CHBE Biodiesel Production Manual

Last Updated – November 1st, 2013

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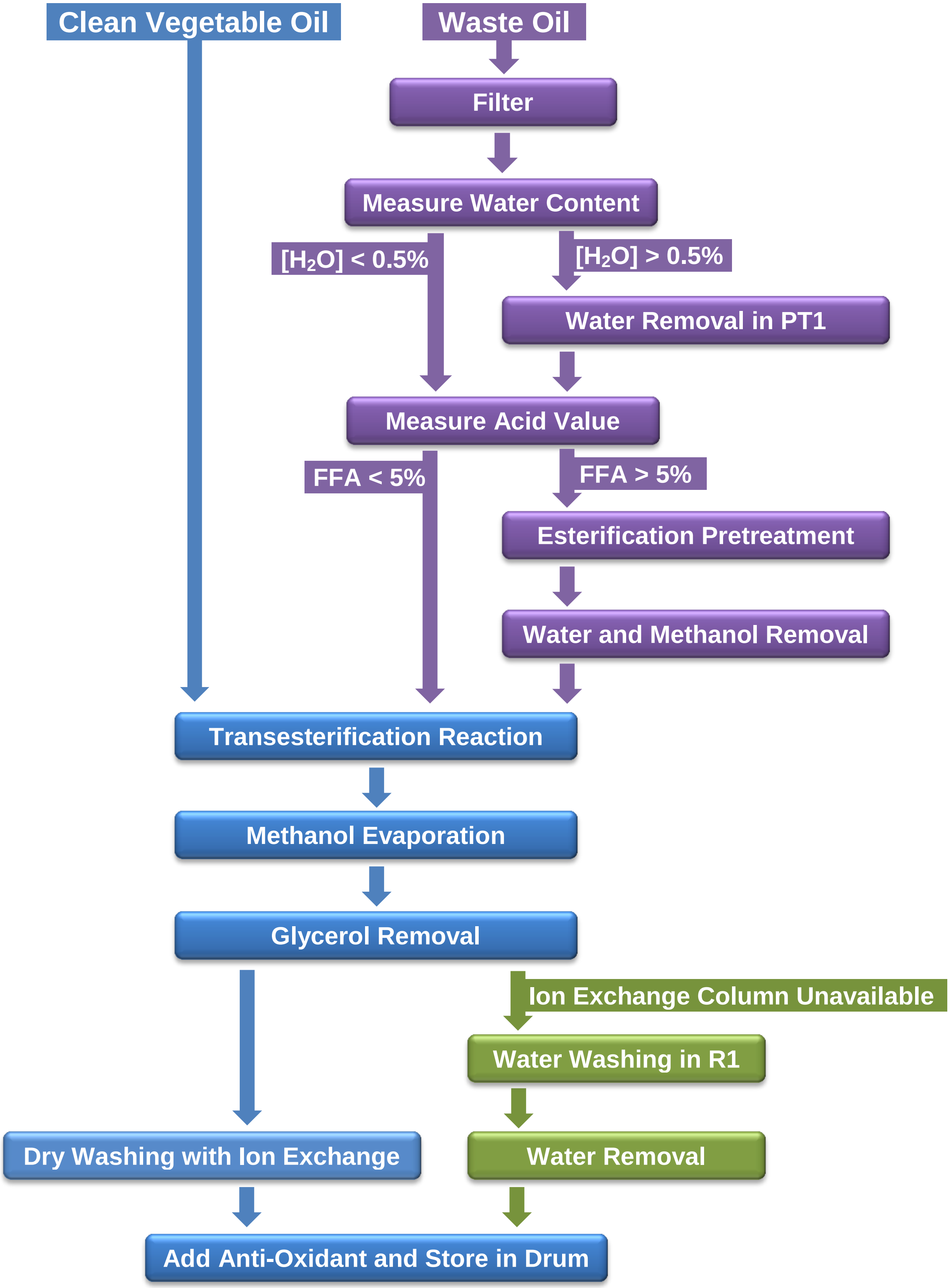
1. Production Steps



2. Reactant Procurement

2.1 Waste or fresh vegetable oil

- The fresh vegetable oil can be obtained free of charge from Allied Reclamation Services in Vancouver - Contact Larry Murphy at 604-232-9550 or larry@alliedrec.com

2.2 Acid esterification

2.2.1 Methanol

- Methanol can be obtained from the Chemical Exchange Program at UBC - contact Bang Dang at bang@interchange.ubc.ca

2.2.2 Sulphuric acid

- Can be obtained from Chemistry Stores with a journal voucher (~$20 / 4L)

2.3 Transesterification

2.3.1 Methanol

- As above

2.3.2 Potassium Hydroxide

- Fisher Scientific - Potassium Hydroxide, Flakes (1kg, 232550010, $46.80)

3. Safety Considerations

1. Ensure the ventilation system is working.
2. Gloves, lab coat and safety glasses are to be worn at all times.
3. Do not use electrical equipment in the cage while the unit is in operation.
4. Methanol handling:
    a. Never handle methanol outside of the cage
    b. Wear a respirator, full mask or half mask with goggles, at all times when handling open methanol within the cage.
    c. Keep the doors to the cage closed when handling methanol
    d. After handling methanol in the cage, allow 20-30 minutes for the vapors to be removed before entering without a mask
    e. Use the black neoprene gloves when handling methanol.

