



STUDENT SUSTAINABILITY COMMITTEE

Final Report

Thank you for your commitment to green initiatives at the University of Illinois. One of the final steps in completing the terms of the funding agreement for your project is the submission of a Final Report with key information about your project. You will also need to submit a detailed report of expenses (if you don't list it within this document) as well as supporting photos to showcase your project.

Please be as accurate as possible in describing the project (including possible setbacks or challenges in meeting the initial goals of the project). Not fully meeting your project's goals will not disqualify you from making future funding requests as long as your reports are as complete and accurate as possible. If you have any questions, please contact the Student Sustainability Committee, at sustainability-committee@illinois.edu.

Project Name: Brewing the Best Bankable Biodiesel

Date of Report Submission: 5/31/2019

Project Purpose:

The Illinois Biodiesel Initiative (IBI) is a student lead RSO that produces biodiesel (intended for campus vehicles) from used vegetable oil obtained from the campus dining halls. IBI also produces soap (intended for commercial sale) from a glycerol byproduct generated from the biodiesel production.

The project being funded is the establishment of in-house quality control testing of our biodiesel. Our largest customer, Garage and Carpool, requires that our biodiesel meets the ASTM D6751 standard set for biodiesel (B100). Out of house testing through a third party would be economically unviable for our organization, therefore we are aiming to conduct all required quality tests in our lab. Funds will go towards the purchase of analytical equipment for conducting quality tests and purchase of reagents.

Project Summary:

Performing all tests within the ASTM D6751 standard would be costly and certain properties are more susceptible to fail the standard than other properties. The BQ-9000 is a subset of tests in the ASTM D6751 that industry has identified as a higher priority. The included tests are the cold soak filterability, water and sediment, cloud point, glycerin content, oxidative stability, visual inspection, sulfur content, flash point (closed cup), and acid number. In order to have in house quality assurance, the necessary testing equipment for each of the above tests is required.

Upon further review of the standards and several tests, the produced biodiesel would need to be blended with regular diesel. The blended fuel would allow for better cold flow properties and ensure that quality standards could be met. The ASTM standard for the blended fuel (B20) is ASTM D7467 and includes the same tests as the B100 standard but with different targets.

Under the guidance of Dr. Benjamin McCall, two hourly student interns spent the 2017 summer troubleshooting quality issues. Three 50 gallon batches of biodiesel were produced. The first batch failed multiple quality tests due to long storage time. The second batch failed the cold soak filterability test and contained a large amount of particulates. The third batch was filtered, which dealt with the particulates but did not improve the viscosity of the biodiesel. To improve the cold flow properties, the biodiesel will be blended to be B20 grade diesel fuel.

In the summer of 2018, IBI moved into the IBRL facility and is now under the faculty guidance of Beth Conerty. Additional quality and production equipment was purchased such that all of the BQ-9000 tests can be conducted. A new 50 gallon batch of biodiesel was produced and passed all the required tests.

With the SSC grant, IBI has been able to obtain and setup the necessary apparatuses to conduct in-house testing of our biodiesel. The residual balance of funds will be kept for the purchase of reagents for production and testing.

Summary of Project Expenditures:

Funds from the 2016 grant titled "Illinois Biodiesel Initiative" and funds from the 2017 grant titled "Brewing the Best Bankable Biodiesel" were pooled together in the same account. Remaining funds from the 2016 grant totaled at around \$16,058 when receiving the 2017 grant, this gives a total of \$45350 available for developing our quality and production departments.

The total amount spent is \$34,636 as of May 30, 2017 with \$10,713 remaining. Quality control utilized \$28,303 of the grant money to purchase common lab equipment, reagents, and analytical instruments. The oxidation stability tester costed around \$15,000, the water and sediment centrifuge costed around \$10,000. Production and testing utilized \$3,875 of the grant money to purchase containers for the storage of vegetable oil and production waste. The hourly interns costed \$2,458.

Project Timeline:

- Acquired funding (March 2017)
- Obtain laboratory equipment (March 2017)
- Obtain cloud point apparatus (April 2017)
- Produce batches and conduct testing (March 2017 – December 2017)
- Move to IBRL (June 2018)
- Purchase Oxidation Stability Tester (June 2018)
- Upgrade storage of feedstock (October 2018)
- Produce 50 gallon batch of biodiesel (December 2018)

- Conduct testing on batch #4 (January 2019)
- Purchase centrifuge (April 2019)

Problems/Challenges Encountered

In terms of quality tests, a main problem we encountered was the biodiesel having too high of a kinematic viscosity which can lead to the filter in a diesel engine to plug up. Running engines on B100 fuel is difficult without modifying the engine or using extensive processes to produce high quality biodiesel. For this reason, most engine warranties only cover up to B20 blends.

