The Biodiesel Challenge! C. Kohn, Waterford WI

Partner names: Hour

Date Assignment is due: Why late? Score: + ✓ -  
 Day of Week Date If your project was late, describe why**Objective: in this lab, you will a be competing against other groups to create the highest-quality biodiesel from the lowest-quality and most-used waste vegetable oil (WVO) that you can find.**

**Safety**: this is a potentially dangerous lab experiment! Methanol is very flammable – keep away from flames and sparks and avoid inhaling fumes. Methanol can be hazardous and will be easily absorbed through the skin – avoid contact at all times and do not remove gloves, eyewear, or aprons at any point while performing the lab.

Potassium hydroxide (KOH) will cause chemical burns if inappropriately handled. NEVER remove gloves or goggles when handling.

Mixing KOH with methanol will produce fumes. Perform only in a well-ventilated area. If you feel faint or dizzy, immediately leave the lab and go into the classroom.

DO NOT wear sandals, flip flops, or other open toed shoes. Spills can be hazardous on exposed skin. If you do spill KOH, methanol, or methoxide onto exposed skin, immediately flush with copious amounts of water.

It is VERY important that all materials are safely stored or disposed as instructed. Do NOT leave potentially hazardous chemicals in a location where they may cause later harm or injury. YOU ARE RESPONSIBLE FOR PREVENTING ANY AND ALL PROBLEMS. SAFETY SHOULD NOT HAPPEN BY ACCIDENT!

Never attempt any of these procedures without the supervision of a trained adult. This work should not be performed at home.

**Day 1: Filtration and Titration of oil** (to determine KOH needed). The more the KOH needed, the higher your score. The worse the oil, the more KOH is needed, which would indicate a sample of oil that was used as much as possible. Each group will titrate their own samples as well as two others. Each sample of oil will be titrated by three different groups, and the average of the three titrations will be used to calculate an average KOH level that will be used in scoring.

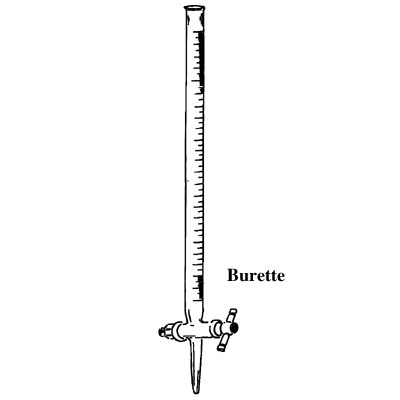
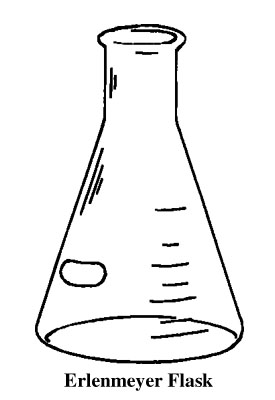
**Day 2: Transesterification** – new vegetable oil (NVO) heated to 55o C will be treated with methoxide (KOH and methanol). After 45-60 minutes of stirring and heat, the mixture will be allowed to cool and settle overnight. In the meantime, teams will start a marketing strategy for their oil and create a hypothetical brand.

**Day 3: Separation and washing** – biodiesel and glycerine will be poured into a separatory funnel. The glycerine will settle to the bottom of the funnel and will be drained. The biodiesel will be washed three times using pure water. The water will be drained as the biodiesel rises to the top. The biodiesel will be allowed to dry overnight. Work will be continued on the marketing component.

**Day 4: Collection** – the biodiesel will be moved into clean mason jars for storage until later testing. Teams will finish their work on their brand.

**Day 5: Presentations** Groups will present their product and company information.

# Day 1: Titration of the oil (gloves, goggles, and aprons are needed for this portion).

1. Measure 200 ml of waste vegetable oil and pour into a clean, dry 400 ml beaker. Provide your instructor with two small samples (about 5 ml) of your oil. Label these samples with your group names.
2. Filter the oil by pouring it into another container through cheesecloth to strain out any large impurities.
3. Return the filtered oil to the beaker. Clean out the second container using soap and water and leave to dry.
4. Fill your burette with 0.1% KOH solution[[1]](#footnote-1). Note the initial volume of your KOH here
5. Measure 10 ml of methanol and pour into a small container.
6. Measure 1 ml of waste oil heated to 55oC. Add this oil to the methanol in the small container. Swirl to dissolve the oil into the methanol.
7. Add 2 drops of phenolphthalein[[2]](#footnote-2) to the oil/methanol solution. Gently swirl the oil/methanol/phenolphthalein to evenly distribute all components of the solution.
8. Slowly add the 0.1% KOH solution to your oil/methanol solution drop by drop, swirling the solution each time a drop is added. **Continue to add the KOH solution to your oil/methanol solution in a drop by drop manner until the mixture holds its pink color for 10-15 seconds.** 
   1. If your solution holds the pink color permanently, you have added too much KOH. (If this happens, start again with Step 7.)
9. Note the FINAL volume of your KOH here
10. Subtract the initial volume of your KOH solution in the burette from your final volume. Record below.  
      