3.1 Emergency shutdown procedure

1. Press the emergency shutoff button near the door
2. Evacuate the lab

4. Reactants Required

4.1 Transesterification

4.1.1 Methanol

- Use two times the stoichiometric amount of methanol:

5. 6:1

moles CH_3OH : moles triglycerides (oil)

$$N_{CH_3OH} = 6 \times N_{Oil}$$

$$N_{Oil} = \frac{V_{Oil} \times \rho_{Oil}}{MM_{Oil}}$$

$$N_{CH_3OH} = 6 \times \frac{V_{Oil} \times \rho_{Oil}}{MM_{Oil}}$$

$$N_{CH_3OH} = \frac{V_{CH_3OH} \times \rho_{CH_3OH}}{MM_{CH_3OH}}$$

$$\frac{V_{CH_3OH} \times \rho_{CH_3OH}}{MM_{CH_3OH}} = 6 \times \frac{V_{Oil} \times \rho_{Oil}}{MM_{Oil}}$$

$$V_{CH_3OH} = 6 \frac{\rho_{Oil}}{\rho_{CH_3OH}} \times \frac{MM_{CH_3OH}}{MM_{Oil}} \times V_{Oil}$$

$$MM_{CH_3OH} = 32.04\ kg/kmol$$

$$\rho_{CH_3OH}(20°\mathrm{C}) = 0.7818 g/mL$$

$$MM_{Oil} = 969.04\ kg/kmol$$ (oleic acid)

$$\rho_{Oil}(20°\mathrm{C}) = 0.914\ g/mL$$ (can measure)

4.1.2 Potassium Hydroxide (KOH)

- Use 1 wt% KOH to triglycerides (oil)
- Add additional KOH according to acid number

$$M_{KOH} = 0.015 \times M_{Oil} + AN \times V_{Oil}$$

$$M_{KOH} = 0.015 \times V_{Oil} \times \rho_{Oil} + AN \times V_{Oil}$$

$$M_{KOH} = (0.015 \times \rho_{Oil} + AN)V_{Oil}$$

1. *AN* found through titration of raw oil. Typically in units of g_{KOH}/mL_{oil}.

4.2 Esterification Pre-Treatment

Esterification is only necessary when the FFA content is greater than 1% by mass of the oil. If FFA content is less than 1 wt% then extra KOH needs to be added to the transesterification reaction according to the acid number, but no esterification pre-treatment is required.

4.2.1 Methanol

Use two times the stoichiometric amount of methanol required:

2 : 1

moles CH_3OH : moles free fatty acids (FFA)

$$N_{CH_3OH} = 2 \times N_{FFA}$$

$$N_{FFA} = \frac{AN}{MM_{KOH}} \times V_{Oil}$$

where A*N* = *acid number of oil in* g_{KOH} / mL_{oil}

see appendix A for titration to obtain acid number

$$N_{CH_3OH} = 2 \times \frac{AN}{MM_{KOH}} \times V_{Oil}$$

$$N_{CH_3OH} = \frac{V_{CH_3OH} \times \rho_{CH_3OH}}{MM_{CH_3OH}}$$

$$\frac{V_{CH_3OH} \times \rho_{CH_3OH}}{MM_{CH_3OH}} = 2 \times \frac{AN}{MM_{KOH}} \times V_{Oil}$$

$$V_{CH_3OH} = 2\frac{AN}{\rho_{CH_3OH}} \times \frac{MM_{CH_3OH}}{MM_{KOH}} \times V_{Oil}$$

$$MM_{CH_3OH} = 32.04\frac{kg}{kmol}$$

$$MM_{KOH} = 56.10\,kg/kmol$$

$$\rho_{CH_3OH}(20℃) = 0.7818 g/mL$$

4.2.2 Sulfuric Acid (H_2SO_4)

Use 5 wt% H_2SO_4 to free fatty acid (FFA)

$$M_{H_2SO_4} = 0.05 \times M_{FFA}$$

$$M_{FFA} = \frac{N_{FFA}}{MM_{FFA}}$$

$$N_{FFA} = \frac{AN}{MM_{KOH}} \times V_{Oil}$$

$$M_{H_2SO_4} = \frac{AN}{MM_{FFA} \times MM_{KOH}} \times V_{Oil}$$

5. Operating Protocols

This protocol describes the production of biodiesel from waste vegetable oil via a two-step method. The various process component referred to in the following protocol are clearly labelled on the attached process flow diagram (PFD) and on the process itself.

