Summer Academy 2013
Making Biodiesel

Description:

There are many benefits of using biofuel as an alternative to petroleum-based fuel. Biodiesel is a renewable fuel made from biologically based oils (vegetable, canola, soybeans etc…) and can be used to power a diesel engine. The chemistry involved in making small scale biodiesel is an easy process that can be done with a few simple chemicals.

In today's lesson, we will be doing background on biodiesel, making a batch of biodiesel and testing it for viscosity,

Objectives:

- Students will compare physical and chemical properties of vegetable oils
- Students will explore the background of biodiesel and look at the economical and environmental benefits of biodiesel
- Student will demonstrate the process of making biodiesel on a small scale

Standards covered:

- 9-10.2.2 Use appropriate safety equipment and precautions during investigations (e.g., goggles, apron, eye wash station)
- 9-10.2.7 Maintain clear and accurate records of scientific investigations
- 9-10.3.2 Classify changes in matter as physical or chemical

Session Organization

9:00-9:30 Cultural connection and general organization
9:30-10:00 Background information
10:00-11:00 Internet activity and discussion finding background on biodiesel
11:00-12:00 Activity making biodiesel
12:00-12:30 Lunch
12:30-1:30 Activity: comparing density and viscosity
1:30-2:30 Activity: calculating heat content in biodiesel vs. diesel
2:30-3:00 Wrap up

Activity One: *Background information on Biodiesel*

Using the internet, find the definitions for the following words:

Biodiesel:

Glycerin

Methanol

Methoxide

Transesterification

What are biofuels made from?

List 5 advantages and 5 disadvantages of using biodiesel

What are three blends of biodiesel commonly used in the US? Which one is the most commonly used?

How much biodiesel is produced in the United states each year?

Where in North Dakota can you buy biodiesel?

Why does biodiesel plug up your fuel filters?

Name 3 pollutants that are reduced by using biodiesel?

How much does B100 reduce carbon dioxide emissions?

Who invented the diesel engine? What fuel did he use in his original engine?

Write the chemical equation for making biodiesel below:

What are the specific gravity, density and boiling point of biodiesel?

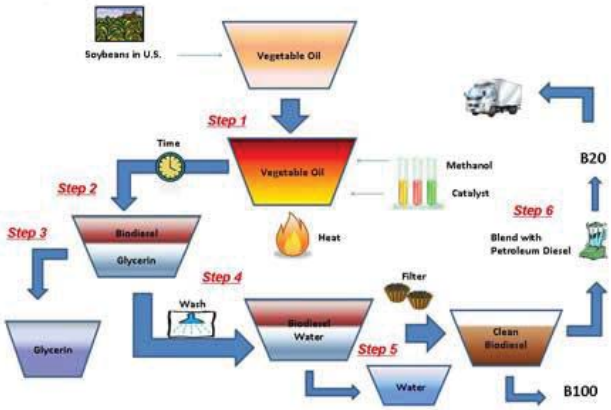
When were laws passed that required diesel fuel to be low sulfur and clean burning?

What day was declared International Biodiesel Day?

Which state was the first state to require all of their diesel fuel to be at least 2% biodiesel? When did they pass that law?

Activity Two-making biodiesel

Figure 1: The Biodiesel Production Process



Materials needed:

1 liter of vegetable oil	4 grams of NaOH
250 ml of methanol	1-2 liter bottle-dry
1 500 ml beaker	1 Erlenmeyer flask
funnel	pan to heat oil
Hot plate	thermometer
Lab scale	Hot pads

Procedure: Making the methoxide

- Measure out 250 ml of methanol add it to an Erlenmeyer flask
- Measure out 4 grams of NaOH add to the flask
- Begin gently swirling the mixture (be careful its very caustic)
- Continue to mix until all the NaOH is dissolved
- If some methanol has evaporated, add methanol until you have 250 ml of liquid

Procedure: preparing the oil

- Add the oil to a pan
- Set the pan on a hot plate
- Heat the oil to 50-55 degrees Celsius

Procedure: Making the biodiesel

- Using a funnel, add the warmed oil to a clean, dry 2 liter bottle
- Using the same funnel, pour the methoxide on top of the oil in the bottle
- TIGHTLY screw on the lid of the bottle
- Shake vigorously for 30 seconds-need at least 60 good shakes
- Place the bottle on a table
- Allow the bottle to settle for an hour

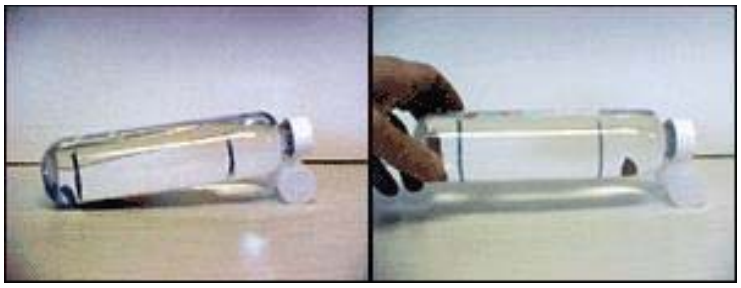
Describe the top layer of your liquid in the bottle.

