SOCIETY OF PHYSICS STUDENTS
An organization of the American Institute of Physics

SPS Chapter Research Award Proposal

Project Proposal Title	Hydrothermal Treatment of Microalgae for Biofuel Production
Name of School	Florida Polytechnic University
SPS Chapter Number	2054
Total Amount Requested	$2000

Abstract

This project will use algae collected from the surrounding water shoreline of Florida coast and to create a biofuel using a Hydrothermal Liquefaction (HTL) process. Under high temperature and pressure, algae will become a biofuel that will be specifically tested for salinity and combusted to measure the impact of its salt content.

Proposal Statement

The entire Proposal Statement should be no more than 4 pages, and organized as follows.

Overview of Proposed Project

- **Research question:**
  Algae are a naturally abundant resource and have a potential of becoming a material for biofuel production, however the process of converting algae to biofuel is currently cost prohibitive compared to diesel and petroleum. This project aims to optimize HTL process of converting algae into biofuel and investigate how salt content of algae influences outcomes of HTL and characteristics of biofuel produced.
- **Motivation:**
  HTL process can be used on collected algae without drying them and therefore will decrease the cost of the algae biofuel production, however, it is important to understand the role salt content plays in algae performance as biofuel, because it will further decrease cost of algae preprocessing for biofuel production.
- **Brief description:**
  The research project entails obtaining algae, testing, and adjusting the salt content of the algae, combusting the algae in a Parr Reactor, converting biocrude to a biodiesel, then testing the biodiesel in an engine.
- **Research goals of the project:**
  This research project will help to answer how the salt content of algae influences the quality of biofuel produced from algae.
- **SPS connection:**

This project will allow our chapter to involve more undergraduate students in scientific research and SPS activities. Furthermore, it is a valuable experience of research documentation and communication for new SPS chapter members.

Background for Proposed Project

Some studies have investigated the use of algae as a fuel source and showed that some Sargassum species have a potential of being used as a solid fuel source [1]. Also, due to the various environmental factors in recent years there has been a trend in increase of blooming and beaching of some microalgae species, specifically Sargassum genus [2]. Given the abundance of the algae and their viability as a fuel source it naturally follows that algae may be also used as a biodiesel fuel. Using Hydrothermal Liquification (HTL) process wet biomass can be converted into a crude-like oil that does meet current emission standards [1]. Sargassum algae, as a wet biomass, can be collected from beaches and oceans during its bloom (when there is a surplus of algae) and converted using HTL process into a crude biodiesel fuel then further refined to possibly be used with similar efficiency as conventional diesel and gasoline. This will provide a cleaner alternative to conventional fuels that will be sustainably sourced and meets emission standards.

Expected Results

Our study will produce data on optimization of algae biofuel production via HTL process by varying Algae/water ratio and salt content along reaction time, pressure, and temperature of HTL process. Fuel produced will also be analyzed for its chemical make-up. The end goal of this study is to determine what combination of parameters will produce fuel of highest quality and greatest amount.

Description of Proposed Research - Methods, Design, and Procedures

Overall methods will be divided into three parts:

Algae Preparation
To be used as a biofuel material, algae need to undergo some preparations:

- Algae are bought (microalgae powder) or gathered (naturally occurring on beaches of Florida).
- Wash the algae.
- Mix/ or put algae in Deionized (DI) water, add salt.
- Put algae with DI water into a blender.
- Resultant emulsion, after algae blending, will be a direct biodiesel material.

HTL Process in Parr (High Temperature/ High Pressure) Reactor

- Emulsion needs to be degassed under Nitrogen atmosphere.
- Then algae Emulsion is placed in a Parr reactor and purged with Nitrogen.
- Emulsion will undergo transformation to crude-biofuel under high pressure and temperature.

Crude biofuel Refinement

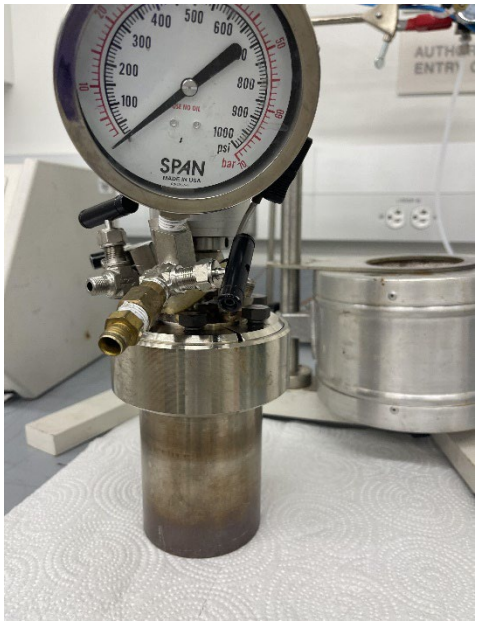
- Next Crude biofuel needs to be refined to eliminate all excess residue of crude biofuel.

