Small Scale Biodiesel Production

Wilson College

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AN INTRODUCTION TO BIODIESEL

What is Biodiesel?

Biodiesel is a clean burning fuel made from various feedstocks, such as waste vegetable oil, virgin vegetable, animal fats, and yellow grease[i]. However, at Wilson College, we brew biodiesel using waste vegetable oil provided by the campus kitchen. What makes biodiesel different from using pure vegetable oil is a process known as transesterification, and this process will be discussed later in this publication.

Biodiesel is one of several biofuels that can be used to meet society's energy needs. For example, ethanol is a very common biofuel made from sugar cane, potatoe, maize and manioc feedstocks. But, biodiesel is not ethanol because ethanol is a renewable biofuel intended for use in gasoline-powered engines[ii].

The interest in biodiesel has increased due to rising fuel prices, the want for energy independence (since biodiesel can be created through domestic sources) and the need for an environmentally responsible fuel source[iii].

Advantages and Disadvantages of Biodiesel

There are many advantages to using biodiesel as a fuel source. First, biodiesel actually cleanses diesel engines

of deposits that may have accumulated over time. Second, biodiesel may cost less than using traditional diesel since a feedstock such as waste vegetable oil can be easily and cheaply obtained from places such as restaurants. However, the time and energy spent to create biodiesel can make it seem to be more expensive than readily available diesel. Third, biodiesel is a renewable and clean burning energy source. Fourth, small-scale biodiesel production does not take more energy to create than it gives back. According to Biodiesel.Org, a leading organization in biodiesel research and marketing:

> Biodiesel has one of the highest "energy balance" of any liquid fuel. For every unit of fossil energy it takes to make biodiesel, 4.5 units of energy are gained. This takes into account the planting, harvesting, fuel production and fuel transportation to the end user[iv].

Some of this calculation is probably due to the fact that feedstocks, such as waste vegetable oil, can be gained domestically, which means no transportation of petroleum from other countries and thereby less fossil fuels and energy spent. Also, biodiesel can be used by itself in modified diesel engines, which can mean no use of petroleum, which is typically gained from other countries.

However, biodiesel does have some disadvantages. One disadvantage is that biodiesel on the small-scale takes great amounts of time and energy on the part of the biodiesel producer to complete. Another disadvantage of biodiesel is that it has a lower energy output than traditional fuel sources such as diesel and gasoline[v]. Also, if one is using waste vegetable oil as a feedstock, for

example, massive amounts of water probably went into growing the vegetable, and this probably had negative impacts on the environment in terms of runoff and pesticides[vi]. Also, washing the fuel takes considerable water usage too.

At any rate, now more than ever it is important to understand the different fuel sources available for vehicles. Our dependence on fossil fuels has caused dependency on foreign sources, environmental degradation and rising costs due to depletion and political instability. Therefore, we must understand and know the options we have as consumers and members of the biosphere in order to make responsible decisions.

Biodiesel as Transportation Fuel Source

Biodiesel can be used as a pure fuel source itself, or it can be mixed with petroleum. In this case, the biodiesel would be labeled "B", followed by the percentage of biodiesel added to the oil. For example, if 20% biodiesel were mixed with 80% petroleum, then the label would be B20. Additionally, blends up to 20% will work in a diesel engine with no modifications[vii]. In fact, biodiesel can cleanse a diesel engine of deposits that may have accumulated from previous fuel use[viii]. Therefore, it is important to check fuel filters frequently[ix]. Also, blends above B20 should be evaluated on a case-by-case basis since damage to the equipment and fuel systems could occur in unknown or untested blends above B20[x].

Biodiesel Emissions Compared to Diesel Emissions

According to Biodiesel.Org, biodiesel is the "first and only alternative fuel to have a complete evaluation of emission results and potential health effects"[xi]. The following chart, from the Environmental Protection Agency outlines the emissions results of biodiesel compared to conventional diesel:

AVERAGE BIODIESEL EMISSIONS COMPARED TO CONVENTIONAL DIESEL, ACCORDING TO EPA		
Emission Type	**B100**	**B20**
Regulated		
Total Unburned Hydrocarbons	**-67%**	**-20%**
Carbon Monoxide	**-48%**	**-12%**
Particulate Matter	**-47%**	**-12%**
Nox	**+10%**	**+2% to -2%**
Non-Regulated		
Sulfates	**-100%**	**-20%***
PAH (Polycyclic Aromatic Hydrocarbons)**	**-80%**	**-13%**
nPAH(nitrated PAH's)**	**-90%**	**-50%*****
Ozone potential of speciated HC	**-50%**	**-10%**

***Estimated from B100 result**

**** Average Reducation across all compounds measured**
*****2-nitroflourine results were within test method variability**
Source: *Biodiesel Emissions.* The National Biodiesel Board. Jefferson City, MO. http://www.biodiesel.org/pdf_files/fuelfactsheets/emissions.pdf

Hydrocarbons, or the components that help to create smog are reduced, as well as carbon monoxide (a poisonous gas), and particulate matter. Additionally, sulfates, which contribute to acid deposition, are completely eliminated as well as a significant reduction in nPAH's and PAH's, which are carcinogenic compounds. Hydrocarbons are also reduced, which includes the greenhouse gas, methane, which is 25% more potent than carbon dioxide[xii]

However, nitrogen oxides increase or decrease with the use of biodiesel. Nitrogen oxides contribute to photochemical smog and can cause respiratory problems[xiii]. According to The National Biodiesel Board, the increase or decrease in NOx emissions with B20, depends "on the engine family and testing procedures"[xiv]. However, the increase in B100 nitrogen oxide emissions is a definite drawback. In spite of this, the Environmental Protection agency states that because biodiesel reduces so many other pollutants, and eliminates sulfur emissions altogether, the increase in nitrogen oxides is small in contrast to what is gained by using biodiesel[xv]. Also, there are many researchers on track to creating blends with specific diesels, which will reduce or eliminate nitrogen oxide emissions, such as the hydrogenation of soybean oil before the transesterification process[xvixvii].

What is Transesterification?

