Tailored Bioblendstocks with Low Environmental Impact to Optimize MCCI Engines, DE-EE000482

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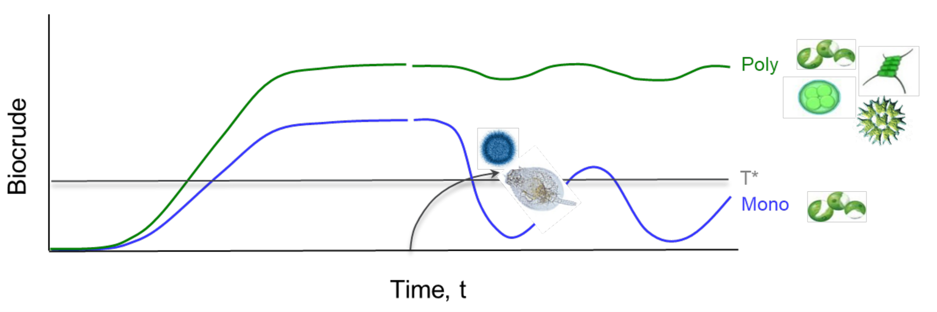
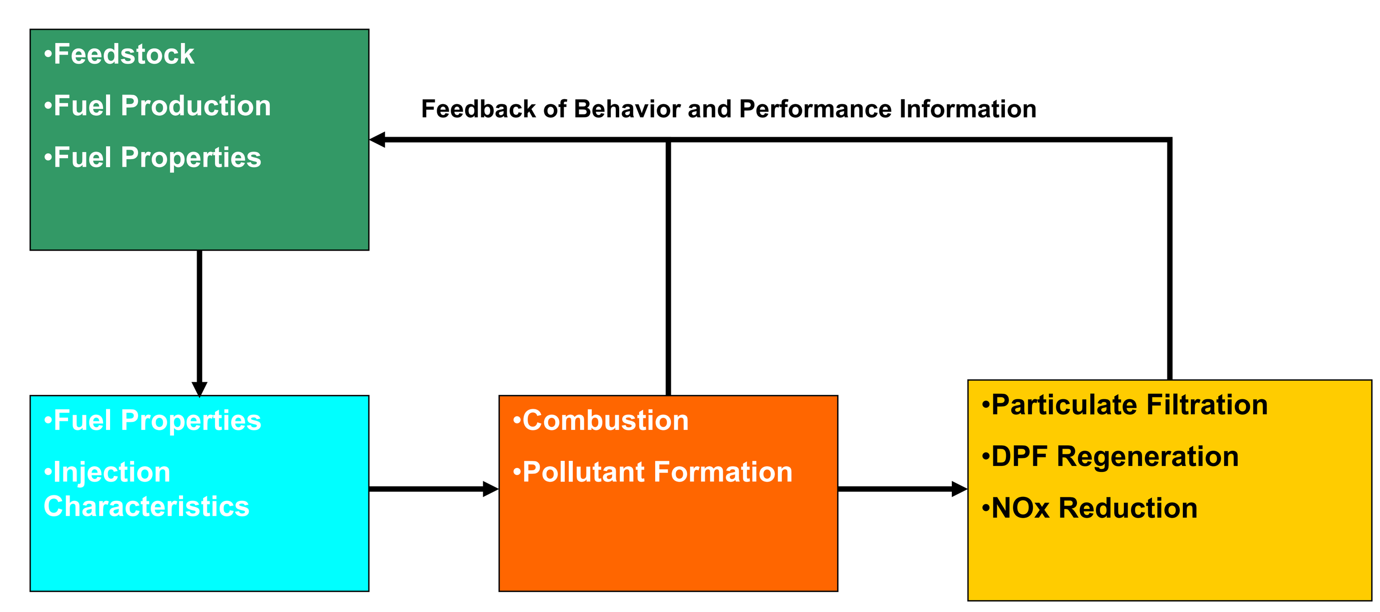
Ecological Engineering

The goal of Ecological Engineering is to design multi-species algal feedstocks that are more stable, more resistant to pests and disease, and thus achieve greater annual production of biocrude with fewer crop loss events



Co-Optimization via a Feedback Loop



Management Approach

- *Link application of fuels in autoignition and mixing controlled compression ignition combustion to the processes for generating biocrude and upgrading the biocrude from algal feedstocks, wherein those algal feedstocks are cultivated using algal polycultures to maxi-mize productivity and robustness*
- *B. Cardinale: cultivation, LCA, TEA*
- *P. Savage: HTL, LCA, TEA*
- *Thompson: upgrading biocrude*
- *Haworth: MCCI engine CFD*
- *Boehman: autoignition, engine, fuel properties experiments*

Task 4: Biocrude Upgrading to Tailored Fuels

Using oleic acid as the surrogate compound, and Ru/C as the catalysts under the above conditions, the resulting solid products were fully hydrogenated C14-C18 paraffin mixture without any trace of oleic acid. The degree of deoxygenation (DoD) of the reactant was 100%. Over 77% of the solid portion of the product was heptadecane ($C_{17}H_{36}$).

