

# STOICHIOMETRY: Making Biodiesel (single-phase reaction)

**Georgia Performance Standards:** SCSH1-9, SC2 a & b, SC5 b, SC7 b

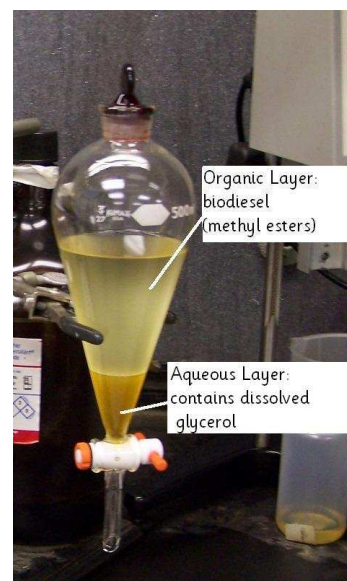
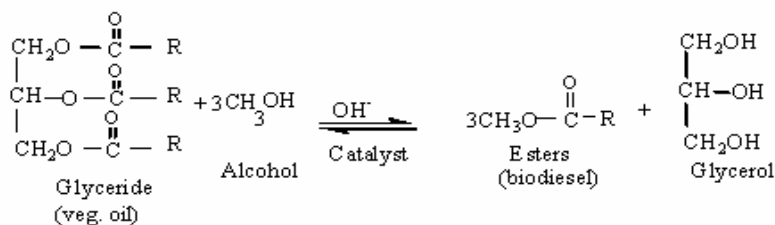
**National Science Standards:** Content Standards A, B: chemical reactions, structure of matter, F: natural resources, environmental quality, science in local, national, and global challenges

**Objective:** Students will learn about the process of transesterification which is the reaction that produces biodiesel. Students will also make their own biodiesel that can be kept for further testing.

**Essential Questions:**

- What is biodiesel?
- Is it difficult to make biodiesel?
- Are there any co-products of biodiesel production and are they useful?

**Background:** Biodiesel is made by a chemical reaction called *transesterification*. It is made from a triglyceride (a fat or oil), which is sometimes called the “feedstock.” The feedstock fat/oil is reacted with an alcohol, such as methanol, in the presence of a catalyst (sodium hydroxide). The reaction yields esters (methyl esters if using methanol) and glycerol.



\*Above picture comes from [http://www.esru.strath.ac.uk/EandE/Web\\_sites/02-03/biofuels/what\\_biodiesel.htm](http://www.esru.strath.ac.uk/EandE/Web_sites/02-03/biofuels/what_biodiesel.htm)

The products must settle for several hours in order to separate the organic from the aqueous. This is usually done in a separatory funnel where the

esters separate into the top layer and the glycerol dissolves in the bottom layer. The esters are the *biodiesel* and the glycerol can be put in a landfill or burned in boilers as fuel.

**Materials:**

- Per lab station
1. 250 mL Soybean, Canola, or other oil from a grocery store
  2. 50 mL Methanol
  3. 2.25 g KOH
  4. 125, 500 mL Erlenmeyer Flask
  5. 100 mL graduated cylinder
  6. balance
  7. Stir/Heat plate
  8. Stir bar
  9. Thermometer
  10. 250mL or 500 mL Separatory funnel
  11. pH paper
  12. two or three 50 mL beakers
  13. Parafilm

**Procedure:**

Part I: Reaction

1. Make sure all glassware is CLEAN and DRY.
2. Measure out 50 mL of methanol using your graduated cylinder (make sure you record the exact volume you use).
3. Weigh 2.25 grams of KOH using the electronic balance. (Make sure you record the exact mass you use)
4. Put the methanol and KOH into the 125 mL Erlenmeyer flask. Add the magnetic stir bar.
5. Place the flask on the stir plate, cover with a little Parafilm and turn on to a medium speed. (You want a good vortex but without splashing).
6. Stir the mixture until the KOH dissolves into the methanol (this may take a little while).
7. Once the KOH has dissolved, you have a substance called potassium methoxide.
8. Add 250 mL of vegetable oil to a 600 mL beaker and record the actual amount of oil. (To calculate the mass of the vegetable oil, use the density 0.90 g/mL). Add a stir bar and all of the methoxide mixture.
9. Turn the heat up until the mixture reaches between 55-60°C and stir at a medium speed for 45 minutes.
10. When the mixture has reacted after about 45 minutes, pour it into a separatory funnel and let it sit for about 10-15 minutes.