Transesterification is the process of converting waste vegetable oil into biodiesel[xviii]. According to Lab 17 written by Matt Steiman of the Miller's *Living in the Environment Instructors Guide for AP Environmental Studies*, "Vegetable oil molecules are triglycerides", this means they are made up of a "heavy glycerol molecule and three lighter fatty acid chains called esters". The point of the transesterification process is to separate these combustible and useful esters from the thick glycerol in order to achieve oil that works properly in diesel engines[xix]. Therefore, use the lye catalyst to split apart the vegetable molecules and then mix them with methanol to create methyl esters. Then drain the glycerol from the oil, and what is left is a crude biodiesel[xx]. The next process involves washing and drying the oil to free it of particulate matter.

The titration process determines how much lye is needed to perform a successful transesterification, and this process is outlined next within this manual. However, for every liter of vegetable oil 20% of the oil needs to be methanol to cause the transesterification process[xxi].

What is Titration?

When vegetable oil is used in a deep fryer the chemical composition of it changes[xxii]. According to the MGEL User Guide, "the combination of triglycerides plus water and heat causes the hydrolysis of ester bonds and the formation of free fatty acid molecules"[xxiii]. Essentially, free fatty acids (FFA's) form within the oil, and a catalyst such as lye must neutralize them to enable the transesterification process to create oil that is effective in diesel engines[xxiv]. But, the amount of FFA's within the oil will vary each time, so we must perform titrations to discover how much lye is needed to neutralize the FFA' and begin the transesterification process. Heavier used oil will require more lye to neutralize the FFA's. This process is outlined in the lab section of this manual.

Time Committment

It is important to understand that biodiesel requires much attention and time on the part of the producers. According to *Bioiesel Safety and Best Management Practices for Small-Scale Noncommerical Use and Production*, the participants in biodiesel creation must have the time to:

- Maintain biodiesel equipment-- 10-15 minutes to clean leaks or spills up

- Collect Oil
- Secure chemicals properly-- 5-7 minutes to get chemicals and put them away properly
- Fuel Processing-- Heating- 2 or more hours

  Cooling- 1 hour or more

  Titration- 15 minutes

  Pumping Oil- 15 minutes

  Mixing- 1 hour
- Washing the Fuel-20 to 30 minutes
- Drying the Fuel- 24 hours
- Disposal of waste products- Composting[xxv]

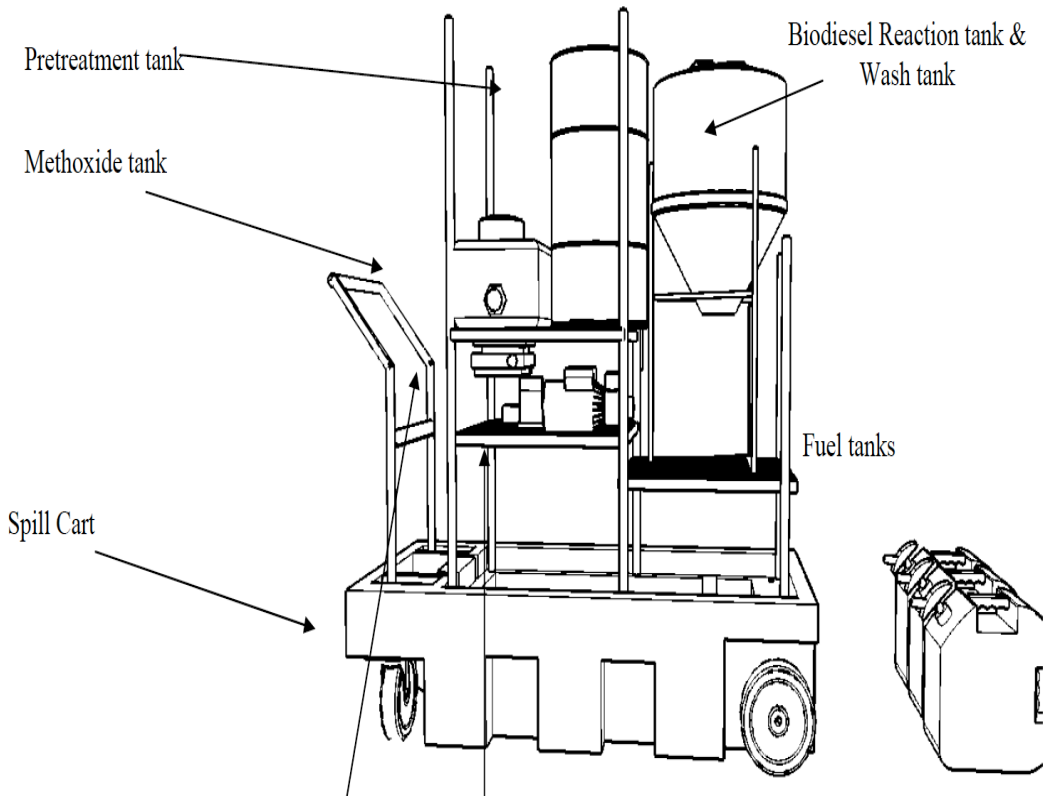
These procedures all require time and attention, and can be disadvantages to people hoping for instant gratification. However, to run a responsible and safe biodiesel project, one must be thoughtful and respectful of each step of the project and allow proper time for each step to take place appropriately.