****Unless indicated otherwise, a valve is open when its handle lies parallel to the valve's body****

5.1 Oil Prescreening

1. Measure water content of oil (section 7.2)
    a. If water content is greater than 0.5%, dewatering is necessary
2. Measure FFA content of oil (section 8)
    a. If FFA content is greater than 2%, esterification pretreatment is necessary

5.2 Filtering waste oil and transferring to holding tank H2

1. If using waste vegetable oil, pour the waste oil into holding tank 1 (waste oil tank)
    i. If using clean oil, pour into holding tank 2 (clean oil tank) and proceed to section **4.iii**

    Open V0 and V1 (bottom of holding tanks)
2. Make sure the valve V23 is in the horizontal position
3. Open the main air valve V21
4. Gently open the needle valve V22 to ensure that the pressure gauge G5 does not exceed 30 psi
5. The air pump AP1 should now be pumping from holding tank H1, through the filter F2 into holding tank H_2
    i. if the oil is flowing very slowly, than the filter cartridge in F2 may need to be replaced, see section 7 on maintenance
6. When holding tank H2 is full, close the needle valve V22 and V0
    i. If the oil transferred to H2 is cloudy then it may need to be re-filtered using a finer filter cartridge
    ii. see section **4.ii** below on transferring back to H1
7. The filtered oil can now be transfered to the pretreatment reactor PT1, see section **4.iii** below
8. This process may need to be repeated after emptying H2 into PT1 to reach the minimum volume of oil of 60L (16 gallons)
    i. This volume ensures that the heaters in both tanks are fully submerged.
    ii. Keep track of the volume using the gradients on the side of the holding tanks

5.3 Transferring from holding tank H2 to holding tank H1

1. Ensure valves V0 and V2 are closed
2. Open valves V1 and V30
3. Ensure that the lid is secured loosely to the top of holding tank H1
4. Switch V23 to power the air pump AP2 (handle in vertical position)
5. Open slowly the needle valve V22 to ensure that you do not exceed 30 psi (gauge G5)
6. When holding tank H2 is empty, close the needle valve V22 and valves V30 and V1
7. Repeat filtering, section **4.1**

5.4 Transferring from holding tank H2 to pretreatment reactor PT1

1. Ensure valve V30 is closed
2. Open valve V2
3. Open valve V7
4. Open valve V6 - place a container at the outlet of V6 when opening it as some fluid remaining in the tubing might come out
5. Ensure A1 is disconnected to allow air to escape when filling PT1
6. Make sure V3 (sampling valve at the bottom of PT1) is closed
7. Switch V23 to power the air pump AP2 (handle in vertical position)
8. Open slowly the needle valve V22 to ensure that you do not exceed 30 psi (gauge G5)
9. Make sure you open the valve of the liquid level on the reactor PT1
10. You should see the level in H1 decreasing and at some point the liquid should be visible in the liquid level on the reactor PT1
11. You must make sure that liquid level in the pretreatment reactor PT1 is at least above the “Min” mark on the liquid level to ensure that the heater and the thermocouple in PT1 are fully submerged (typically the liquid level should be above the 60L mark)
12. When the holding tank H2 is empty close the needle valve V22 and the valve V21
13. Close valves V1 and V2
14. Close valves V6 and V7
15. You are now ready to start the pretreatment phase in PT1

5.5 Esterification pre-treatment in reactor PT1

Esterification pre-treatment is only necessary when using waste oil with FFA greater than 1 wt%, otherwise skip to procedure **4.iv**

5.5.1 HEATING

1. Turn on the main power switch
2. Turn on the circuit breaker labelled “CB 20A” and “CB 27” on the main power box
3. The red light above the circuit breaker should come on
4. Open the main steam valve “87 Steam” located opposite the main entrance door to the lab 5.36
5. Open valve V27
6. Increase the temperature to 60°C using the right hand side temperature controller PLC1
    - Use the arrows to adjust the temperature up and down and press the refresh button to set the temperature
    - You should hear a noise corresponding to the solenoid valve V28 opening
7. Check if the water is coming out of the condensate line and flowing into the drain this is an indication the steam is on
8. Open valve V4
9. Open valve V5 (handle of the valve should be perpendicular to green arrow with label “Recirculation”)
10. Make sure that V8 is closed (handle of the valve should be perpendicular to green arrow with label “Transfer to R1”)
11. Open V7 and make sure V6 is closed
12. You can now start to pump P1 by turning the left hand switch labeled “P1” counter-clockwise
    - The red light above the switch should come on
13. The fluid in PT1 should now be forced to recirculate by the pump P1, ensuring a homogeneous temperature distribution
14. Once the fluid in PT1 has reached 60°C, you are now ready for the dewatering process

5.5.2 DEWATERING

1. Stop the pump P1 by turning the left hand switch labeled “P1” clockwise
    - The light above the switch should go off
2. Close valve V4
3. Close valve V7
4. Close valve V5 (handle should be perpendicular to the green arrow with the label “Recirculation”)
5. Switch V24 to condenser position (handle in horizontal position)
6. Open V25 to start the condenser
    - Monitor the temperature on the condenser and adjust V25 to maintain 5-10°C
7. Increase the temperature on the controller PLC1 to 85°C
8. Open valve V16
9. Start vacuum pump P3 by turning the far right switch labeled “Vacuum” counter-clockwise
    - The red light above the switch should turn on
    - Then use the switch on the vacuum pump to turn it on and off

