RATES OF REACTIONS:
Catalyst Difference in Biodiesel

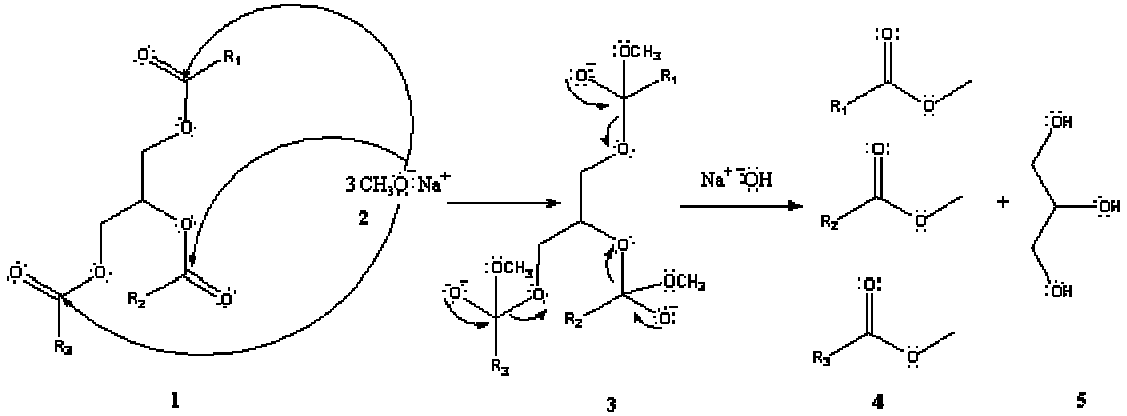
Georgia Performance Standards: SCSh1-9, SC2 a, b, SC5 b, c
National Science Standards: Content Standards A, B: chemical reactions, F: natural resources

Objective: Students will make a batch of biodiesel using NaOH as the catalyst while reaction time remains constant. Students will compare and contrast the yield of biodiesel using NaOH with the previous batch made with KOH catalyst.

Essential Questions:

- Why is a catalyst necessary in biodiesel production?
- Is there any difference in using NaOH or KOH as the catalyst?
- Can acids or other heterogeneous catalysts be used?

Background: Catalysts help a reaction occur more quickly by providing a new pathway at a lower energy. In biodiesel, the cheapest effective catalyst at this time is to use alkali metal hydroxides. The hydroxide reacts with the methanol to make methoxide, which contains ions, and that methoxide can more easily attract to the triglyceride, and therefore it will transform the triglyceride into three methyl esters and glycerol. The mechanism is shown below:



Scheme 1. Transesterification of triglyceride

Picture from: http://ciitn.missouri.edu/testsite/www/cgi-bin/pub_view_project_ind.cgi?g_num=8&c_id=2005002

The alkali hydroxide can be recovered from water used in a wash process of the biodiesel. Since the hydroxide can be recovered, it is not actually a reactant and is therefore a catalyst.

Materials: Per lab station

1. 250 mL Soybean, Canola, or other oil from a grocery store
2. 50 mL Methanol
3. 0.875 g NaOH
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: Follow the procedure for making biodiesel from the stoichiometry lab but use NaOH instead of KOH. Measure the actual yield and calculate the theoretical and percent yields the same way. Compare and contrast your results of the two biodiesel processes.

Record your hypothesis before you begin

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).
15. Weigh 0.875 grams of NaOH using the electronic balance. (Make sure you record the exact mass you use in your lab notebook)
16. Put the methanol and KOH into the 125 mL Erlenmeyer flask. Add the magnetic stir bar.
17. 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).
18. Stir the mixture until the NaOH dissolves into the methanol (this may take a little while).
19. Once the NaOH has dissolved, you have a substance called potassium methoxide.
20. Add 250 mL of vegetable oil record the actual amount of oil. (To calculate the mass of the vegetable oil, use the

density 0.83 g/mL). Add a stir bar and all of the methoxide mixture.

21. Turn the heat up until the mixture reaches between 55-60˚C and stir at a medium speed for 45 minutes.
22. 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

23. 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.
24. 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.
25. 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).
26. Set the biodiesel aside and make sure your name and period are on the bottle.

Data and Calculations:

4. 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.
5. 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 873.01 g/mol.
6. Using your actual yield, calculate the percent yield of your reaction.

Assessment: Lab rubric

Questions: 1. How did your percent yield using NaOH compare with your percent yield with KOH catalyst in the stoichiometry lab?

2. Why do you think you had to use less NaOH than KOH?

Lab Data Sheet – Reaction Rates

Hypothesis:

Actual volume of methanol used: _____mL

Actual mass of NaOH 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:

Comparison of percent yield using KOH to NaOH: _____

RATES OF REACTION:
Instructor Notes

Make sure that the students react the vegetable oil and sodium methoxide mixture at the exact same temperature and for the same amount of time as they did with the stoichiometry lab using KOH. This will ensure accurate comparisons between the two.

As another option for this lab, half the groups could re-do the reaction with KOH while the other half did it with NaOH and they could compare results among the class.