

## **Project # 2: Making Biodiesel for Research and Education**

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### **Abstract**

Inhalable diesel particulate matter (DPM) is in  $\mu\text{m}$  (micrometer) sizes and once it enters the respiratory system it can result in asthma, allergies, bronchitis, and lung cancer. Children are at a higher risk since their respiratory systems are still developing and they breathe faster. Many of you may have heard of the "Clean Schoolbus USA" initiative. The Hamilton County Environmental Services has installed many diesel oxidation catalysts (DOC) in the school buses in the Tri-state public schools. This six-week RET project will show how the DOC and biodiesel can reduce diesel particulate matter (DPM) emissions. Although we do not have a school bus, we have an on-road diesel generator to measure the pollutants with.

Biodiesel can be obtained from renewable sources, such as plant oil, recycled cooking oil, and animal fat. The chemical structure is mainly fatty acid esters and contains almost no aromatics and sulfur. It is expected that the use of biodiesel can result in less DPM emissions. With this context, the goal of this project is to investigate the impacts of DOC and biodiesel in the reduction of diesel emissions and develop lesson plans related to alternative energy use. We will compare DPM emissions from the use of regular diesel and biodiesel, and see how the DOC installed in your schoolbuses can further cut down pollutant emissions. The teachers will take samples from a diesel generator at the UC Center Hill Research Facility, and will collect DPM at various engine loads (idle, low, medium, and full load). They will learn standard sampling techniques, setting up generator loads, filter preparation, conducting gravimetric measurements, and calculate concentrations of the DPM. The graduate student will assist them in their work. The RET participants will better understand air quality issues caused by diesel trucks, busses, and machines and why the use of DOC and biodiesel can result in less pollutant emission.

The tentative schedule of the project is as follows:

Weeks 1-2: Introduction to the project and basic lab safety training pertaining to making of biodiesel. Biodiesel will be made from cooking oil from the UC dining facilities and other sources (such as the Cincinnati Zoo). The conventional base catalytic method will be used and acid pretreatment, if necessary, kinetic study of a high FFA feedstock will be performed.

Week 3-4: Other ways of making biodiesel will also be tested, such as using alcohols (for example, ethanol or isopropyl-alcohol) and using other feedstocks (animal fat, oils with high C18:3). Although these are not yet the mainstream methods, they have the potential to improve the properties or production processes of the current technology, and therefore may have future applications.

Week 5: Biodiesel compositional analysis with Gas chromatography-mass spectrometry (GC-MS). Biodiesel emission studies will be performed for each generator engine load (idle, low, medium, and full load). A field trip to Univenture to see the algae biodiesel process is planned.

Week 6: Data analysis and project summary.

The teachers will be training to use following instruments and devices during the project (see Figures 1 to 3):

1. High volume sampling pump
2. Testo gas analyzer
3. Filter system
4. Freedom Fueler for making biodiesel
5. Gas chromatography mass spectroscopy (GC-MS) system for pollutant analysis
6. Using diesel generator with a load simulator

### **Possible Ideas for Classroom Implementation**

Learning modules on global and local air quality issues and preventive measures can be developed for use in general science, math, chemistry, and earth science courses. The use of renewable biodiesel will greatly reduce our nation's dependence on imported petroleum, and DPM emission reduction can also be expected. This experience will convince the teachers of the benefit of using biodiesel in school buses, and they can potentially promote biodiesel adaptation to better protect school children's health. They can design a class project for their general science class to compare particulate emissions from biodiesel and regular diesel. In various science classes (e.g., general science and earth science) they can present the regional, global, and local air quality issues and preventive activities. The data from the class project comparing particulate emissions with and without control technologies can be used in math classes to teach data analysis techniques and graphical display of data using Excel. Students can practice making biodiesel in their chemistry class. Principles of sampling, concentration calculation, and the math balance of the filter can be integrated in math and physics classes.



**Figure 1. The Filter System**



**Figure 2. The Freedom Fueler for Making Biodiesel**



**Figure 3. The Gas Chromatography Mass Spectrometer (GC-MS)**