    - The vacuum pump will cycle on and off according to the pressure switch PS1
    - If the vacuum pump is running for a long period the pump may flip the breaker and stop running, ensure all breakers on the main power box are in the one position (up)
10. Evaporated water will condense in the condenser and fill waste tank W1
11. Leave the tank under vacuum and at temperature for 30-60 mins, or until no more water is seen entering the condenser
12. Reduce the temperature on process controller PLC1 to 60^{o}C
13. To re-pressurize the reactor PT1, open V6 then slowly open valve V7
14. Monitor the pressure gauge G1, the pressure in the reactor PT1 should increase back to 0 psi
15. Open V16
16. Once the temperature has decreased back to 60^{o}C, you are now ready to load the Methanol-Sulphuric acid mixture for the esterification reaction

5.5.3 LOADING OF A1

1. Put on appropriate PPE for handling methanol
    - Mask with organic gas filter
    - Goggles
    - Solvent resistant gloves
2. Measure calculated quantity of methanol using 4L plastic graduated cylinder
    - See section 3.b for calculating reactant quantities
3. Pour methanol into bottle A1
4. Measure calculated quantity of sulfuric acid using 1L glass graduated cylinder
5. Pour sulfuric acid into bottle A1 with methanol
6. Tighten the cap of A1
7. Swish the mixture in A1 by hand to ensure it is well mixed
8. Connect the tubing from A1 to the valve V6 via the quick connect fitting and make sure the fitting is attached properly
9. Check that V16, V6 and V7 are open
10. Start the vacuum pump
11. Monitor the pressure in the PT1 by checking the pressure gauge G1
12. Once the pressure has reached -3 inHg, stop the vacuum pump
13. You can now start transferring the mixture from A1 to PT1, by letting air in A1 by adjusting the valve V19. This can be done by turning the adjustment nut counter-clockwise to let more and more air in (whistling noise) and thus pushing the mixture from A1 to PT1
14. You can repeat steps iv - vii as many times as needed to fully empty A1
    - *****Make sure that you do not vacuum too much otherwise A1 will collapse*****
    - If this happens, open V19 immediately
15. Once A1 is empty as well as the tubing from A1 to V6, fully open V19 by turning it counter-clockwise, until the pressure in PT1 is back to 0 psi
16. Close V6
17. CAREFULLY disconnect A1 from V6. Some liquid residual containing vegetable oil, methanol and sulphuric acid might drip when disconnecting the tubing
18. Close V16 (check that the vacuum pump is turned off)
19. You can now stop the condenser by closing V25

20. You are now ready to proceed to the reaction phase

5.5.4 REACTION: ACID ESTERIFICATION

1. Open valve V5 (handle of the valve should be parallel to green arrow with the label “Recirculation”)
2. Open V4
3. Start pump P1
4. Increase the temperature on PLC1 to 62^{o}C
    - The boiling point of methanol is 64^{o}C at atmospheric pressure
        - if the temperature increases above this you should see a corresponding increase in pressure as the methanol vapour pressure increases
    - There will be a loud click corresponding to the solenoid valve V28 opening
5. Monitor the process until the reaction is completed
    - Approximately 1hr
    - Temperature and pressure should be continuously monitored for safety
6. Once the reaction is complete stop pump P1
7. Close V5
8. Close V4
9. Close V7
10. Open V25 to start the condenser
11. Valve V24 should be on condenser positions (handle in horizontal position)
12. You are now ready to remove any methanol excess

5.5.5 METHANOL AND WATER REMOVAL

1. Increase the temperature on controller PLC1 to 90^{o}C
2. Open valve V16
3. Start vacuum pump P3 by turning the far right switch labeled “Vacuum” counter-clockwise
    - The red light above the switch should turn on
    - Then use the switch on the vacuum pump to turn it on and off
    - The vacuum pump will cycle on and off according to the pressure switch PS1
    - If the vacuum pump is running for a long period the pump may flip the breaker and stop running, ensure all breakers on the main power box are in the one position (up)
4. Check V24 is in the condenser position (handle in horizontal position)
5. Open V25 to start the condenser
    - Monitor the temperature on the condenser and adjust V25 to maintain 5-10^{o}C
6. Leave the tank under vacuum and at temperature 1-2 hrs or until no more liquid is seen coming out of the condenser
    - Temperature in reactor should be above 80^{o}C under vacuum (-15 inHg)
7. Any remaining methanol will be evaporated, and then recondensed in the condenser and finally trapped in the waste tank W1
8. To re-pressurize the reactor PT1, open Valve V6 then open slowly Valve V7
9. Then open V16
10. Monitor the pressure gauge G1, the pressure in the reactor PT1 should increase back to 0 psi