## Part II: Separation

11. The bottom layer is the glycerol layer that you do NOT want; the biodiesel is in the top layer. Slowly drain the bottom layer into a small beaker by turning the stopcock until the liquid starts to flow. YOU MUST REMOVE THE STOPPER AT THE TOP OF THE FUNNEL TO GET IT TO DRAIN. When you see that the biodiesel layer is getting close to the bottom of the funnel, turn the stopcock so only one drip comes out at a time (you can put the top back on the funnel to help you). When you see the first drop of biodiesel leave the funnel, close the stopcock completely.
12. What you now have is CRUDE biodiesel. Since we did not wash it, it is NOT the high quality fuel you would need to put into a vehicle.
13. Weigh the clean bottle you brought (including the cap). Drain the biodiesel out into the clean bottle and weigh it again (don't forget to include the cap).
14. Set the biodiesel aside so it can be used in future laboratory assignments. Make sure your name and period are on the bottle.

### **Data and Calculations:**

1. In your data section make sure you have recorded any physical observations you see as you do the lab (color change, texture change, temperature change, etc). Also make sure to include the masses of all your starting materials and your final product.
2. Using the equation given to you above (take note of the coefficients – the equation is already balanced), calculate the limiting reactant and the theoretical yield of the biodiesel (methyl esters). Use the approximation of molar mass of the oil (glyceride – hint: that is all one molecule) to be 885.4 g/mol.
3. Using your actual yield, calculate the percent yield of your reaction.

### **Questions:**

1. What differences do you see in the characteristics of the starting materials and the final products? Record your observations in the data/observations section of your lab notebook.
2. What were some signs that the chemical reaction took place? How did you know the reaction occurred? Record your observations in the data/observations section of your lab notebook.
3. What are the reasons that you have to wash the biodiesel? What is the effect if you do not have a neutral pH?

4. In a commercial plant's production of biodiesel, they put in 1200 grams of oil and get out 1092 grams of crude biodiesel. What is the percent yield of this reaction? What was your percent yield and how does your yield compare to the commercial plant's yield?

**Assessment:** Lab Rubric

## Lab Data Sheet – Stoichiometry

Actual volume of methanol used: \_\_\_\_\_ mL

Actual mass of KOH used: \_\_\_\_\_ g

Actual volume of oil used: \_\_\_\_\_ mL

Calculated mass of oil used: \_\_\_\_\_ g

*Show calculation here –*

Mass of bottle (and cap) empty: \_\_\_\_\_ g

Mass of bottle (and cap) + biodiesel: \_\_\_\_\_ g

Physical observations:

Coefficients of:

Oil \_\_\_\_\_

Methanol \_\_\_\_\_

Biodiesel \_\_\_\_\_

Calculation of limiting reactant:

Calculation of theoretical yield:

Calculation of percent yield:

## STOICHIOMETRY: Instructor Notes



If you do not have access to separatory funnels, you may use unitary wash bottles, such as the ones pictured (from Fisher Scientific).

The students can perform the reaction directly in the wash bottle and let it settle. Since the wash bottle pulls from the bottom, the glycerol can easily be removed by simply squeezing the bottle.

You can adjust the amounts of methanol, potassium hydroxide and oil used as long as you use the following ratio: 1000mL oil to 200 mL of methanol to 9 grams of KOH.

If you prefer to use NaOH, the correct amount in the ratio would be 3.5 grams. NaOH does not dissolve as easily in the methanol.

Make sure you are in a well-ventilated area when using the methanol and performing this lab. Students should also wear gloves when handling the methanol and catalyst.

If you choose to make biodiesel from used vegetable oil, such as your cafeteria waste, then you must perform the free fatty acid titration to determine the amount of catalyst used (see the procedure in the acid/base lab). You can perform the titration ahead of time and then tell the students of the adjusted catalyst amount. The amount of methanol and oil stays the same.

The density and molar mass given are soybean oil numbers. If you use another type of oil, you can search for those values on the internet.