    ***We used ml of KOH.***
11. Divide the ml of 0.1% KOH used by 5 to determine the g of KOH needed per 200 ml.   
      
    ***We used \_\_\_\_ ml of KOH. This number divided by 5 = \_\_\_\_. This means that we need 1.3 g + g KOH = \_\_\_ g***
12. Turn off your heaters and cover your oil. Be sure to clean up all messes around your lab area.
13. Dump your 0.1% KOH solution from your burettes into a sink with running water. Rinse your burettes and dry.
14. Your instructor will provide you with two samples from other groups. Each sample will be given a generic label. Repeat this titration process each of the two samples given to you. Record the g KOH needed for each sample and label the sample. Record the information below:   
      
    g of KOH needed for …. Sample : g Sample : g  
    *Be sure to label each sample above accurately – this information will be needed later.*  
    **Day 2 Part A: Transesterification of the oil (you will need gloves, goggles, and aprons for this entire portion).**
15. Heat 200 ml of your waste oil to 55o C and stir using the magnetic stir bar.
16. While the oil is heating, measure 40 ml of methanol and pour into a clean Erlenmeyer flask. Stopper the flask.
17. Using the scales at your stations and the paper holders, measure 1.3 g of potassium hydroxide (KOH) plus what you calculated in #13 yesterday.
    1. It takes 1.3 g per 200 ml of new vegetable oil to cause a complete reaction. Because we are working with waste oil, we will need to add additional KOH to completely react the extra FFAs in the oil due to its use in frying. Add 1.3 to your calculated KOH from your titration for your total amount.
18. After checking to ensure that the room exhaust fans are running, add your calculated KOH amount to your flask of methanol and quickly stopper the flask (do this away from your face).
19. Swirl your flask until all of the KOH dissolves (it will take some time; be persistent with your swirling).
    1. CAUTION: this solution is extremely caustic and produces toxic fumes. Keep your flask sealed until you are ready to add your solution to your oil. Once the solution is in the heated oil, its danger is reduced by the transesterification reaction.
20. When the oil is between 55-57o C, quickly but carefully pour your 40 ml of methoxide into the oil. Re-cap your flask. Continue stirring – stirring should be vigorous but not so fast that it forms a vortex.
21. Keep your reaction between 55-57o C; shoot for 56o C. Allow your mixture to stay at this temperature for 45-60 minutes. Keep the solution mixing using the magnetic stir bar.
22. After 45-60 minutes, turn off your heat source and stop the mixing. Allow the mixture to cool and settle overnight (or at least 2 hours).
23. Rinse your flasks in a well-ventilated area. Wash with soap, water, and a bottle brush. Rinse well and hang on the drying rack.
24. Continue to **Part B** on the next page.

**Day 2 Part B: Business & Marketing Plan**

Like any new product, biodiesel manufacturers must sell to customers that may not be fully aware of the benefits of this new type of fuel. In this case, you will be making a presentation at the end of the week related to your product. Your entire group will present your biodiesel to the class as if they were a group of potential financial investors (i.e. these are people who would pay money into your company with the hopes that they will be able to make money off their investment). Begin organizing your group and compiling your information today. As a group, you will need to start preparing a presentation that you will give on Friday using a poster or PowerPoint. Your marketing plan should consist of:

* **Business Details**
  + Business Name – develop a creative (and appropriate) business name that reflects the fact that you produce biodiesel and reflects why you produce it.
  + Business Philosophy – create a brief explanation of the top priorities of your company. Why does your company exist? Besides making money, what do you try to do as a business to impact the world?
* **Product Specifications** – address the following in your presentation (you will need to use the internet to find some of this information; you will need to record and state the sources of your information in your presentation):
  + Fuel efficiency – how many miles per gallon does biodiesel get on average?
  + Cost of production – how much does it cost on average to produce a gallon of biodiesel?
  + Safety – what safety concerns exist in the production and use of biodiesel?
  + Labor and production – how is biodiesel made? What is needed to produce biodiesel?
  + Pro’s and Con’s – what are the benefits and drawbacks of this as a source of fuel?
* **Marketing** – how will you effectively sell this product in order for your company to make money? Be sure to address each of the following:
  + Likely market – what kind of customers are most likely to purchase this product?
  + Target market – what kind of customers will purchase this product only with the right advertising?
  + Non-markets – what kind of people will not purchase biodiesel even with strong marketing?
  + Selling points – what are the key advantages of biodiesel and how can they be used to sell this product?
  + Marketing strategy – how will you convince the customers who are “on the fence” that they should purchase your biodiesel over conventional diesel fuel at the pump?
* **Cited Sources** – list all sources used to create your presentation using the following format:   
  *Last Name, First Name. Year. Title of Document/Website/Resource. Location published or website.*  
  *E.g. 🡪 Kohn, Craig. 2012. Why Biofuels? (PowerPoint Presentation) Waterford, WI*