Safety Precautions

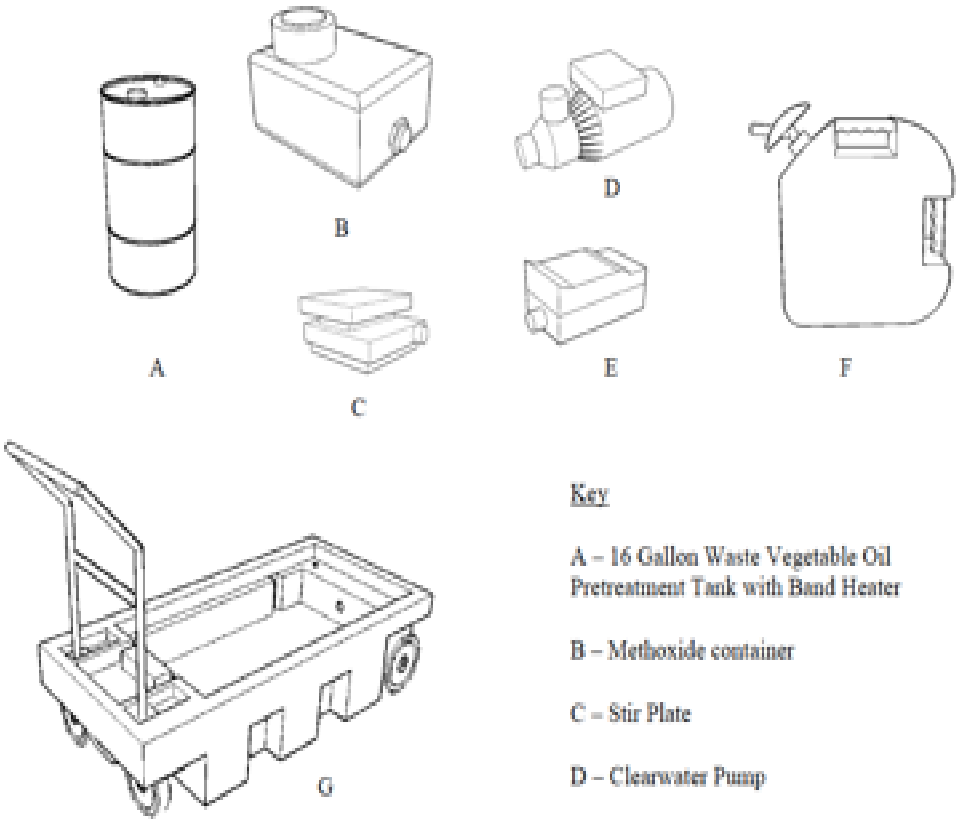
The chemicals used to produce biodiesel are potent and some are very toxic. It is important to follow the safety procedures outlined in Appendix A. Proper clothing for the process includes closed-toed shoes, goggles, aprons, and

gloves. It is also necessary when mixing the lye and methanol, to be under a fume hood in the lab. Methanol can irritate the lungs, cause eye damage, and overexposure can have serious neurological impacts and it is a serious fire risk[xxvi](more outlined in Appendix A).Lye can also irritate the lungs and skin, cause eye damage[xxvii]. Therefore, again, it is important to follow the safety procedures outlined to protect yourself and fellow producers.

The Mobile Green Energy Lab



Source: Mobile Green Energy Lab User Guide Version 1.1. Center for Urban Environmental Research and Policy. 2010. Loyola University: Chicago, IL. Pg. 4



Source: *Mobile Green Energy Lab User Guide Version 1.1*. Center for Urban Environmental Research and Policy. 2010. Loyola University: Chicago, IL.

These are diagrams of the system and the system components. Each component of the system is labeled in these diagrams and valves are labeled on the system itself.

The Components of the MGEL Biodiesel Production System:

Pretreatment tank- This is where the oil is first collected and heated

Methoxide container- This is where the lye and methanol are mixed for transesterification

Stir plate- the device used to agitate the methanol and lye to become methoxide

Clearwater pump- Circulates around the methanol and lye and oil during transesterification

Bubbler- Used to dry the oil

Reaction Tank- Where the transesterification, drying and washing processes take place

Fuel Tanks- The containers in which to store the biodiesel

Spill Cart- Prevents spills from reaching the floor

THE PRODUCTION OF BIODIESEL

A LAB PROCESS

Pretreatment of Waste Vegetable Oil[1]:

Make that all valves are closed (they will be perpendicular to pipe if they are closed.)

First, you must pretreat the waste vegetable oil (WVO) to remove contaminants within the oil. You want the oil as clean as you can get it. Therefore, you must pour the WVO into the 25-micron sock filter on top of the pretreatment tank. This sock filters out the particles within the WVO to create cleaner oil and thereby a cleaner burning oil.

- **First, note the date, participant names and gallons of WVO to be converted to biodiesel.**

Note: You want to put in more oil than you intend to make; for example if you wish to create 3 gallons of biodiesel, begin with 5 gallons! This is because you may not get to use all of the oil due to spills, oil being left in the tank and draining particulate matter and glycerol.

- **Open the pretreatment tank, within it is a 25-micron sock filter. Pour the WVO through the sock filter carefully. Note the temperature once the WVO is filled in pretreatment tank in lab sheets provided.**

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[1] Source for this section of Lab Manual: Mobile Green Energy Lab (MGEL) User Guide. 2009. Center for Urban Environmental Research and Policy. Pg 10. Loyola University, Il.

Note: The WVO container should be held in a secondary container in case of spills! If there is any WVO that is unused, place it back in secondary container. This unused WVO should be returned to the central accumulation area along with rags and towels used to clean spills. Because the flashpoint of WVO is so high, 162 to 282 degrees C (323 to 540 degrees F), it does not have to be stored in flammables cabinet. It should only be stored in flammables cabinet after it has been converted to biodiesel.

- **Next, turn on band heater by plugging in the main power for the Mobile Green Energy Lab. Next, turn on switch #4 on the band heater labeled," heat tank" and switch #2 which is the temperature. This begins the next process of heating the WVO to assist the separation of the water and oil (water sinks to the bottom).**

- **Allow the WVO to heat to 50°C. Note the temperature on the Lab Sheet.**
- **After 50°C is reached, take sample from top and sample from the bottom of pretreatment tank, this will be used for titrations.**

- **After the oil is heated to 70°C, switch off the "heat tank" button and wait for the oil to then cool to 50°C. Note the temperature on Lab Sheet. You must heat and cool the waste vegetable oil in order to break**

some of the fatty acids from the glycerol[2].

