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Advancement of Petroleum Diesel Alternatives Utilizing a Multifaceted and Interdepartmental Approach

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**ABSTRACT**

The advancement of biologically derived alternatives to petroleum diesel fuel requires a multifaceted approach. At Utah State University we use an interdisciplinary team including the Colleges of Engineering, Agriculture & Applied Sciences, and Science in conjunction with industry partners to drive innovation in improving the science behind petroleum diesel alternatives. With increasing petroleum use, depleting reserves, increasing emissions standards, and other factors, there is need for petroleum diesel alternatives that are cost effective, offer improvement, and perform similarly to petroleum diesel. Our team has focused on the use of oleaginous microbes utilizing low value effluent and other high value co-products from oleaginous heterotrophic microorganisms including yeast and bacteria. The team has also focused to include the College of Agriculture and Applied Science. With expertise from the scientists including; professors, graduate students, undergraduate students, and technicians the team has made advances in:

- Strain selection
- Conversion process creation
- Engine and emissions analysis
- Co-product evaluation
- Economic and environmental analysis

Utilizing expertise from the interdepartmental team and industry partners USU is rapidly making advances in many critical areas necessary for process and product optimization to improve the properties and availability of biologically derived petroleum diesel alternatives.

**INTRODUCTION**

Beginning 7 years ago Utah State University began working to utilize CO2 and sunlight to create biodiesel from microalgae as a team comprising the Colleges of Engineering, and Science. Since then the project has grown to include carbon rich low value effluent sources to create biodiesel and other high value co-products from oleaginous heterotrophic microorganisms including yeast and bacteria. The team has also focused to include the College of Agriculture and Applied Science. With expertise from the scientists including; professors, graduate students, undergraduate students, and technicians the team has made advances in:

- Strain selection
- Conversion process creation
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**OVERVIEW**

![Diagram of photosynthesis](Image)

**MICROBIAL BIODIESEL PRODUCTION**

![Diagram of algae production](Image)

USU’s patented conversion process converts photosynthetic and neutral lipids for a greater total biodiesel yield per biomass conversion.

**FUEL PROPERTIES**

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Density (g/mL)</th>
<th>Kinematic Viscosity at 90°C (cSt)</th>
<th>Density at 15°C (g/mL)</th>
<th>Kinematic Viscosity at 37°C (cSt)</th>
<th>Density at 7°C (g/mL)</th>
<th>Kinematic Viscosity at 4°C (cSt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>0.850</td>
<td>9.22</td>
<td>0.860</td>
<td>9.29</td>
<td>0.870</td>
<td>9.34</td>
</tr>
</tbody>
</table>

**Table 1**: Properties of fuels

**HYDROTHERMAL LIQUEFACTION OF WET YEAST BIOMASS**

![Diagram of liquefaction process](Image)

**Table 3**: Emissions for biodiesel fuels and petroleum diesel

**Table 4**: Bonneville Salt Flats performance results

**Table 5**: Quantitative Analysis of HTL blockage

**Table 2**: Fatty acid composition of biodiesel fuels

**CONCLUSIONS**

- All microbial biodiesel fuels were found to generate similar power and torque outputs compared to soybean.
- Microbial biodiesel do not show an increase in BSFC relative to soybean.
- Hydrocarbon and CO emissions are reduced compared to diesel 2 levels for microbial and soybean biodiesel.
- CO2 levels are increased for the biofuels indicating improved combustion.
- NOx emissions for soybean, yeast, and bacteria biodiesel were higher than the measured levels for diesel 2.
- Microalgal biodiesel produced the lowest NOx emissions of any fuel tested.
- Reduced smoke opacity observed with microalgal biodiesel on the Bonneville Salt Flats.
- Economic analysis improves experimental design leading to improved petroleum diesel alternatives.
- Low temperature hydrothermal liquefaction creates experimentally significant volumes of alkanes.