11. Once the pressure is back to 0 psi, close V16
12. You can now stop the condenser by closing V25
13. You are now ready to transfer the mixture to reactor R1 for the transesterification reaction

5.6 Transfer from pre-treatment reactor PT1 to reactor R1

1. Turn off heating of PT1:
    - Decrease the temperature 0 degrees C on the right hand side temperature control by using the down button and press the refresh button to set the temperature
    - Close valve V27
2. Open valve V4
3. Valves V7 and V6 should be opened and A1 should be disconnected. This is to allow the air to get in when emptying PT1
4. Make sure V3 (sampling valve at the bottom of PT1) is closed
5. Valve V5 should be closed (handle of the valve should be perpendicular to green arrow labelled “Recirculation”)
6. Open valve V8 (handle of valve should be parallel to green arrow labelled “Transfer to R1”)
7. Open V9
8. Open V29 (if the outlet of the valve is capped off, remove the cap)
9. You can now start to pump P1 by turning the switch to the left
10. Check to make sure the pump is on by listening and observing the cooling rotor inside the pump housing
    - If the pump is not running, very carefully attempt to ‘bump’ start it by spinning the cooling rotor counter-clockwise (??)
    - *****This should only be done by an experienced operator*****
11. Ensure the valve on the liquid level on reactor R1 is open
12. You should see the level in PT1 decreasing and at the some point the liquid level on R1 should start rising
    - Depending on the colour of the original oil the line will be very faint
13. You must ensure that the liquid level in the reactor R1 is at least above the “2 inch above heater” mark on the liquid level to ensure that the heater and the thermocouple in R1 are fully submerged
    - *****If the heater is not fully submerged when turned on, it will fail*****
14. Monitor the pressure in the filter housing F1
15. When the pre-treatment reactor PT1 is empty (the pump P1 should start making a rattling noise), immediately stop the pump P1
16. Close valve V4
17. Close valve V8
18. Close valves V6 and V7
19. Close V9
20. Close V29
21. You are now ready to start the second reaction phase in reactor R1
22. **NB** About 3L of mixture will be lost in the filter housing F1. This should be taken into consideration when loading the holding tank H1, to ensure that the heaters in both PT1 and R1 are fully submerge

5.7 Transesterification in reactor R1

5.7.1 HEATING

1. Ensure the heater in R1 is fully submerged , 2” above minimum line
    - *****If the heater is not fully submerged when turned on, it will fail*****
2. Turn on the circuit breaker labelled “CB 20A” on the main power box
    - The red light above the circuit breaker should come on
3. Increase the temperature in R1 to 65 degrees C on the left hand side temperature control panel by pressing the up button until the desired temperature is reached, and then pressing the button that looks similar to a webpage’s “refresh” button to set the desired temperature.
4. Open valve V11
5. Open valve V12 (handle of the valve should be parallel to blue arrow with the label “Recirculation”)
6. Make sure that V15 is closed (handle on the valve should be perpendicular to blue arrow with the label “Transfer to FP1”)
7. Open valve V14
8. Make sure valves V10, V13 and V18 are closed
9. You can now start the pump P2 by turning the middle switch on the control box labeled “P2” counter-clockwise
    - a red light should come on above the switch
10. Monitor continuously the temperature evolution in reactor R1 by checking the temperature in the top line of the temperature control (PV)
11. The fluid in R1 should now be forced to recirculate by the pump P2, ensuring a homogeneous temperature distribution
12. Once the fluid in R1 has reached 65 degrees C, you are ready for the dewatering phase

5.7.2 DEWATERING

Dewatering is only necessary if water content of oil > 0.5%

1. Stop pump P2 by turning the switch labeled “P2” clockwise
    - the red light above the switch should turn off
2. Close V11
3. Close V14
4. Close V12 (Handle of the valve perpendicular to the blue arrow with the label “Recirculation”
5. Make sure V10 and V18 are closed
6. Check V24 is in the condenser position (handle in horizontal position)
7. Open V25 to start the condenser
    - Monitor the temperature on the condenser and adjust V25 to maintain 5-10^{o}C
8. Increase the temperature on controller PLC2 to 90^{o}C
9. Open V17 and close V29
10. Start vacuum pump P3 by turning the far right switch labeled “Vacuum” counter-clockwise
    - The red light above the switch should turn on
    - Then use the switch on the vacuum pump to turn it on and off
    - The vacuum pump will cycle on and off according to the pressure switch PS1

    - If the vacuum pump is running for a long period the pump may flip the breaker and stop running, ensure all breakers on the main power box are in the one position (up)
11. Leave the tank under vacuum at temperature for 30 - 60 minutes or until no more liquid is coming out of the condenser
12. To re-pressurize the reactor R1, open valve V29 very slowly
13. Monitor the pressure gauge G3, the pressure in R1 should increase back to 0 psi