- **The next step is to drain both the water and particulate matter from the bottom of the tank.**

- **Place a waste container under valve 9. Slowly drain the oil. At first, the oil should be very dark; this signifies the water and particulate filled oil. However, once you notice amber colored oil, the process is completed and the oil should be clean. Close valve 9 once you notice this change in color.**

Titration[3]:

Next, you must perform titration to determine the amount of free fatty acids (FFAs) within the WVO and the amount of lye needed to neutralize them. To perform titration, you will need, four empty cups or beakers, turmeric (indicates pH however, phenol red or another pH indicator can also be used), 1 mL oil for each beaker, 10 mL isopropyl alcohol (known base). Use the top and bottom

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[2] Biodiesel-Fuel.co.uk. "What is Biodiesel?". 2006-2009. Renewable Energy Association. http://www.biodiesel-fuel.co.uk/what-is-biodiesel/.

[3] Source for this section of Lab Manual: Mobile Green Energy Lab (MGEL) User Guide. 2009. Center for Urban Environmental Research and Policy. pp 10-11. Loyola University, Il.

collections from the previous step. You will need 2 from the top of the pretreatment tank and 2 from the bottom.

- **Be sure to perform titration under a fume hood. Wear protective gloves and goggles, and closed toed shoes!**

- **First, add 1 gram of KOH or NaOH to 1 liter of distilled water into burette. This will later be added to the isopropyl alcohol, WVO feedstock, and turmeric (or phenoyl red) to indicate the amount of catalyst needed to neutralize FFAs in the larger batch of WVO.**

- **Measure 10 mL of isopropyl alcohol (this alcohol is extremely flammable and dangerous, take precautionary measures stated above). Also you must use a 91% or greater concentration of Isopropyl alcohol!**

- **Add the 10 mL of isopropyl alcohol to each of the 4 beakers.**

- **Place turmeric on the open palm of your hand and lightly dust the turmeric into the beaker[4].**

[4] Just dust the turmeric in the solution. Turmeric is more qualitative than quantitative, therefore, if you add a little too much it will not matter.

- **Next, add 1 mL of the WVO (feedstock) into each beaker filled with the alcohol and dusted with the turmeric. Swirl to mix.**
- **Record the initial amount of the KOH or NaOH and water mixture. Slowly add the solution from the burette at about .5 mL at a time into the beaker. Both KOH and NaOH should be treated the same way regardless of which you are using.**
- **Stop adding the burette solution when the beaker solution becomes a pinkish red color and stays at this color for 30 seconds. This indicates the solutions pH is between 8 and 9.**
- **To determine the amount of solution used, subtract the Final quantity of the burette solution from the Initial quantity of the burette solution. For example, if you started with 5 mL of solution in the dropper and removed 1.5 mL of solution, the end result would be 3.5.**
- **Perform this test another three times, and take the average amount. If there is an anomaly, or one number that is not close to the other numbers, throw it out. Record this amount on Lab Sheet.**

Determining Amounts of Oil, Methanol and Lye Needed for Reaction[5]

- **Close all valves on the reactor then open valves 2 and 3.**

- **The oil should then begin to pump from the pretreatment tank to the reactor. This will show you how much WVO you are working with but, make sure that ALL the WVO has been drained from the pretreatment tank because this affects titration numbers! Note this amount on your Lab Sheet.**

- **Activate the switch labeled, "Pump"; you should now see oil being pumped from the pretreatment tank to the reactor.**

- **After the specific amount of oil has been moved into the reactor, or if 12 gallons enters the tank, or air**

[5] Source for this section of Lab Manual: Mobile Green Energy Lab (MGEL) User Guide. 2009. Center for Urban Environmental Research and Policy. pp 12. Loyola University, Il.

bubbles prevent any further oil from entering reactor, turn off the switch labeled "Pump".

- **1.5 gallons will remain at the bottom of the tank so place bucket underneath valve 9 and open valve 9. After draining the remaining oil, pour it into the reactor/wash tank with the rest of the oil.**

- **Measure and document the amount of WVO within the reactor and record that number on Lab Sheet. Round to the nearest quarter of a gallon if need be.**

- **There may be oil left over since the pump may have stopped due to air pockets within the tubing. Remove this excess oil by opening valve 9 and draining the excess into a bucket labeled waste vegetable oil and place it within secondary containment. We do not want any wasted oil or oil left within the pretreatment tank.**

- **To determine the catalyst or NaOH or KOH, take the titration average from before. Plug the values into the following formula on the next page to determine the amount needed.**

Determining Amounts of Methanol and Lye

T= Average Titration Value

X= The amount of lye (NaOH or KOH) needed in grams

1 Gallon= 3.79 Liters

(? L)= Amount of WVO or Feedstock

? L(.2)= Liters of Methanol

X= (T+ (4))

X(?L)= g Lye

Example:

20% of the volume should be methanol (e.g. 10 gallons of waste vegetable oil = 2 gallons of methanol

To get liters, multiply 3.79 by the gallons of oil you have (e.g. 6 gallons of oil= 3.79 x 6= 22.74)

You need 4 grams per liter of oil. To get amount of grams needed total, add the titration number to 4, (e.g. .8 titration number + 4 = 4.8)

Multiply 4.8 by the liters to get amount of grams needed total to complete transesterification (e.g. 4.8 x 22.74= 109 grams of lye to methanol).

Mixing Methanol and Lye to Create Methoxide[6]

- ***When handling methanol and lye it is extremely vital that you wear proper protective clothing underneath fume hood, this includes gloves, mask, goggles, and closed toed shoes! If there are others in the laboratory, they should stand far away from the methanol and lye unless they are also covered in protective clothing and apparatus!***

- **Under the fume hood measure the appropriate amount of methanol you calculated. Pour this into the methoxide tank and be sure to close the lid tightly.**

- **Next, measure the appropriate amount of lye needed in a coffee filter on top of a balance, and then add the lye to the methoxide tank. Seal the tank tightly before beginning the agitation.**

- **Next, be sure the methoxide tank is on top of stir plate. Turn on stir plate. Slowly increase the power**

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[6] Source for this section of Lab Manual: Mobile Green Energy Lab (MGEL) User Guide. 2009. Center for Urban Environmental Research and Policy. pp 12- 13. Loyola University, Il.

of the stir plate but never exceed one quarter of the full power of the stir plate. Therefore, no more than 300 on stir plate power.

