**Potent Plant Power…Living Fuels**

**Standards:**

1.1.11E- Establish a reading vocabulary by identifying and correctly using new words acquired

through the study of their relationships to other words. Use a dictionary or related reference.

1.2.11.A- Read and understand the central content of informational texts and documents in all

academic areas.  
1.6.11 A- Listen to others.

1.6.11 D- Contribute to discussions.

1.6.11 E- Participate in small and large group discussions and presentations.

2.3.11 A- Select and use appropriate units and tools to measure to the degree of accuracy required in

particular measurement situations.

3.2.10 A- Apply knowledge and understanding about the nature of scientific understanding and

technological knowledge.

3.4.10 A- Explain concepts about the structure and properties of matter. Know that atoms are

composed of even smaller sub-atomic structures whose properties are measurable.

* + 1. Analyze how human activities may cause changes in an ecosystem.

**Introduction and background:**

With the ever present need of creating a renewable fuel supply to supplement/replace our dependence on fossil fuels, scientists have been working on creating biodiesel from various plant oils. With a process known as trans-esterification, plant and animal oils can be transformed using an alcohol to turn a fatty acid into biodiesel and glycerin. There is little waste and even the by-product is used, which makes this biodiesel/plant oil cycle even more worthwhile. The by-product, glycerin, can be then be used to make soap or as a catalyst for composting bins. This process is a very simplified version and can be done at home, with products found at the local hardware store.

Many people find biodiesel production exciting and are waiting for more dependence on some of our staple agronomic crops to help cut down on foreign oil dependence. Though, using our feed grains, such as corn and soybeans, for fuel purposes, does drive the price of feed for livestock up and affects the local farmer. Much research has been done on the various plant oils and their effectiveness as fuels. In this lab we will compare six common household oils by making biodiesel, analyzing it and determining its heat of combustion.

**Guiding questions:**

1. Fossil fuels are nonrenewable resources that are being consumed at a rapid rate, what are some possible fuel ideas that are renewable?
2. What are some advantages of using biodiesel?

**Vocabulary**:

* + **Biodiesel:** A fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats.
  + **Trans-esterification:** The chemical process used to separate biodiesel from glycerin in the fatty acids of plant oils.
  + **Fatty Acid**: molecule made of carbon, oxygen and hydrogen, arranged as a carbon chain skeleton with a carboxyl group (-COOH) at one end.
  + **Methanol:** A chemical compound with chemical formula CH3OH. It is used in the trans-esterification process to help split the fatty acid chains.
  + **Glycerin:** A byproduct of biodiesel, key component of soap.
  + **Joule:** Unit of Energy

**Materials:**

Part 1: Part 2: Part 3:

\* gloves \*Eppendorf tube \*Compression Nut

\*3 plastic pipettes \*Centrifuge \*Cotton cosmetic pad

\*autopipette & tip \*2 plastic pipettes \*Penny

\*3 small beakers \*FT-IR machine \*2 Plastic pipettes

\*methanol \*Printer/paper \*Ring stand

\*9M KOH \*Acetone wash bottle \*Ring Clamp

\*NaCl \*Kimwipes \*Stirring Rod

\*anhydrous NaSO4 \*Biodiesel sample \*Soda Can

\*various oils \*Glycerin sample \*Graduated Cylinder

\*25 mL grad. Cylinder \*Oil Spectra \*Water

\*2 test tubes \*Thermometer

\*Stopper or cap for tubes \*Long stemmed lighter

\*test tube rack \*small beaker

\*analytical balance

\*forceps

**Safety:**

Goggles must be worn for this lab at all times.

KOH is caustic, please use caution.

Gloves should be worn during the biodiesel production process.

Please dispose of biodiesel and glycerin in the waste jars provided for proper disposal.

**Procedure:**

**Part 1: Biodiesel Production**

1. In your notebooks, record name and general observations of the oil at your station, noting color, viscosity and odor.
2. Using a plastic pipette, transfer 3 mL of methanol into the larger twist top test tube.
3. Using an autopipette, transfer 0.5 mL of 9M KOH (potassium hydroxide) into the methanol and swirl gently.
4. Pour 12 mL of warm oil into a graduated cylinder and transfer to the test tube.
5. Put on gloves, twist cap on test tube and begin shaking the mixture. Be sure to release pressure in tube by untwisting the cap several times.
6. Shake mixture for 10 minutes, switching halfway through.
7. Using a plastic transfer pipette, place 1mL of salt water into the tube and invert gently (with lid on) three times. This will wash the biodiesel free from the glycerin.
8. Place the test tube in the test tube rack and allow the biodiesel and glycerin to separate.
9. Put 4-5 drops of salt water into your test tube to help the products separate.
10. Carefully remove the top layer of biodiesel using a plastic pipette and put into the small twist top test tube. Try to not pull up any salt water or glycerin.
11. Add a small scoop of anhydrous sodium sulfate and swirl gently.
12. Record your observations of both the biodiesel and glycerin in your notebooks, again noting the viscosity, color and odor.