In your groups, you will need to decide who is doing each section. In the space below, record who will be in charge of each component. Remember, you are not done until your entire group is done! If you finish first, help your group members finish their sections. Beside each section, write the name of the student responsible for that section.  
  
Business Details: Product Spec’s:   
  
Marketing Plan: Cited Sources:

Other Responsibilities (describe) :

# Day 3 Part A: Separation and washing (you will need gloves, goggles, and aprons for this entire portion).

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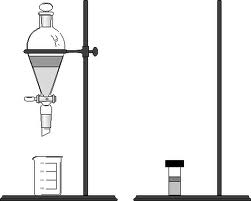
1. If your reaction was performed correctly, you should now see a dark layer of glycerine on the bottom of the flask with the clear-ish yellow biodiesel on top.
2. Carefully pour your light yellow biodiesel into a separatory funnel (NOTE: make sure it is closed before your pour!). Try to not transfer any of the dark glycerine at the bottom. Dispose of the glycerine as instructed.
3. Add 50 ml of fresh water to the separatory funnel with your biodiesel.
4. Gently swirl the funnel to mix the diesel and water. Allow the mixture to settle (this may take a few minutes). After the water has settled to the bottom, drain into a collection jar under the funnel. Stop draining when all of the water has been removed.
5. Add 50 ml of fresh water again and repeat the two steps above. You should notice the wash water getting clearer each time and that it should separate more quickly from the biodiesel each time.
6. Add 50 ml of fresh water for a third time and drain when it settles to the bottom.
7. Allow your wash water to stand in the well-ventilated lab for a day to allow the excess methanol to evaporate.

Figure A Separatory Funnel

1. Allow your biodiesel to dry open overnight in the separatory funnel.
2. After ensuring that no glycerine remains in your beaker, rinse your beaker in a well ventilated area (glycerine will clog drains – be sure none remains before you rinse!). Wash your beaker with soap, water, and a bottle brush. Rinse well and hang on the drying rack.

# Day 3 Part B: Business Plan

Using the information you have already compiled, begin to assemble your presentation. Remember that all group members should be involved in this process.

Remember that all sources must be cited. Only use sources are credible – in most cases, these would be government or educational websites (these websites end in .gov or .edu). Organizational websites (.org) can be credible but be careful! Do NOT use .com websites or Wikipedia.

You will be presenting your work to the class. You should use a poster, PowerPoint, or other method of group presentation (see your instructor to determine if any other options would work). Each section should be its own slide or poster. In other words, you should have different slides or posters for each of the following: **Business Details, Product Specifications** , **Marketing** , **Cited Sources**.

# Day 4 Part A: Collection (you will need gloves, goggles, and aprons for this entire portion).

1. Remove any remaining impurities in your biodiesel by draining them from the separatory funnel.
2. Remove your waste collection jar and dispose of your waste as instructed.

Figure A beaker

1. Place a clean dry mason under your separatory funnel and slowly transfer your biodiesel into your jar. Seal your jar.
2. Carefully wash your separatory funnel and collection jar with soap and water and hang on the drying rack. Acquire your instructor’s initials HERE after you have completed this step.
3. Label your jar of biodiesel using tape with your group names and date. Place your jar in the location provided by your instructor.
4. Compare your biodiesel from waste vegetable oil to your biodiesel from the new vegetable oil from the previous lab. Note any differences. Hypothesize whether there will be a difference in performance between the two fuels.

# Day 4 Part B: Tests of Quality

You will be testing your batch and two other batches from different groups for each of the following:

**Test 1 – Level of Reaction Completion**: Dissolve 1 ml of biodiesel in 10 ml of methanol. If you observe undissolved material at the bottom of the sample the reaction did not proceed to completion.

**Test 2 - Emulsification**: Combine one part biodiesel with one part water (50/50 mix) and shake vigorously. If the resulting mixture separates quickly and the biodiesel phase on top appears clear and bright and the water phase at the bottom appears clear and free of debris your fuel is clean.