- **If stir plate is not working, gently shake the methoxide tank, but, DO NOT OPEN IT!**

- **If using KOH, it ought to dissolve in 5 minutes; however, NaOH could take up to 15 minutes or more.**

- **Once all the catalyst has been dissolved, it is ready to be mixed into reactor.**

- ***Return methanol and lye to appropriate storage containment. Methanol MUST be placed in flammables cabinet. SEE MSDS Sheets in Appendix!***

Transesterification[7]

- **Next, you must heat oil in preparation for the reaction. Move the temperature probe to the reactor tank.**

[7] Source for this section of Lab Manual: Mobile Green Energy Lab (MGEL) User Guide. 2009. Center for Urban Environmental Research and Policy. pg 13. Loyola University, Il.

- **Turn on the switches, labeled, "Temperature", "Pump", and "Heat Pump". Note: NEVER TURN ON HEAT PUMP WITHOUT TURNING ON PUMP! Note the start time on Lab Sheet.**

- **Allow the temperature to reach 50°C, the control panel will hold the temperature at 50°C to protect the integrity of the plastic.**

- **Once the temperature has reached 50°C, TURN OFF HEAT PUMP! TURN OFF HEAT PUMP! Methoxide cannot come into contact with direct heat! Note the stop time on Lab Sheet. If temperature drops below 50°C, turn on switch #3 but #3 can only be on if #1 is on.**

- **Next, you must open valve 5 and 6 so the methoxide can enter the tubing, which will connect it to the reaction tank.**

- **You will need to tip the methoxide tank to get the rest of the methoxide out. When methoxide is emptied, close valves 5 and 6 and turn off pump switch.**

- **Allow the pump to run for 1 hour, also, record the start time of the reaction on Lab Sheet and any special comments about the reaction.**

- **After 1 hour, close valve 6 and 7. Allow it to settle overnight, turn off all switches on power station.**

Drain Glycerin and Washing Fuel

- **Lastly, get a Hazardous Waste container labeled, "Glycerin" along with the date of the collection, and place it under valve 1. Slowly open**

valve 1 and valve 6 to drain out the glycerin. The glycerin will be a darker, thicker liquid than the biodiesel. Compost this glycerin (we will have it tested for methanol content). After draining close valves 1 and 6.

When you come in to wash the fuel, you should drain out remaining glycerin at the bottom of the tank—some will have settled out over night. In fact, since we are going to wait a day anyway, might as well just drain all the glycerin out the next day before you wash the fuel.

Washing the Fuel[8]

In order to remove the impurities from the biodiesel you have just created, the fuel must be washed. This process gathers the contaminants to the bottom of the tank so they may be drained out. After the washing process the biodiesel must then be dried since water can affect the quality of the biodiesel.

- Setup the wash system by connecting tubing to the drill holes at the top of the reactor.

- Secure the wash system in place with use of the Velcro.

- Connect wash system to the faucet, and turn on the sink; it would be best to use warm or hot water to quicken the separation. Make sure the water pressure is a fine mist. You will need to add 20% to 25% water

[8] Source for this section of Lab Manual: Mobile Green Energy Lab (MGEL) User Guide. 2009. Center for Urban Environmental Research and Policy. Pg 14-15. Loyola University, Il.

to the biodiesel in the tank. For example, if you have 10 gallons of biodiesel, add between two and one-half gallons. Once you've reached this amount turn off the water.

- **Allow the contents to settle for 20-30 minutes and record on the Lab Sheet the amount of wash water.**

- **Get a container labeled wash water and place it underneath valve 1. Slowly open valves 1 and 6 to drain the wash water and stop when you begin to notice biodiesel being released from reactor. Note the gallons on the lab sheets after you have removed the wash water. (The washwater will be a white color at the bottom of reactor tank). After it drains close valves 1 and 6.**

Note: Be careful not to open valve 1 too quickly during the washing process, it could cause a too much wash water and once and you will need to reheat to separate mixture again!

- **Collect a sample of the wash water in order to test the pH. Dip pH paper into the sample of wash water and record the pH onto the Lab Sheet. If pH of wash water is neutral then it can be dumped down drain. If the wash water is basic, add vinegar to lower the pH to around 7**

- **Repeat the washing process and remember to note start gallons and stop gallons on Lab Sheet.**

- **After washing is completed and the pH is achieved, drain all water out of the tubing and return tubing to the bottom of the MGEL system.**
- **Only if oil is excessively dirty should you perform a third wash, but this is rare.**

- **Remove hoses from wash tank after the wash is complete.**

Drying Biodiesel[9]

- **Next, you must dry the biodiesel, which means removing water vapor from the fuel. When the pump is turned on water evaporates through the top of the tank.**

    - **Place the tubes from the air pump into the holes at the top of the reactor. Make sure wood coated tubes are in the fluid. Plug the air pump into it's designated switch,(switch 8) and turn it on. Note the start time of bubbler (air pump) on Lab Sheet.**

- **Allow the bubbler or air pump to run for 24 hours, remove any water that has accumulated at the bottom of the tank. Then, switch off the air pump and remove the tubing from the top of the reactor. Note the stop time of bubbler on Lab Sheet.**

Emptying Biodiesel from the Reactor

- **You may find excess wash water after allowing the bidiesel to dry overnight. If so, open valves 1 and 6 and collect the wash water. Then close valves 1 and 6.**
- **Finally, open valves 2 and 6 to release the biodiesel through the filter using the hand pump. Collect the biodiesel into a designated yellow container, and place that in secondary containment. Then close all valves and turn off power station, and unplug power station. Document in the lab sheet how much biodiesel was removed and when.**

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[9] Source for this section of Lab Manual: Mobile Green Energy Lab (MGEL) User Guide. 2009. Center for Urban Environmental Research and Policy. Pg 15. Loyola University, Il.

APPENDIX A

Material Safety Data Sheets

Biodiesel

Glycerin

Isopropyl Alcohol

Methanol

Potassium Hydroxide

Sodium Hydroxide

BIODIESEL

Health Effects:

Inhalation: No effects can occur at room temperature, but when heated, vapors of biodiesel may irritate mucous membranes, cause dizziness and nausea.

Eye Contact: May cause irritation.

Skin Contact: Repeated or prolonged contact with the skin will not cause problems unless the oil is heated.