Biofuel Analysis

Refined biofuel will be subjected to several characterization methods to determine the final fuel make up.

- ICP-MS (Mass Spectrometry)
- Optical Emission Spectrometry (OES)
- UV-Vis Spectrometry

- Dynamic Light Scattering (DLS)
- Burn Test (for octane count)
- Liquid Chromatography (LC-MS)



Images (Left to Right):
1) Assembled parr reactor, with pressure gage.
2) Mantle of the Parr reactor with crude biofuel inside (black slurry).
3) Cap of a Parr reactor with a stir bar and Temperature, Pressure sensors.

The amount of water, algae, and salt added will vary along with temperature, pressure, and time of reaction in Parr reactor. Data from varying inputs and reaction conditions will be combined with elemental analysis of the fuel to determine which process yields the most fuel of best quality and how salt content influences characteristics of the final fuel product.

Plan for Carrying Out Proposed Project

This section should detail the plan for carrying out the project, in bullet or paragraph form. Include, at minimum:

- **Personnel - Who will be involved in the research activities and in what way? How many participants are likely to be SPS members?**
  - **Anand Dewansingh**– SPS Member and Vice-President, Chapter 2045, Zone 6, Full Time Undergraduate Research Student, Florida Poly
  - **Marlon Nunez**– Not SPS member, Full Time Undergraduate Research Student, Florida Poly
  - **Dr. Sesha Srinivasan** – SPS Member and Zone 6 ZC, Assistant Professor of Engineering Physics, Faculty Advisor, SPS Chapter 2054, Florida Poly
- **Expertise - Are there SPS members or others with special expertise that will help to ensure success?**
  Yes, Dr. Sesha Srinivasan is an expert in materials' development and synthesis, analytical characterization studies and scientific publication preparation.

- **Research space - Where will the research activity be carried out? Is there lab space or other space that will be designated for this activity?**
  We will conduct this proposed work in the wet chemical research laboratory of Florida Polytechnic University. We have a Characterization Lab where we will execute various characterization studies

such as SEM, XRD, EDS, FTIR, UV-Vis, DLS, TGA/DSC and CIE Lab. We will also collaborate with Professors and researchers from nearby R1 institution, University of South Florida, Tampa, FL.

- **Contributions of faculty advisors or the department (equipment, space, etc.):** Faculty Advisor Dr. Sesha Srinivasan will provide his valuable time to design the project goals and define the protocols for undergraduate research studies. Equipment such as synthetic reaction glassware and characterization equipment is housed at Florida Polytechnic University. Dr. Srinivasan has a dedicated fume hood lab space for the HTL process and other treatments.

Project Timeline

Task	Start date - End date	Description
1	1/1/2024 - 2/29/2024	Literature Analysis, obtaining materials, and training personnel.
2	3/1/2024 - 4/30/2024	Prepare Parr reactor and begin biofuel production and optimization.
3	5/1/2024 - 5/31/2024	Drafting and Interim report.
4	6/1/2024 - 9/1/2024	Finish biofuel production, start characterization process.
5	9/2/2024 - 10/31/2024	Obtain characterization data and analyze it
6	11/1/2024-12/31/2024	Compile and submit the final report

Budget Justification

Chemicals/Solvents/Gases, Materials and Supplies: Large quantity of algae need to be purchased/gathered in order to conduct many iterations of HTL process and conduct optimization. Additionally different solvents for algae reaction may be used (such as biodiesel fuel).

Parr Reactor Parts: some additional parts need to be purchased from Parr corporation to ensure proper function of our current reactor. Parts to be purchased: Parr reactor canister, Parr reactor liner. Liner is needed to store the reactants under high pressure and temperature, reactor canister is what encompasses the liner and allows reactor to safely be heated and pressurized.

Characterization: ICP-MS and OES characterization are available at Florida Phosphate Research Institute which is part of Florida Polytechnic University. Additionally, we may look for outside help for conducting combustion tests on the resultant fuel, since we do not have a testing facility available.

In-Kind Support: Glassware, DI water, state-of-the art instruments, expert research personnel and their time (my mentor, laboratory staff and other senior researchers) will be extensively available to support this project.

Bibliography

[1] L. B. López-Sosa et al., "A prospective study of the exploitation of pelagic Sargassum spp. As a solid biofuel energy source," Appl. Sci. (Basel), vol. 10, no. 23, p. 8706, 2020.

[2] D. A. Devault et al., "The silent spring of Sargassum," Environ. Sci. Pollut. Res. Int., vol. 28, no. 13, pp. 15580–15583, 2021.

[3] J. Ramirez, R. Brown, and T. Rainey, "A review of hydrothermal liquefaction bio-crude properties and prospects for upgrading to transportation fuels," Energies, vol. 8, no. 7, pp. 6765–6794, 2015.