Table 3. Summary of solid product for oleic acid conversion over Ru/C

Peak	RT (min)	Compound	Area %
1	10.619	Tetradecane ($C_{14}H_{30}$)	7.7
2	11.976	Pentadecane ($C_{15}H_{32}$)	9.5
3	12.594	Hexadecane ($C_{16}H_{34}$)	2.4
4	13.189	Heptadecane ($C_{17}H_{36}$)	77.2
5	13.735	Octadecane ($C_{18}H_{38}$)	3.1

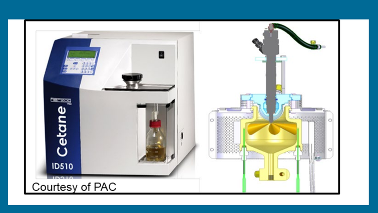
Task 1: Demonstration Project

Algae Cultivation Demonstration with "BACI" led to a successful polyculture versus a monoculture comparison and achieved our areal productivity and harvest mass targets. Collaboration with AzCATI.

Date	Mono	Poly	Total
6/20/2019	5.5	3.0	8.5
6/25/2019	3.0	2.0	5.0
7/3/2019	5.5	4.0	9.5
7/12/2019	6.3	4.5	10.8
7/18/2019	4.6	4.8	9.4
7/25/2019	4.6	3.9	8.5
Average per harvest	4.9	3.7	8.6
Sum of all harvests	34.4	25.8	60.2

Task 5: Engine Studies and Simulation

Combining fuel property studies, autoignition measurements, sooting tendency, of model compounds and fuel blends. Leveraging Co-Optima team efforts on MCCI fuel compound studies and our in-house expertise to envision how best to use the opportunity to convert algae into a tailored bioblendstock.



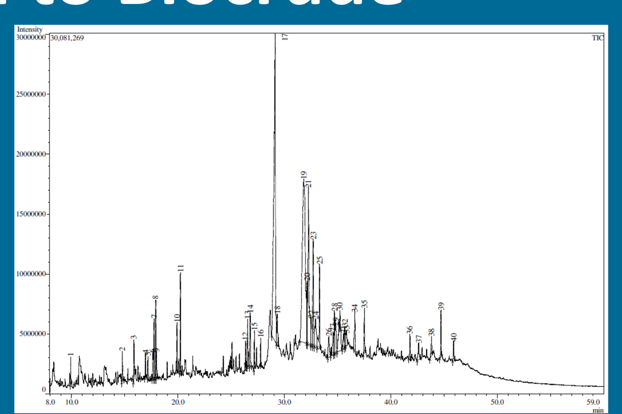
Cetane Ignition Delay (CID) instrument


Cooperative Fuels Research (CFR) engine


ASTM Smoke Point Lamp

Task 2: Hydrothermal Liquefaction to Biocrude

HTL of bench-scale processing of algae samples, leading to definition of optimal process conditions. HTL studies ongoing for both monoculture and polyculture samples. Based on GC-MS analyses of the biocrude samples, we are projecting what blendstock compounds will be possible.



Chromatogram of HTL biocrude from *S. capriconutum, C. sorokiniana, S. obliquus*

Next Steps

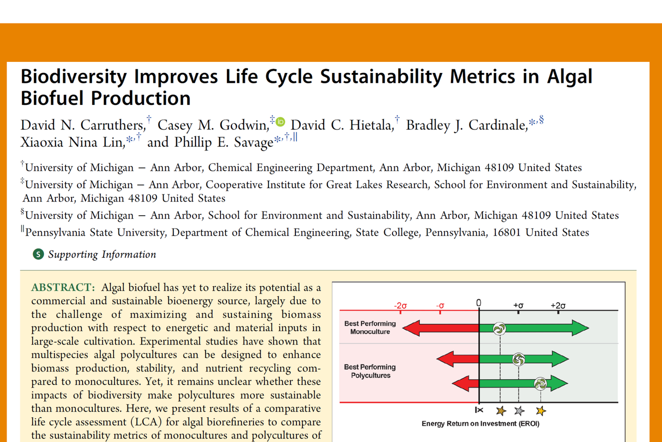
Acquisition and installation of scale up reactors from Parr Instruments to perform larger scale HTL and upgrading reactions on the algae from the demonstration project.

Expand engine studies to include multi-cylinder and single cylinder engine experiments to test the limits of how far we can improve MCCI combustion toward lower emissions and higher fuel conversion efficiency.


Acquiring two 1.8L high pressure reactors: one for HTL and one for upgrading of algae grown under the demonstration project

Task 3: LCA and TEA

Incorporating GREET into algae production framework, to consider batch production. Uses An algal hydrothermal liquefaction module (AHM) provides inputs to GREET.


Biodiversity Improves Life Cycle Sustainability Metrics in Algal Biofuel Production

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Supporting Information

ABSTRACT: Algal biofuel has yet to realize its potential as a commercial and sustainable bioenergy source, largely due to the challenge of maximizing and sustaining biomass production with respect to energetic and material inputs in large-scale cultivation. Experimental studies have shown that multispecies algal polycultures can be designed to enhance biomass production, stability, and nutrient recycling compared to monocultures. Yet, it remains unclear whether these impacts of biodiversity make polycultures more sustainable than monocultures. Here, we present results of a comparative life cycle assessment (LCA) for algal biorefineries to compare the sustainability metrics of monocultures and polycultures of six fresh-water algal species. Our results showed that when algae were grown in outdoor experimental ponds, certain

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