SAND2017-12717C

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Production, upgrading, and testing of fusel alcohols as high performance fuels from whole algae bioconversion

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Abstract

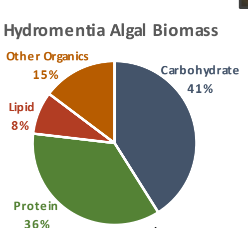
•To further catalyze development of sustainable algae biomass technologies for fuels, our group has developed strategies for bioconversion of whole algae biomass of both attached and suspended microalgae into advanced biofuels. Our strategy utilizes co-cultures of engineered strains of *E. coli* or Corynebacterium to utilize complex sugars and amino acids in algae hydrolysates as substrates for the production of branched C4 and C5 fusel alcohols. Bench scale tests have shown titers of >12 g/L of these products. We have further shown low cost isolation and upgrading of these of biofuel intermediates to finished fuels for both spark ignition (SI) and compression ignition (CI) engine architectures. Our data demonstrate that branched C4 and C5 alcohols show significant potential as high performance drop-in fuels or blending agents with gasoline due to their high octane number as well as their low corrosivity and high energy density, especially when compared to ethanol. Our results also indicate that these compounds can be chemically upgraded with residual lipids in the algae hydrolysate for the production of high performance biodiesel that shows improved combustion properties and cold flow properties compared to traditional biodiesel products. Whereas the C4 and C5 fusel alcohols display excellent properties in SI engines, the fatty acid esters show similar promise for CI engines, indicating that substantial fuel production and tunability can be attained from diverse algal biomass sources, regardless of lipid content. Utilizing all components in the biomass for biofuel production allows prioritization of biomass productivity over accumulation of starches or lipids, opening the door to a wide variety of new algae technologies with the potential for significant market impact.

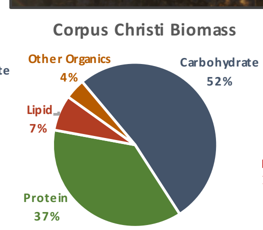
Biomass Conversion

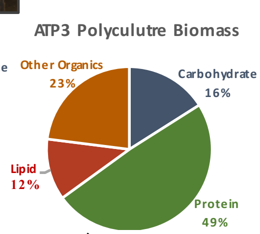
Hydromentia Benthic Algae Turf Scrubber
-Vero Beach, Florida

Sandia/Hydromentia Benthic Algae Turf Scrubber
-Corpus Christi, Texas

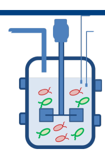
ATP3 Pond Microalgae Consortium
-ASU, Arizona



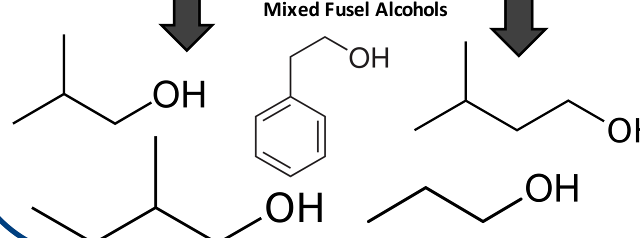




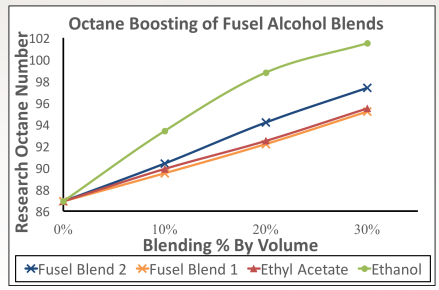
Engineered *E. Coli* consortium bioconversion process utilizing in house developed protein fermentation strain (AY3) and mixed sugar fermentation strain (BLF2)



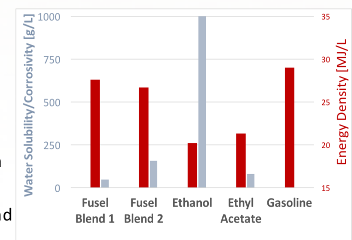
Varying Proportions of Mixed Fusel Alcohols



Fusel Alcohols as High Performance SI (gasoline) fuels

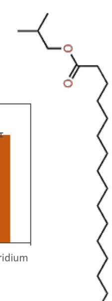


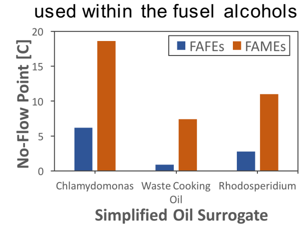
- Octane boosting ability similar to ethanol.
- Energy Density is ~36% higher than ethanol (36% better MPG)
- Significantly less corrosive than ethanol therefore compatible with current engine and fuel distribution infrastructure at high blend levels.
- Vapor Pressure of 10% volume blend ~1 psi less than ethanol blends

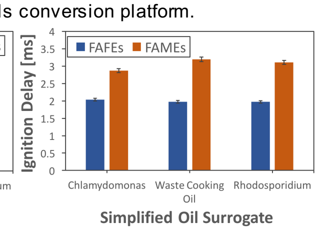


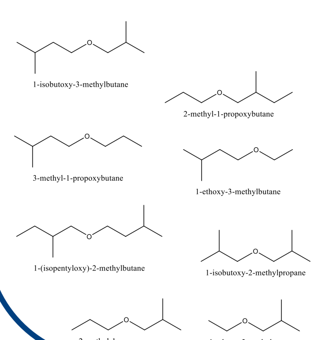
Upgrading to CI (Diesel) Fuels

- Demonstrated the use of a liquid lipase catalyst to utilize fusel alcohols as reactants with lipid feedstocks for production of Fatty Acid Fusel Esters (FAFEs) with improved ignition and cold-flow properties as compared to methyl esters (FAMEs).
- Allows all major biochemical components of biomass to be used within the fusel alcohols conversion platform.









- Upgrading of fusel alcohols symmetrical and assymetrical ethers for use as diesel fules
- Demonstrating upgrading techniques on real biomass hydrolysate samples

Acknowledgements

This research was conducted as part of the Co-Optimization of Fuels & Engines (Co-Optima) project sponsored by the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE), Bioenergy Technologies and Vehicle Technologies Offices. Sandia National Laboratories is a mult-mission laboratory managed and operated by National Technology and Engineering Solutions of Sanda, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.