Project 2 : Making Biodiesel for Research and Education

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Project Summary

Over the past few decades, biodiesel has drawn more and more importance as an attractive alternative fuel due to the depleting fossil fuel resources and the environmental pollution caused by abundant use of traditional fuels. It can be obtained from renewable sources, such as plant oil, recycled cooking oil, and animal fats. The chemical structure of biodiesel is mainly fatty acid esters and contains almost no aromatics and sulfur, and it is non-toxic and biodegradable. Compared to petroleum-based diesel, biodiesel has more favorable combustion profile, such as lower emission of carbon monoxide, particulate matter and unburned hydrocarbon. A joint study conducted by the U.S. Departments of Agricultural and Energy has shown soy-based biodiesel has 78 percent carbon dioxide reduction over petroleum-based diesel. Biodiesel can be used by mixing it with petroleum diesel at any concentration level or even can be directly used in its pure form, 100% Biodiesel (B100), and it needs little engine modification. So the application of biodiesel can be expected to be prosperous.

However, the production cost of biodiesel is a major barrier to its commercialization and the cost of the raw materials accounts for the majority of the total cost, varying from 70% to 95%. Currently, the most popular feedstock for biodiesel production in America is soybean oil, while low cost oils and fats that are available in large amounts as a byproduct could be utilized, for example the waste cooking oil and trap grease. A large amount of such waste vegetable oils are produced in the restaurants every day. Currently, they sell this grease to oil-recycling companies and pay a pick-up fee for this service. Trap grease is kitchen waste that has been trapped in a grease trap; it is a mixture of oils, greases and food debris and the restaurants need to dispose it properly, which increases the restaurants' operation costs. Due to their low market values, the restaurants will be willing to provide the wastes , waste cooking oils and trap grease, to those who can recycle them for free.

Transesterificaiton (Figure 1) is currently the most widely used method for generating biodiesel from vegetable oil. In this process triglycerides reacts with alcohol with the aid of the catalyst and are converted into alkyl esters, which is biodiesel. The chemical structure of triglyceride can be described as three esters attached to a molecule of glycerin. During the transesterification process, the glycerin molecule is replaced by an alcohol molecule. Many types of alcohols have been investigated for biodiesel production; the results turned out to be that methanol is most ideal one, for its low cost and ease of reaction. As to the catalyst, the base catalysts such as sodium hydroxide or potassium hydroxide are commonly used.

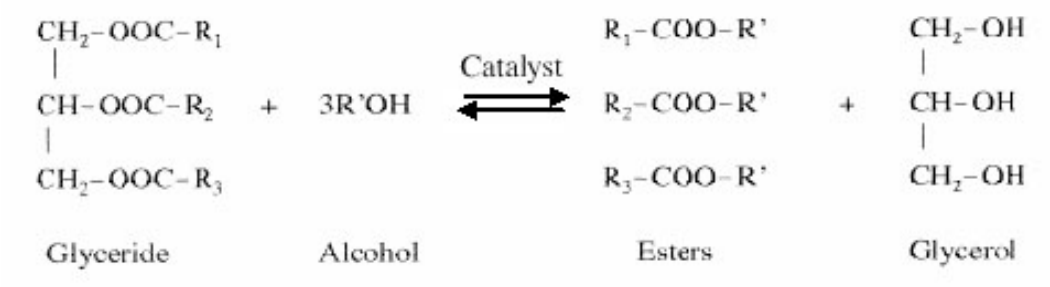

Figure 1. Process of Transesterification

The goal of this project is to investigate making biodiesel from waste cooking oil from UC dining facilities and other sources (such as the Zoo) via transesterification process, perform preliminary study on trap grease and develop lesson plans related to alternative energy use. The teachers will learn moisture measurement skills, acid-base titration and biodiesel production process. The graduate student will assist them in their work. And a field trip to Metropolitan Sewer District will be planned. There, teachers will be able to learn how trap greases are generated from the reality and they will have a chance to collect trap grease samples. Thus, they will better understand the meaning and importance of developing renewable energy source.

The tentative schedule of the project is as follows:

Weeks 1-2: Introduction to the project and basic training of lab safety regarding making biodiesel. Titration, which is used to obtain the free fatty acid content, and experiments to determine the amount of required catalyst will be performed.

Week 3-4: Move onto small scale test on production of biodiesel. The conventional base catalytic method will be used and acid pretreatment and, if necessary, kinetic study on esterification of a high FFA feedstock will be performed.

Week 5: Large-scale production will be performed. Introduction to trap grease as an alternative feedstock for making biodiesel will be done and a preliminary study on trap grease, such as moisture measurement, will be performed.

Week 6: Data analysis and project summary.

Instruments/devices to be used in the project include the following:

1. Freedom Fueler for making Biodiesel (Figure 2)
2. Electronic balance
3. Heater
4. Desiccator
5. Thermo couple

Possible Ideas for Classroom Implementation

The use of renewable biodiesel will greatly reduce our nation's dependence on imported petroleum. This experience will convince the teachers of the idea that biodiesel is a green and nearly carbon neutral fuel and has numerous advantages over petroleum diesel fuel. In various science classes (e.g., general science and earth science) they can present the regional, global and local air pollution and energy issues caused by fossil fuels and the preventive activities. The data from the class project can be used in math classes to teach data analysis techniques and graphical display of data using Excel. High School students can practice titration skills and lab-scale biodiesel production in the chemistry class.

Figure 2. The Freedom Fueler for Making Biodiesel