Advancement of Petroleum Diesel Alternatives Utilizing a Multifaceted and Interdepartmental Approach

Michael Morgan
Utah State University

Follow this and additional works at: https://digitalcommons.usu.edu/ucur

Part of the Chemistry Commons

Recommended Citation
https://digitalcommons.usu.edu/ucur/7
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 grown 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.

OVERVIEW

Fuel

Sun + CO2 = Glucose

Microalgae Photosynthesis

Sugar

Yeast Respiration

Fuel

USU's patented conversion process converts photosynthetic and natural inputs into a greater total biodiesel yield per biomass conversion.

MICROBIAL BIODIESEL PRODUCTION

Advancement Of Petroleum Diesel Alternatives
A Multifaceted And Interdepartmental Approach

Michael R. Morgan1, Alex T. McCurdy1, Rhesa N. Ledbetter1, Lance C. Seefeldt1
1Chemistry and Biochemistry Department, Utah State University, 0300 Old Main Hill, Logan, UT 84322

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 waste sources including sugars and CO2 to create biofuels. We have focused on a yeast, Cryptococcus curvatus, and a microalga, Nannochloropsis salina which have shown high yields of fuel per cell mass. Using these microbes we have utilized USU’s own direct trans-esterification reaction to create sufficient quantities of biodiesel for engine performance and emissions testing, including a subset of ASTM tests characterizing the fuels from each organism. Our initial engine testing used petroleum diesel as a baseline in conjunction with commercial soybean biodiesel to establish the quality of our microbially derived biodiesel. Testing in stationary diesel engines and on the Bonneville Salt Flats has proven our microbial fuels perform similarly to soybean biodiesel and comparably to petroleum diesel. To further improve biological diesel replacements we have begun working to create green diesel, hydrocarbons from a biological source, using a novel method of hydrothermal liquefaction. Preliminary results of those tests are presented here. Through a multifaceted and interdisciplinary approach USU is successfully improving petroleum diesel alternatives from microbial sources including characterization of the properties of these fuels and is working to create the fuels at the scale necessary for exhaustive engine performance and emissions testing including ASTM testing of all important fuel properties.

FUEL PERFORMANCE AND EMISSIONS

Table 1: Properties of fuels

Table 2: Fatty acid composition of biodiesel fuels

Each microorganism has its own unique fatty acid profile which affects overall engine performance and emissions profile characteristics.

CONCLUSIONS

- All microbial biodiesel fuels were found to generate similar power and torque outputs compared to soybean.
- Microbial biodiesel does 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.
- NOx emissions for soybean, yeast, and bacterial biodiesel were lower 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.