Following what is standard in the industry, we have decided to switch to a B20 blend of biodiesel and petrodiesel. Another challenge is the pretreatment process of the used cooking oil. The presence of food particles, high moisture content, and high free fatty acid content require that used cooking oil be pretreated to produce quality biodiesel. To solve this, IBI has invested in equipment for filtration and settling steps in the pretreatment process.

In terms of organization, one main challenge to running production and testing is maintaining a base of student volunteers and organizing the part-time student volunteers. Since students have obligations to classes and minimal obligation to IBI, retaining members proves to be difficult. Our solution around this has been to give research credit through the ABE department for CHBE majors. However, we additionally plan to hire student interns when we become economically sustainable.

Student Involvement and Outreach to Date:

The majority of the organization is student ran with only our accounts being managed by our faculty advisor. Additionally, our faculty advisor provides both guidance and assistance when dealing with challenges that our group faces. Students are involved in four different departments; leadership, biodiesel production, quality control, and soap production. Leadership consists of the organization's president, vice president, treasurer, and secretary which organize recruitment, outreach, purchases, and leading the other departments. Biodiesel production focuses on operating our reactor along with the logistics of acquiring reagents and distributing product. Quality control focuses on testing biodiesel and researching improvements to the production process. Soap production focuses on the production of soap from glycerin.

Marketing and Promotion Efforts to Date:

The current efforts of promoting IBI have been hosting a booth for quad day, RSO involvement fair, engineering open-house, and earth-day quad day. Our booth for quad day and the RSO involvement fair focused on recruiting new members for the club. For engineering open house, we displayed samples of our soap and a viscosity demonstration. We have also distributed free samples of our soap during the earth-day quad day for the purpose of acquiring survey results about the quality of the soap.

Additional Comments:

This section contains details relevant to the nine tests which make up the BQ9000 standard.

1. Visual Appearance (ASTM 4176) – Visual inspection for contaminants in the biodiesel by comparing the biodiesel sample to a standard photo. The test requires two standard photos for comparison which were obtained with no expense.
2. Acid Number (ASTM D974) – Measures the acidity of the fuel using a standard acid-base titration. The test requires common laboratory equipment, solvents, and reagents (burette, isopropyl alcohol, toluene, potassium hydroxide, barium hydroxide, naphthalene, and phenolphthalein.)
3. Cloud Point (ASTM D2500) – Determines the temperature point at which the fuel begins to gel and is commonly reported with the fuel. The test requires a glass apparatus which was custom built through the School of Chemical Sciences shops.
4. Water and Sediment (ASTM D2709) – Determines the amount of water and sediment in the biodiesel by centrifugation of the sample in a specialized centrifuge. The test requires centrifuge tubes with a graduated capillary tip.
5. Flash Point (ASTM D93) – Checks for the presence of methanol in the fuel by measuring the temperature at which vapors ignite in a closed cup test. The test requires a flashpoint tester instrument.
6. Cold Soak Filterability (ASTM D7501) – Certifies that the fuel will not plug the engine filter under standard weather conditions. The test requires the fuel to be heated and cooled with water baths and then filtered through a specific apparatus.
7. Oxidative Stability (ASTM D7545) – Since biodiesel is prone to oxidation, the oxidative stability of the fuel must be measured. The test requires an oxidative stability instrument.
8. Glycerin Content (ASTM D6584) – Measures the amount of free glycerin and total glycerin contained in the fuel using gas chromatography (GC). The test requires a GC and reagents for establishing a retention time standard and quantitative internal standard.
9. Sulfur Content – Measures the amount of sulfur contained within the biodiesel using inductively coupled plasma optical emission spectroscopy (ICP-OES). Tests can be conducted at the microanalysis facility of the School of Chemical Sciences for a small fee.

In addition to the above fields, please provide a detailed accounting of how the funding was spent as well as pictures of the final project in an email to sustainability-committee@illinois.edu. Thank you again for your commitment to sustainability.