Ingestion: No hazards anticipated from ingestion incidental to industrial exposure.

First Aid Measures:

Inhalation:

Remove from area to fresh air. Seek medical attention if symptoms persist.

Eye Contact:

Flush eyes with a heavy stream of water for 15 to 20 minutes. Seek medical attention if symptoms persist or worsen.

Skin:

Wash contaminated areas of the body with soap and water.

Ingestion:

Give one to two glasses of water to drink. If gastro-intestinal symptoms develop, seek medical attention. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON!

Fire Safety:

Flashpoint:

130.0 C or 266.0 F min.

Extinguishing Media:

Dry chemical, foam, halon (where permissible), CO2, water spray (fog), (water stream may splash the burning liquid and spread fire).

Special Fire Fighting Procedures:

Use water spray to cool drums exposed to fire.

Explosion Hazards:

Oil soaked rags or spill absorbents (i.e. oil dry, polypropylene socks, sand, etc.) can cause spontaneous combustion if stored near combustibles and not handled properly. Store biodiesel soaked rags in special approved safety containers and dispose of them properly. Oil soaked rags may be washed with soap and water and allowed to dry in a well ventilated air. Firefighters should use self-contained breathing apparatus to avoid exposure to smoke and vapor. Evacuate non-emergency personnel to safe area.

Accidental Release and/or Spill:

Remove sources of ignition, contain spill to smallest area possible. Stop leak if possible. Pick up small spills with absorbent materials and dispose of properly to avoid spontaneous combustion.

Recover large spills for salvage or disposal. Wash hard surfaces with safety solvent or detergent to remove remaining oil film. Watch for slippery surface caused by the greasiness of the oil.

Handling and Storage:

Store in closed containers between 50 F and 120 F. Keep away from oxidizing agents, excessive heat, and ignition sources. Store and use in well ventilated areas. Do not store near heat, spark, flame or sunlight. Do not puncture, drag or slide containers. Drum is not a pressure vessel; never use pressure to empty.

Disposal Considerations:

Waste may be disposed of by a licensed waste disposal company. Contaminated absorbent material may be disposed of in an approved landfill. Follow local, state, and federal disposal laws.

SOURCES:

Biodiesel. Organic Fuels: Fuel Solutions. June 30, 2006.

http://www.organicfuels.com/biodiesel/msds

Biodiesel Sample Material Safety Data Sheet. Jefferson City, MO.

Glycerin

Health Effects:

Inhalation:

Due to low vapor pressure, inhalation of vapors is unlikely, however, inhalation may cause irritation.

Eye Contact:

Can cause irritation

Skin Contact:

Can cause irritation

Ingestion:

Low toxicity but could cause nausea, diarrhea, or headache.

First Aid Measures:

Inhalation:

Move to fresh air. Get medical attention for any breathing difficulty.

Skin Contact:

Flush eyes with water for 15 minutes. Remove contaminated clothing and shoes and wash clothes. Get medical attention if irritation develops!

Eye Contact:

Immediately flush eyes with plenty of water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get medical attention if irritation persists!

Ingestion:

Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention!

Fire:

Flashpoint:

199C or 390F

Extinguishing Media:

Use any means suitable for extinguishing surrounding fire. Water spray may be used to extinguish surrounding fire and cool exposed containers. Water spray will also reduce fume and irritant gases.

How to Extinguish:

In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

Explosion Hazards:

Above flash point, vapor-air mixtures may cause flash fire.

Accidental Release and/or Spill:

Ventilate area of leak or spill. Wear appropriate personal protective equipment. Contain and recover liquid when possible. Collect liquid in an appropriate container or absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer!

Handling and Storage:

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Isolate from incompatible substances. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

Personal Protection:

Ventilation System:

A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):

If the exposure limit is exceeded and engineering controls are not feasible, a half facepiece particulate respirator (NIOSH type P95 or R95 filters) may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest.. A full-face piece particulate respirator (NIOSH type P100 or R100 filters) may be worn up to 50 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency, or respirator supplier, whichever is lowest. Please note that N filters are not recommended for this material. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.

Skin Protection:

Wear protective gloves and clean body-covering clothing.

Eye Protection:

Use chemical safety goggles. Maintain eye wash

fountain and quick-drench facilities in work area.

Disposal Considerations:

Waste Disposal:

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Test for methanol, if there is none, it can be composted. Processing, use or contamination of this product may change the waste

management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

Source: Glycerol. No. G4774. Mallinckrodt Baker, Inc; Philipsburg, NJ.
http://www.jtbaker.com/msds/englishhtml/g4774.htm

Isopropyl Alcohol

Health Effects:

Inhalation:

Inhalation of vapors can irritate the respiratory tract. Exposure to high concentrations can cause effects such as dizziness, drowsiness, headache, staggering, unconsciousness and possibly death.

Eye Contact:

Vapors cause eye irritation, possible corneal burns and eye damage.

Skin Contact:

May cause skin irritation with redness and pain. Could be absorbed through the skin and cause systemic effects.

Ingestion:

Can cause drowsiness, unconsciousness, or death. Gastrointestinal pain, nausea, vomiting, or diarrhea. The lethal dose for an adult is about 250 mls (8 ounces).

First Aid Measures:

Inhalation:

Move to fresh air, if not breathing, give artificial respiration. If breathing is difficult, give oxygen. CONTACT MEDICAL PROFESSIONAL!

Eye Contact:

Flush eyes with water for at least 15 minutes, lift upper and lower lids occasionally. SEEK MEDICAL ATTENTION!

Skin Contact:

Flush skin for at least 15 minutes. Contact

medical professional if irritation develops.

Ingestion:

Give large amounts of water to drink. Never give anything by mouth to an unconscious person. GET MEDICAL ATTENTION!

Fire:

Flashpoint:

12 C or 53.6 F

Extinguishing Media:

Water spray, dry chemical, alcohol foam, CO2. Water spray may be used to keep fire exposed containers cool, dilute spills and nonflammable mixtures.

