NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Algae Biofuels Collaborative Project

Cooperative Research and Development Final Report

CRADA Number: CRD-10-371

NREL Technical Contact: Richard J. French

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Cooperative Research and Development Final Report

In accordance with Requirements set forth in Article XI.A(3) of the CRADA document, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

CRADA number: CRD-10-371

CRADA Title: Algae Biofuels Collaborative Project

Parties to the Agreement: Seambiotic/CEHMM

Joint Work Statement Funding Table showing DOE commitment:

Estimated Costs	**NREL** Shared Resources
Year 1	$ 250,000.00
Year 2	$ 250,000.00
Year 3	$ 00.00
TOTALS	$ 500,000.00

Abstract of CRADA work:

The goal of this project is to advance biofuels research on algal feedstocks and NREL's role in the project is to explore novel liquid extraction methods, gasification and pyrolysis as means to produce fuels from algae. To that end several different extraction methods were evaluated and numerous gasification and pyrolysis conditions were explored. It was found that mild hydrothermal treatment is a promising means to improve the extraction and conversion of lipids from algae over those produced by standard extraction methods. The algae were essentially found to gasify completely at a fairly low temperature of 750°C in the presence of oxygen. Pyrolysis from 300-550°C showed sequential release of phytene hydrocarbons, glycerides, and aromatics as temperature was increased. It appears that this has potential to release the glycerides from the non-fatty acid groups present in the polar lipids to produce a cleaner lipid.

Further research is needed to quantify the pyrolysis and gasification yields, analyze the liquids produced and to test strategies for removing organic-nitrogen byproducts produced because of the high protein content of the feed. Possible strategies include use of high-lipid/low-protein algae or the use of catalytic pyrolysis.

Summary of Research Results:

The compounds found in our low-severity hydrothermal experiments represent very interesting and potentially valuable long-chain hydrocarbon and oxygenated hydrocarbons that can serve as excellent precursors for fuels manufacture. These materials can be readily deoxygenated and isomerized for synthesis of molecules that are in the diesel and jet fuel boiling range. Additional work is needed to determine the yield of these materials and to quantify the compounds present in the aqueous phase as well; this work is currently in progress. A manuscript is in preparation summarizing this work, with the aim of submission in the spring of 2012.

Nitrogen containing compounds such as pyridine, chinoline and indole, originating from the high protein content of the algae are produced in both gasification and pyrolysis. These are toxic compounds and are not acceptable in fuels so they need to be removed from the product. Further research is needed to determine the amount of these tars to determine the cost of cleanup needed. Nitrogen depleted biomass would reduce the amount of these undesirable compounds.

Pyrolysis starts at about 300°C and is virtually complete at about 550°C. The first products to be released are phytenes (from chlorophyll) and dianhydro sugars followed by fatty acids and diglycerides and then aromatics as the temperature is increased. Since saturated fatty acids are recovered well but polyunsaturated ones are not seen, it is important to determine the fate of these valuable sources of hydrocarbons by future research. Precise determination of the yields of pyrolysis products as a function of conditions is also needed.

Catalytic pyrolysis needs to be explored as an option for improving the selectively to the desired products. Since algae contain more hydrogen than most terrestrial biomass, low-nitrogen high-lipid algae in particular are good candidates for this approach.

Subject Inventions listing:

We have filed a ROI on the NREL ROI 11-65. We are collecting further information to support the claims made and we will follow through with pursuing IP for this work in collaboration with the NREL legal team.

Report Date: 1/17/2012

Responsible Technical Contact at Alliance/NREL: Richard J. French, Ph.D., Senior Scientist

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