5.7.3 LOADING OF M1

1. Open V17
2. Set temperature on controller PLC2 for R1 to 62^{o}C
3. Once the temperature has reached 62-65^{o}C, close V29
4. You are now ready to load the Methanol-Potassium Hydroxide mixture into M1 for the transesterification reaction
5. See section 3.4 for methanol handling safety precautions
6. Measure calculated volume of methanol using 4L plastic graduated cylinder
    - See section 4.1 for calculating reactant quantities
7. Pour methanol into bottle M1
8. Measure calculated mass of potassium hydroxide flakes using the scale in rm5.18
    - limit the amount of time the KOH is exposed to the air as it will rapidly absorb moisture from the air
9. Pour the KOH into bottle M1 with methanol using a funnel
10. Tighten the cap of M1
11. Swish the mixture in M1 by hand to ensure it is well mixed
    - All the KOH should be dissolved
12. Connect the tubing from M1 to the valve V13 via the quick-connect fitting
13. Ensure that the quick-connect fitting is attached properly
14. Open valves V13 and V14
15. Check that V17 is opened
16. Start the vacuum pump P3 to transfer the methanox mixture
    - Monitor the pressure in R1 by checking the pressure gauge G3
    - Once the pressure had reached **-5 inHg**, stop the vacuum pump
    - You can now start transferring the mixture from M1 to R1. Let air into M1 by adjusting valve V20. This can be done by turning the adjustment nut counter-clockwise to let more and more air in and thus pushing the mixture from M1 to R1.
17. Repeat steps 16 as many times as necessary to fully empty M1
    - *****Ensure the vacuum is not too low, otherwise the bottle M1 will collapse*****
18. Once M1 is empty, as well as the tubing from M1 to V13 stop pump P3
19. Fully open V20 by turning it counter-clockwise or loosen the cap of M1, until the pressure in R1 is back to 0 psi
20. Close V13
21. CAREFULLY disconnect M1 from V13. Some liquid residual containing vegetable oil, methanol and potassium hydroxide might drip when disconnecting.
22. Close V17 (check the vacuum pump is turned off)
23. You can now stop the condenser by closing V25

24. You are now ready to proceed to the reaction phase

5.7.4 REACTION: TRANSESTERIFICATION REACTION

1. Open valve V12 (Handle of the valve should be parallel to blue arrow with the label “Recirculation”)
2. Open V11 and check that valve V14 is opened
3. Start pump P2
4. Increase the temperature on controller PLC2 to 62^{o}C
    - 64^{o}C is the boiling point of methanol
5. Monitor the process until the reaction is completed for temperature and pressure
    - the reaction should be complete in 1 hr
6. Once the reaction has been carried out to completion stop pump P2
    - Check the completeness of the reaction by performing a water test, (Appendix B: Water Wash Test)
    - The 3/27 converstion test could also be performed at this point (7.3)
7. Close V12
8. Close V11
9. Close V14
10. Check V24 is in the condenser position (handle in horizontal position)
11. Open V25 to start the condenser
    - Monitor the temperature on the condenser and adjust V25 to maintain 5-10^{o}C
12. You are now ready to remove any catalyst (potassium hydroxide) and/or methanol excess

5.7.5 BASE CATALYST NEUTRALIZATION (not possible in current setup)

1. Any excess catalyst should be neutralized before removing any excess methanol and before proceeding to the water-wash step. Otherwise it is very likely that the potassium hydroxide will react with any water present in the mixture and will form soap which is an unwanted product.
2. Typically a stock solution of sulfuric acid can be added very carefully to the mixture to neutralize any remaining catalyst
3. However, it is not possible with the present setup the current setup to add such a solution without releasing potential methanol vapours
4. The process should be modified to allow for this extra step

5.7.6 METHANOL REMOVAL

1. Increase the temperature on controller PLC2 to 80^{o}C
    - Use the ‘reset’ button to change the decimal place and the ‘up’ and ‘down’ arrows to set the temperature
    - When heating R1 from room temperature without mixing, the heater may auto shutoff due to elevated local temperature
2. Open valve V17
3. Ensure valve V16 is closed
4. Start vacuum pump P3 by turning the far right switch labeled “Vacuum” counter-clockwise
    - The red light above the switch should turn on
    - Then use the switch on the vacuum pump to turn it on and off

  - The vacuum pump will cycle on and off according to the pressure switch PS1
  - If the vacuum pump is running for a long period the pump may flip the breaker and stop running, ensure all breakers on the main power box are in the one position (up)
5. Check V24 is in the condenser position (handle in horizontal position)
6. Open V25 to start the condenser
   - Monitor the temperature on the condenser and adjust V25 to maintain 5-10^{o}C
7. Leave the tank under vacuum and at temperature 1-2 hrs until methanol removal is complete
   - No more liquid is seen coming out of the condenser
   - Temperature in reactor should be above 65^{o}C under vacuum (-15 inHg)
   - 95% of the calculated excess methanol should be recovered from W1
8. Any remaining methanol will be evaporated, and then recondensed in the condenser and finally trapped in the waste tank W1
9. Turn off pump P3
10. To re-pressurize the reactor R1, slowly open Valve V29
11. Monitor the pressure gauge G1, the pressure in the reactor PT1 should increase back to 0 psi
12. Once the pressure is back to 0 psi, close V17
13. You can now stop the condenser by closing V25
14. You are now ready to start the conditioning phase of the biodiesel
15. Leave the mixture to settle for 12-24 hrs to allow glycerol to settle out