Explosion Hazard:

Above flash point, vapor air mixtures are explosive within flammable limits noted above. Contact with strong oxidizers may cause fire or explosion. Vapors can flow along surfaces to distant ignition and flash back. It is also sensitive to static discharge.

Accidental Release and/or Spill:

Ventilate area of leak or spill. Remove all sources of ignition. Isolate area of spill. Keep unnecessary and unprotected personnel from entering. Recover all liquid, do not use equipment that will spark. Place liquid and inert absorbents into chemical waste container. Do not dispose of waste in sewer!

Handling and Storage:

Protect against physical damage. Store in a cool, dry and well ventilated area. Keep away from any area where potential fire hazard is present. Containers which used to hold this substance can be hazardous since residue could still be present.

Disposal Considerations:

Waste Disposal:

Whatever cannot be recovered should be disposed of and treated as hazardous waste.

Source: *Isopropyl Alcohol*. No. 67-63-0. Kinetronics Corporation; Sarasota, FL. Www.kinetronics.com

Methanol (Methyl Alcohol)

Health Effects:

Inhalation:

Can be slightly irritating to mucous membranes. Can greatly effect optic nerve, and other parts of the nervous system. Once absorbed into the body, it is very slowly eliminated. Overexposure can cause drowsiness, headache, vomiting, blurred vision, blindness, nausea, coma, or death. A person could get better but worsen up to 30 hours later.

Eye Contact:

Can cause eye irritation. Continued exposure could cause eye lesions.

Skin:

Methanol is a defatting agent, which means it an cause skin to become cracked and dry. Since it can be absorbed through the skin, symptoms could parallel inhalation.

Ingestion:

Toxic! Can intoxicate and cause blindness. Lethal dose 100-125 milliliters. Symptoms can parallel inhalation.

First Aid Measures:

Inhalation:

Move to fresh air. If not breathing then give artificial respiration. If breathing is difficult give oxygen and seek medical attention!

Eye Contact:

Flush eyes with water for at least 15 minutes. Lift upper and lower lids occasionally while flushing eyes. Seek medical attention!

Skin:

Flush skin with water for 15 minutes while removing contaminated clothing and shoes. Get medical attention! Wash clothing and shoes before reuse.

Ingestion:

Induce vomiting immediately as directed by medical personnel. Do not give anything by mouth to unconscious person. Get medical attention immediately!

Fire:

Flashpoint:

12 C or 54 F (Flammable liquid and vapor)

Extinguishing Media:

Alcohol foam, carbon dioxide, dry chemical (water may be ineffective).

How to Extinguish:

In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode. Use water spray to blanket fire, cool fire exposed containers, and to flush non-ignited spills or vapors away from fire. Vapors can flow along surfaces to distant ignition source and flash back.

Explosion Hazards:

Moderate explosion hazard and dangerous fire hazard when exposed to heat, sparks or flames. Sensitive to static discharge.

Accidental Release and/or Spill:

Ventilate area of leak or spill. Remove all sources of ignition. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Use non-sparking tools and equipment. Collect liquid in an appropriate container or absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a

chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! If a leak or spill has not ignited, use water spray to disperse the vapors, to protect personnel attempting to stop leak, and to flush spills away from exposures. US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.
J. T. Baker SOLUSORB® solvent adsorbent is recommended for spills of this product.

Handling and Storage:

Protect against physical damage. Store in a cool, dry well-ventilated location, away from any area where the fire hazard may be acute. Outside or detached storage is preferred. Separate from incompatibles. Containers should be bonded and grounded for transfers to avoid static sparks. Storage and use areas should be No Smoking areas. Use non-sparking type tools and equipment, including explosion proof ventilation. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product. Do not attempt to clean empty containers since residue is difficult to remove. Do not pressurize, cut, weld, braze, solder, drill, grind or expose such containers to heat, sparks, flame, static electricity or other sources of ignition: they may explode and cause injury or death.

Personal Protection:

Ventilation System:

A system of local and/or general exhaust is

recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details. Use explosion-proof equipment.

Personal Respirators (NIOSH Approved):

If the exposure limit is exceeded and engineering controls are not feasible, wear a supplied air, full-facepiece respirator, airlined hood, or full-facepiece self-contained breathing apparatus. Breathing air quality must meet the requirements of the OSHA respiratory protection standard (29CFR1910.134). This substance has poor warning properties.

Skin Protection:

Rubber or neoprene gloves and additional protection including impervious boots, apron, or coveralls, as needed in areas of unusual exposure.

Eye Protection:

Use chemical safety goggles. Maintain eye wash fountain and quick-drench facilities in work area.

Disposal Considerations:

Waste Disposal:

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved incinerator or disposed in a RCRA approved waste facility. Processing, use or contamination of this product may change the waste

management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

Source: *Methanol*. No. M2015. Mallinckrodt Baker, Inc: Philipsburg, NJ. http://www.jtbaker.com/msds/englishhtml/M2015.htm

Potassium Hydroxide

Health Effects:

Inhalation:

Severe irritant. Effects from inhalation of dust or mist vary from mild irritation to serious damage of the upper respiratory tract, depending on the severity of exposure. Symptoms may include coughing, sneezing, damage to the nasal or respiratory tract. High concentrations can cause lung damage.

Eye Contact:

Highly Corrosive! Causes irritation of eyes with tearing, redness, swelling. Greater exposures cause severe burns with possible blindness resulting.

Skin Contact:

Corrosive! Contact with skin can cause irritation or severe burns and scarring with greater exposures.

Ingestion:

Toxic! Swallowing may cause severe burns of mouth, throat and stomach. Other symptoms may include vomiting, diarrhea. Severe scarring of tissue and death may result. Estimated lethal dose: 5 grams.

First Aid Measures:

Inhalation:

Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

Ingestion:

If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Skin Contact:

In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Eye Contact:

Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

Fire:

Flashpoint:

Not combustible, but contact with water or moisture may generate enough heat to ignite combustibles.

Extinguishing Media:

Use any means suitable for extinguishing surrounding fire.

How to Extinguish:

Solution process causes formation of corrosive mists.

Hot or molten material can react violently with water. In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

Explosion Hazards: Can react with chemically reactive metals such as aluminum, zinc, magnesium, copper, etc. to release hydrogen gas which can form explosive mixtures with air.