Describe the bottom layer

Activity 3: ***Comparing density and viscosity of liquids***

Materials needed:

- 100 ml of the following liquids: water, glycerin-bottom layer of biodiesel, biodiesel-top layer, methanol, and vegetable oil)
- 100 ml graduated cylinder
- Scale
- Pop bottle with two marks
- Marble
- Stop watch



Procedure: ***finding density***

- Find the mass of a graduated cylinder empty
- Add 100 ml of one of the liquids to the cylinders
- Record the mass of the liquid and cylinder
- Calculate the density of the liquid
- Repeat this procedure for each liquid

Results table for Density

Type of Liquid	Mass of cylinder empty (g)	Mass of cylinder and liquid (g)	Mass of liquid (both –empty) (g)	Density of liquid (mass/volume)

Procedure: ***measuring viscosity***

- Take a bottle of one of the liquids provided
- Raise one up slightly by adding film canister of something of similar size under one end
- Have another person time how long it takes the marble to roll from one mark to the other.
- Repeat this two more time for a total of three trials
- Repeat this procedure for the other liquids provided

Results: ***Viscosity***

Type of liquid	Time (sec)	Time (sec)	Time (sec)	Average

Questions:

1. Is there a correlation between density and viscosity?

2. What do you think would happen to the viscosity if you heated the liquids?

3. After doing this experiment, in your own words, write a definition of density and a definition and viscosity?

Activity 4: ***Calculating the heat content of diesel and biodiesel***

Background

Combustion involves a series of chemical reactions between a fuel (ie. a hydrocarbon) and oxygen. The result is a major reorganization of both matter and energy.

Matter

Combustion can be complete or incomplete depending on how much oxygen is present. The diagrams below represent complete combustion, which happens in the presence of ample oxygen. When complete combustion occurs, all of the carbon atoms in a fuel (ie. the diesel and biodiesel molecules below) will be converted to carbon dioxide molecules. Also, the hydrogen atoms that were attached to each carbon atom in the fuel bind with oxygen to form water.

Complete combustion:

Fuel + Oxygen ----→ Carbon Dioxide + Water + Energy

$$C_{12}H_{24} + 18\,O_2 \longrightarrow 12CO_2 + 12H_2O + Energy$$

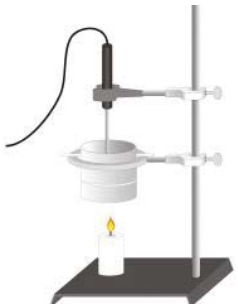
Complete combustion of biodiesel

$$CH_3 - O - \overset{\overset{O}{\|}}{C} - R + O_2 \dashrightarrow CO_2 + H_2O + Energy$$

R-is a hydrocarbon chain based on the oil used

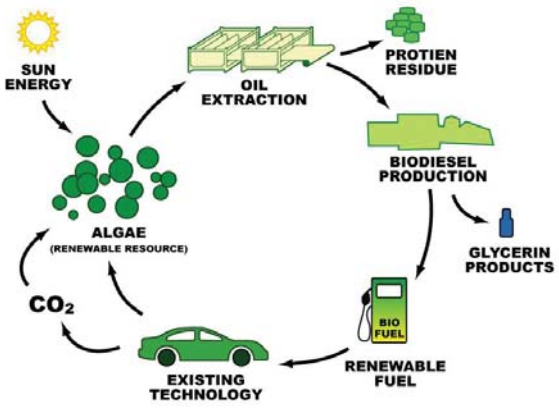
Materials:

Small can — CBL with temperature probe
Ring stand with ring — 100 ml graduated cylinder
Scale — Some type of alcohol burner
Baby food jar — small wick



Procedure:

- Find the mass of the can empty and record in the table
- Measure out 100 ml of water and pour in the can
- Find the mass of the can with the water and record in the table
- Set up a baby food jar with a wick in it (half of the wick should be in bottom of the jar.)
- Add 50 ml of biodiesel/diesel to the jar
- Set up the ring stand with the temperature probe
- Program your CBL to record the temperature every 30 seconds for 5 minutes
- Light the wick and press start on the CBL
- After 5 minutes, blow out the wick and record the highest and lowest temp from the CBL and record in the table
- Repeat this procedure for the other fuel you didn't use the first time



Data table:

	1	2
Fuel	**Biodiesel**	**Diesel**
Mass of can empty (g)		
Mass of can and water (g)		
Mass of water (g)		
Final water T (ºC)		
Initial water T (ºC)		
T change (ºC) (Δ temp)		
Total heat absorbed (cal) **		
Final mass of burner (g)		
Initial mass of burner (g)		
Mass of fuel burned (g)		
heat per gram of burned fuel (calories/g) ***		

** Total heat absorbed = Δ Temp x mass of water x specific heat of water (4.18 J/g°C = specific heat of water)

*** Total heat absorbed / mass of fuel burned

Questions:

Which fuel had the greatest energy content? Explain your answer

After all the activities, sum up the differences between diesel and biodiesel.

Give a reason why more biodiesel isn't used in the United States.