5.8 Switching off the biodiesel unit

1. Turn off the electrical heater in R1
    - Set the temperature to 0 degrees C on both temperature controllers PLC1 and PLC2
    - Turn off the circuit breaker labelled “CB 20A” on the main power box
    - The red light above the circuit breaker should turn off
2. Check the following:
    - Pump P1 should be off
    - Pump P2 should be off
    - The temperature setpoint for both heaters should be 0 degrees C
    - Vacuum pump P3 should be off
3. Turn off the circuit breaker labelled “CB 27” on the main power box
    - The red light above the circuit breaker should turn off
4. Switch off the main power box labelled “CB Panel 5L” using the toggle switch
    - The yellow light should turn off

5.9 Biodiesel Washing in Reactor (if not using ion exchange)

5.9.1 BIODIESEL / GLYCEROL SEPARATION

1. After allowing 12-24hrs of gravity separation the glycerol may be removed
2. Connect a piece of tubing to valve V10
3. Place the other end of the tubing in a suitable container to collect the glycerol phase
    - expect approximately 6L to 10L to come out depending on triglyceride volume
4. Open V29
5. Open slowly valve V10
6. Drain the glycerol phase (dark brown colour)
7. When the colour changes from dark brown to light yellow, quickly close V10
8. Set aside glyceror for soap production
9. Place a new container at the end of the tubing connected to V10
10. Open again the valve V10
11. Drain, if present, any soap layer ("mayonnaise" or "milky" appearance) until you reach a uniform yellowish layer
12. Close quickly V10
13. Dispose of the soap layer in a proper manner
    - Neutralize, dilute and pour down drain
14. Disconnect the piece of tubing from V10
15. You are now ready to water-wash your biodiesel

5.9.2 BIODIESEL WATER WASHING

1. Check that valve V10 is closed and valve V29 is open
2. Open V18
3. Check that V14 is closed
4. Switch V24 from condenser to R1 position (handle in vertical position)
5. Open V25
6. Typically, you should add between 20 - 50% volume of biodiesel in water
7. Use the liquid level on R1 to monitor how much water has been added
8. When the desired volume of water has been added, close V25
9. Switch V24 from R1 to condenser position (horizontal position)
10. Close V18
11. Close V29
12. Leave the mixture to settle for at least 24 hours
13. Connect a piece of tubing to valve V10
14. Place the other end of the tubing in a suitable container to collect the waste water
15. Uncap and open valve V29
16. Open slowly valve V10
17. Drain the waste water phase (murky water)
18. When the colour changes to a light yellow, quickly close V10
19. Dispose of waste water phase in a proper manner

   - Skim off top biodiesel layer using absorbent pads
   - Neutralize the pH using a weak acid such as acetic

20. Repeat steps washing 2 to 3 times
    - When the produced waste water is clear and its pH is close to 7 washing is complete

5.9.3 BIODIESEL DRYING

1. Ensure that the liquid in the reactor R1 is at least above the “2 inch above heater” mark on the liquid level. It is to ensure that the heater and the thermocouple in R1 are fully submerged.
   - *****If the heater is not fully submerged when turned on, it will fail*****
2. If the volume of the biodiesel is not sufficient in R1 to fully cover the heater (>50L), one solution could be as follows:
   - Check that valve V10 is closed and valve V29 is uncapped and open
   - Open V18
   - Check that valve V14 is closed
   - Switch V24 from condenser to R1 position (handle in vertical position)
   - Open V25
   - Add enough water so the level of liquid is above the “2 inch above heater” mark on the liquid level
   - Use the liquid level on R1 to monitor how much water has been added
   - When the desired volume of water has been added, close V25
   - Switch V24 from R1 to condenser position
   - Close V18
   - Close V29 and cap it
3. Switch on the main power box labelled “CB Panel 5L” using the toggle switch
   - The yellow light should come on
4. Turn on the circuit breaker labelled “CB 27” on the main power box
   - The red light above the circuit breaker should come on
5. The current temperature in PT1 and R1 should now be displayed on the right and left temperature control panels respectively
6. The heater in R1 is an electrical heater
7. Turn on the circuit breaker labelled “CB 20A” on the main power box
   - The red light above the circuit breaker should come on
8. Increase the temperature in R1 to 95^{o}C using PLC2
9. Open V17
10. Start vacuum pump P3 by turning the far right switch labeled “Vacuum” counter-clockwise
    - The red light above the switch should turn on
    - Then use the switch on the vacuum pump to turn it on and off
    - The vacuum pump will cycle on and off according to the pressure switch PS1
    - If the vacuum pump is running for a long period the pump may flip the breaker and stop running, ensure all breakers on the main power box are in the one position (up)
11. Check V24 is in the condenser position (handle in horizontal position)
12. Open V25 to start the condenser
    - Monitor the temperature on the condenser and adjust V25 to maintain 5-10^{o}C