Accidental Release and/or Spill:

Ventilate area of leak or spill. Keep unnecessary and unprotected people away from area of spill. Wear appropriate personal protective equipment. Spills: Pick up and place in a suitable container for reclamation or disposal, using a method that does not generate dust. Do not flush caustic residues to the sewer. Residues from spills can be diluted with water, neutralized with dilute acid such as acetic, hydrochloric or sulfuric. Absorb neutralized caustic residue on clay, vermiculite or other inert substance and package in a suitable container for disposal.

Handling and Storage:

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Isolate from incompatible substances. Protect from moisture. Addition to water releases heat which can result in violent boiling and spattering. Always add slowly and in small amounts. Never use hot water. Containers of this material may be hazardous when empty since they retain product residues (dust, solids); observe all warnings and precautions listed for the product.

Personal Protection:

Airborne Exposure Limits:

- OSHA Permissible Exposure Limit (PEL):

2 mg/m3 Ceiling

- ACGIH Threshold Limit Value (TLV):

2 mg/m3 Ceiling

Ventilation System:

A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):

If the exposure limit is exceeded and engineering controls are not feasible, a half facepiece particulate respirator (NIOSH type N95 or better filters) may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest.. A full-face piece particulate respirator (NIOSH type N100 filters) may be worn up to 50 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency, or respirator supplier, whichever is lowest. If oil particles (e.g. lubricants, cutting fluids, glycerine, etc.) are present, use a NIOSH type R or P filter. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.

Skin Protection:

Rubber or neoprene gloves and additional protection including impervious boots, apron, or coveralls, as needed in areas of unusual exposure.

Eye Protection:

Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

Disposal Considerations:

Waste Disposal:

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

Source: Potassium Hydroxide. No. P5884. Mallinckrodt Baker, Inc; Philipsburg, NJ.
http://www.jtbaker.com/msds/englishhtml/P5884.htm

Sodium Hydroxide

Health Effects:

Inhalation:

Severe irritant! Effects from inhalation vary from mild irritation to serious damage of the upper respiratory tract, depending on exposure. Symptoms include sneezing, sore throat and runny nose. Severe pneumonitis may occur.

Eye Contact:

Corrosive! Causes irritation of eyes, and with greater exposures it can cause burns that may result in permanent impairment of vision, even blindness.

Skin Contact:

Corrosive! Contact with skin can cause irritation or severe burns and scarring with greater exposures.

Ingestion:

Corrosive! Swallowing may cause severe burns of mouth, throat, and stomach. Severe scarring of tissue and death may result. Symptoms may include bleeding, vomiting, diarrhea, fall in blood pressure. Damage may appear days after exposure.

First Aid Measures:

Inhalation:

Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

Eye Contact:

Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

Skin Contact:

Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician, immediately. Wash clothing before reuse.

Ingestion:

DO NOT INDUCE VOMITING! Give large quantities of water or milk if available. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Fire:

Flashpoint:

N/A

Extinguishing Media:

Use any means suitable for extinguishing surrounding fire. Adding water to caustic solution generates large amounts of heat.

How to Extinguish:

In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

Explosion Hazards: No explosive hazard

Accidental Release and/or Spill:

Ventilate area of leak or spill. Keep unnecessary and unprotected people away from area of spill. Wear appropriate personal protective equipment. Spills: Pick up and place in a suitable container for reclamation or disposal, using a method that does not generate dust. Do not flush caustic residues to the sewer. Residues from spills can be diluted with water, neutralized with dilute acid such as acetic, hydrochloric or sulfuric. Absorb neutralized caustic residue on clay, vermiculite or other inert substance and package in a suitable container for disposal.

US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

Handling and Storage:

Keep in a tightly closed container. Protect from physical damage. Store in a cool, dry, ventilated area away from sources of heat, moisture and incompatibilities. Always add the caustic to water while stirring; never the reverse. Containers of this material may be hazardous when empty since they retain product residues (dust, solids); observe all warnings and precautions listed for the product. Do not store with aluminum or magnesium. Do not mix with acids or organic materials.

Personal Protection:

Ventilation System:

A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):

If the exposure limit is exceeded and engineering controls are not feasible, a half facepiece particulate respirator (NIOSH type N95 or better

filters) may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest.. A full-face piece particulate respirator (NIOSH type N100 filters) may be worn up to 50 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency, or respirator supplier, whichever is lowest. If oil particles (e.g. lubricants, cutting fluids, glycerine, etc.) are present, use a NIOSH type R or P filter. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.

Skin Protection:

Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

Eye Protection:

Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

Disposal Considerations:

Waste Disposal:

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

Source: *Sodium Hydroxide.* No. S4034. Mallinckrodt Baker, Inc; Philipsburg, NJ. http://www.jtbaker.com/msds/englishhtml/s4034.htm

APPENDIX B

Lab Sheets

BIODIESEL LAB SHEETS
WILSON COLLEGE
MOBILE GREEN ENERGY LAB

General Information	
Waste Vegetable Oil (gallons)	
Start Date	
Producers	
Catalyst Amount Added (KOH or NaOH)	
Methanol (gallons)	
Titration #1	
Titration #2	
Titration #3	
Titration #4	
Average Titration Number	

Biodiesel Reaction:

	Date	Notes
Pump Oil into Reactor		

Note Oil Temperature		
Note Oil Amount		
Heat Oil and Note Time		
Note Heat Stopping Time		
Note Pump Start Time		
Note Reaction Temperature		
Inject Methoxide		
Note Total Mix Time		
Comments		

Washing Biodiesel:

	DATE	**NOTES**
WASH ONE		

Note start gallons		
Note stop gallons (after water added)		
Note pH		
WASH TWO		
Note start gallons		
Note stop gallons		
Note pH		
WASH THREE		
Note start time		
Note stop time		
Note pH		
Comments		

Drying Biodiesel

	Date	**Notes**
Note Temperature		
Note heat and pump start time		

Note heat and pump stop time		
Note Air Pump start time		
Note Air Pump stop time		
Comments		

APPENDIX C

Sources & Resources

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