**Test 3 – pH**: Washed biodiesel should have a pH close to 7.

**Test 4 – Visual Inspection**: Biodiesel will be clear if it is free of water. It passes the test if you can easily read this text on the other side of a glass jar of biodiesel.

# Data for Your Batch:

Group Names: Date:

**Test 1 – Level of Reaction Completion**: Dissolve 1 ml of biodiesel in 10 ml of methanol. If you observe undissolved material at the bottom of the sample the reaction did not proceed to completion.  
  
*Check where most appropriate:*

\_\_\_\_\_ Undissolved material settled at the bottom after test was completed.

\_\_\_\_\_ No undissolved material settled at the bottom after test was completed.

**Test 2 - Emulsification**: Combine one part biodiesel with one part water (50/50 mix) and shake vigorously. If the resulting mixture separates quickly and the biodiesel phase on top appears clear and bright and the water phase at the bottom appears clear and free of debris your fuel is clean.

*Check where most appropriate*

\_\_\_\_\_ Mixture separated quickly; biodiesel stays clear on top while water remains clear on bottom.

\_\_\_\_\_ Mixture separated but was cloudy.

\_\_\_\_\_ Mixture did not separate or took a long time to separate

**Test 3 – pH**: Washed biodiesel should have a pH close to 7. Test using pH strips or a pH meter.

*Check where most appropriate*

\_\_\_\_\_ pH was 7

\_\_\_\_\_ pH was below 7 (Record pH here: )

\_\_\_\_\_ pH was above 7 (Record pH here: )

**Test 4 – Visual Inspection**: Biodiesel will be clear if it is free of water. It passes the test if you can easily read this text on the other side of a glass jar of biodiesel.

*Check where most appropriate*

\_\_\_\_\_ Text is easily readable through biodiesel

\_\_\_\_\_ Text is readable with some effort through biodiesel

\_\_\_\_\_ Text is not readable through biodiesel

**Final Conclusion: Is this batch of biodiesel saleable? Explain:**

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**Test 2 - Emulsification**: Combine one part biodiesel with one part water (50/50 mix) and shake vigorously. If the resulting mixture separates quickly and the biodiesel phase on top appears clear and bright and the water phase at the bottom appears clear and free of debris your fuel is clean.

*Check where most appropriate*

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\_\_\_\_\_ Mixture did not separate or took a long time to separate

**Test 3 – pH**: Washed biodiesel should have a pH close to 7. Test using pH strips or a pH meter.

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\_\_\_\_\_ pH was above 7 (Record pH here: )

**Test 4 – Visual Inspection**: Biodiesel will be clear if it is free of water. It passes the test if you can easily read this text on the other side of a glass jar of biodiesel.

*Check where most appropriate*

\_\_\_\_\_ Text is easily readable through biodiesel

\_\_\_\_\_ Text is readable with some effort through biodiesel

\_\_\_\_\_ Text is not readable through biodiesel

**Final Conclusion: Is this batch of biodiesel saleable? Explain:**

Group Names:

# Final Results (leave blank – your instructor will complete this)

Code Name:

KOH Needed (as determined by group): (as determined by other groups):

**Average KOH Needed:** *Subtract 1.3 from this number and then divide by 1.3 to get the point score:*

**Test 1 – Level of Reaction Completion**:   
  
*Checks received:*

\_\_\_\_\_ Undissolved material settled at the bottom after test was completed (0 points).

\_\_\_\_\_ No undissolved material settled at the bottom after test was completed (1 point per check).

**Test 2 - Emulsification**:

*Checks received:*

\_\_\_\_\_ Mixture separated quickly; biodiesel stays clear on top while water remains clear on bottom (2 points per check).

\_\_\_\_\_ Mixture separated but was cloudy (1 point per check).

\_\_\_\_\_ Mixture did not separate or took a long time to separate (0 points per check).

**Test 3 – pH**:

*Checks received:*

\_\_\_\_\_ pH was 7 (1 point per check).

\_\_\_\_\_ pH was below 7 (Record pH here: ) (0 points per check).

\_\_\_\_\_ pH was above 7 (Record pH here: ) (0 points per check).

**Test 4 – Visual Inspection**:

*Checks received:*

\_\_\_\_\_ Text is easily readable through biodiesel (2 points per check).

\_\_\_\_\_ Text is readable with some effort through biodiesel (1 points per check).

\_\_\_\_\_ Text is not readable through biodiesel (0 points per check).

KOH Score: Reaction Completion: Emulsification: pH: Visual: **TOTAL**:

1. 0.1% KOH = 1 g KOH dissolved in 1000 ml of water [↑](#footnote-ref-1)
2. Phenolphthalein is an indicator solution that changes color in response to changes in pH  
    [↑](#footnote-ref-2)