 2% absolute. The data precision on the analytical measure (ppmc) is 1 sigma (relative standard deviation). The reported result only applies to the analyzed material. The amount of the % biogenic carbon result relies on the carbon present in the analyzed material having been in recent equilibrium with CO2 in the air and/or food chain living systems more than 40,000 years old. "Percent biogenic carbon" specifically refers to organically derived carbon as total carbon (TC), not to total mass. Percent biogenic carbon is calculated by dividing ppmc by the applicable RF adjustment factor specified in ASTM D6866-15: % biogenic carbon = [ppmc] / [RF] +/- 2% absolute.
First History Commercial Flight with 20% Blend ATJ Cellulosic Renewable Jet Fuel
• Strategy: Leverage installed assets at Luverne and adding the capability to produce 7-10 MGPY of hydrocarbons. Luverne is a proving ground for products and supply chain development.

Potential Buildout Overview

- Isobutanol Production: ~14-16 MGPY
- Hydrocarbon Production: ~10 MGPY
  - Jet Fuel: 8 MGPY
  - Isooctane: 2 MGPY
- Animal feed: ~65-70 kt
- Not publicly announced yet

& others
Those participating at Luverne will be advantaged for future volumes from future expansion

Commercial Buildout Overview (Beyond Luverne)

- Isobutanol Production: ~48 MGPY
- Hydrocarbon Production: ~30 MGPY
- Jet Fuel: 24 MGPY
- Isooctane: 6 MGPY
- Animal feed: ~223 kt
- IBA: ~10 MGPY

13 MGPY
If you had the chance to make 3 policy requests to States to facilitate the development and deployment of alternative fuels, what would they be?

1-Stability

2-Simple

3-Support