**Part 2: Analyzing the Products**

1. Obtain an Eppendorf tube and label the tube with your specific type of biodiesel.
2. Using a clean plastic pipette, transfer approximately 1 mL of your biodiesel sample into an Eppendorf tube.
3. Once all groups have their samples ready, bring them to the centrifuge.
4. The samples will be centrifuged for approximately 5 minutes. Once your sample is ready, it can be analyzed in the FT-IR spectrometer.
5. Bring your Eppendorf tube and your glycerin (the bottom layer remaining in the larger twist top test tube) to the IR.
6. The IR will be on already, following these instructions to test your samples:
   1. Open the collect tab at the bottom of the screen and click on background.
   2. Type b in the textbox, back away from the machine (breathing on the collection plate will influence your results) and hit OK.
   3. Once the background collection is complete, place two drops of your glycerin onto the IR plate and click on collect, then sample. In the textbox, type in Glycerin and click OK.
   4. Once completed, open Analyze Tab at bottom and click on Find Peaks. Click at the highest peak on the screen. If you need help locating where to click, please ask. Click OK. Then open the view tab and click on show report.
   5. Go to file, print, and change printer to inkjet and layout to landscape. Click OK. While spectrum is printing, use a Kimwipe to clean off IR plate. Place a few drops of acetone onto the plate and wipe clean/dry with a Kimwipe.
   6. Complete steps a-e using your biodiesel sample.
7. Return to your lab station and compare your two spectra. Do you notice any major differences? Record any observations in your lab notebook.
8. Bring your spectra to the front and compare your biodiesel and glycerin spectra to the spectrum for your specific oil.
9. Record any observations in your lab notebook.

**Part 3: Determining Heat of Combustion**

1. Prepare your personal Homemade Bunsen burner.
   1. Obtain a compression nut, cotton cosmetic pad and a penny.
   2. Place the penny in the bottom of the compression nut.
   3. Push the entire cosmetic pad into the compression nut until it is flush with the top.
   4. Place approximately 3 mL of your biodiesel into the cotton cosmetic pad and this completes your homemade Bunsen burner.
2. Using the analytical balance, mass the Bunsen burner. Record the mass in Data Table 1.
3. Place the Bunsen burner on the base of a ring stand.
4. Obtain an empty soda can and carefully pour 75 mL of water into the can. (Remember that 1 mL of water has a mass of 1 gram.)
5. Bend the soda tab up and place a stirring rod through the tab so that it can rest on the ring clamp above the Bunsen burner.
6. Place a thermometer into the can and allow it to sit for 5 minutes. Record the starting temperature of the water in Data Table 1.
7. Remove thermometer and light Bunsen burner.
8. Allow Bunsen burner to burn for 2-3 minutes to get an even burning flame.
9. Gently lower the soda can and clamp so that the flame is touching the bottom of the can.
10. Let the Bunsen burner burn for 5 minutes. Raise the soda can and clamp away from the flame.
11. Put thermometer into the can and record final temperature of the water into Data Table 1.
12. Extinguish your flame by placing a small beaker over your flame.
13. While your Bunsen burner is cooling, calculate your change in temperature by subtracting your starting temperature from your final temperature.
14. Then calculate your ΔE using the equation:

s = 4.184 J/g°C

m = mass of water

(HINT: 1 mL of water has a mass of 1 gram.)

ΔT = from data table

ΔE = s x m x ΔT

1. Carefully pick up your Bunsen burner and mass it using the analytical balance. Record the mass in Data Table 1.
2. Determine the change in mass of your Bunsen burner.
3. Using the forceps, pull the cotton pad out of the compression nut and place in the disposal container.
4. Wash the compression nut and washer with soap and dry them both.
5. Collect the class data and complete Data Table 1 and 2 with your classmates’ data.
6. Looking at the ΔE column of Data Table 2, rank the biodiesels from highest to lowest.
7. Compare and discuss the various biodiesels made from different plant oils.

**Data tables:**

Table 1: Info for Heat of Combustion

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Type of Biodiesel** | **Initial Mass**  **(g)** | **Final Mass**  **(g)** | **Change in Mass (Initial-Final)** | **Starting Temp. of Water (°C)** | **Ending Temp. of Water (°C)** | **Change in Temp. (Final - Initial)**  **ΔT** |
| **Canola** |  |  |  |  |  |  |
| **Coconut** |  |  |  |  |  |  |
| **Corn** |  |  |  |  |  |  |
| **Olive** |  |  |  |  |  |  |
| **Safflower** |  |  |  |  |  |  |
| **Vegetable** |  |  |  |  |  |  |

Table 2: Heat of Combustion Values for Each Biodiesel

|  |  |  |
| --- | --- | --- |
| **Type of Biodiesel** | **ΔE** | **Rank from Highest to Lowest** |
| **Canola** |  |  |
| **Coconut** |  |  |
| **Corn** |  |  |
| **Olive** |  |  |
| **Safflower** |  |  |
| **Vegetable** |  |  |

**Calculations:**

1. To Calculate Heat of Combustion (ΔE):

**ΔE = s x m x ΔT,** where s = 4.184 J/g°C

m = mass of water in can

ΔT= Tfinal - Tinitial

**\*\*The unit of ΔE will be in Joules.**

**Questions:**

1. Which oil produced the best biodiesel and why? Use the data to support your answer.
2. What sources of error could affect your yield of biodiesel from your specific oil and determining the heat of combustion?
3. When making the biodiesel, how do you know that a chemical reaction actually takes place?

**References:**

<http://www.toshiba.com/taf/common/docs/Biofuels.pdf>

<http://www.umsl.edu/~biofuels/Biodiesel%20activites/Lab-Workshop-BIODIESELmicroscale-07.pdf>

<http://www.instructables.com/id/The-Pocket-bunsen-burner/>