13. Leave the tank under vacuum and at temperature 1-2 hrs until water removal is complete
    - No more liquid is seen coming out of the condenser
    - Temperature in reactor should be above 95^oC under vacuum (-15 inHg)
14. Open V29 very slowly to re-pressurize R1
15. Decrease the temperature on the R1 temperature control (PLC2) to 0^oC
16. Turn off the circuit breaker labelled “CB 20A” on the main power box
    - The red light above the circuit breaker should turn off
17. Close V17
18. Close V29
19. You can now stop the condenser by closing V25
20. Stop Control Unit by turning off the circuit breaker “CB 27” on the main power box
    - The red light above the circuit breaker should turn off
21. Switch off the main power box labelled “CB Panel 5L” using the toggle switch
    - The yellow light should turn off
22. Once the biodiesel has cooled to < 40 ^oC it can be transfered to the storage container

5.9.4 DRAWING OFF BIODIESEL

1. Connect a piece of tubing to valve V10
2. Place the other end of the tubing in a suitable container to collect the biodiesel (steel bucket)
3. Open V29
4. Open slowly valve V10
5. If soap comes out first, quickly close V10 and discard soap
6. Drain the biodiesel slowly
7. Close V10 and V29
8. Disconnect the piece of tubing from V10
9. Add biodiesel anti-oxidant to buckets
    - 400 ppm concnetraion

5.10 Biodiesel Dry Washing (under construction)

1. Open valve V11
2. Open V29 (if the outlet of the valve is capped off, remove cap) to allow air to get in when emptying R1
3. Make sure V10 (sampling valve at bottom of PT1) is closed
4. Valve V12 should be closed (handle of valve perpendicular to blue arrow labelled “Recirculation”)
5. Open V15 (handle of valve parallel to blue arrow labelled “Transfer to FP1”)
6. Place a suitable container after the pressure gauge G4 to collect the finished biodiesel product
7. Turn on pump P2
    - Switch on main power box labelled “CB Panel 5L”
    - Turn on circuit breaker labelled “CB 27”
    - Turn pump P2 switch to the right
8. Turn off pump P2 when container is filled
9. Close valves V11, V29 and V15

6. Fueling Station Procedures

6.1 Fuel Dispensing Procedure

1. Position vehicle so that the fuel intake is within 5ft of the cage doors.
2. Turn off vehicle
3. Loosen the two small caps on the top of the two fuel drums enough to allow air to enter
4. Turn on fueling station by turning on power bar
    - To change the biodiesel or diesel prices, enter 987 as the biodiesel blend and follow prompts
5. Enter the desired biodiesel blend and press the green button
6. Press the green button again to start the pump
7. Place the nozzle in the fuel intake of the vehicle and squeeze the handle to begin fueling
8. When the tank is full, the nozzle will automatically stop
9. Return the nozzle to its place on the pumping station
10. Turn off the pumps by pressing the red button
11. Wait for the receipt to print
12. Give customer copy of receipt
13. Record the amount of fuel pumped on the clipboard
14. Calculate the amount of fuel remaining in each of the drums
15. Turn off the system by turning off the power bar
16. Re-tighten the small drum caps

6.2 Drum-Filling Procedure

1. Remove the small cap from the drum to be filled
2. Place the fuel nozzle into the hole
3. Detach the outlet line at the swagelok fitting, from the top of the drum to be filled
4. Place the detached line into the fuel source (jerry can, steel bucket, etc.)
5. Ensure this line remains in the fuel for the entire re-fill
6. Turn on fueling station by turning on power bar
7. Enter either 100 or 0 % biodiesel concentration depending on which drum is to be filled (0% for re-filling petro-diesel drum, 100% for biodiesel)
8. Turn on the pump
9. Squeeze the nozzle handle to begin re-filling
10. When the fuel source is empty, release the handle
11. For multiple fuel sources, place the outlet line into the next source
12. When all sources have been emptied, stop the pumps by pressing the red button
13. Return the nozzle to its place on the fueling station
14. Record the amount of fuel pumped on the clipboard
15. Calculate the amount of fuel remaining in the re-filled drum
16. Turn off the system by turning off the power bar
17. Replace and tighten the small drum cap
18. Replace and tighten the drum outlet line

6.3 Accidental Release & Spill Clean-up

Provincial Spill Reporting
Regulations http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/46_263_90

1. Remove sources of ignition
2. Contain spill to the smallest area possible, preferably inside the berm, and prevent the fuel from entering the sewer drains, soil or surface water using fuel absorbent materials and drain covers
3. If possible, stop the leak
4. Use absorbent materials, such as paper towels, sand, kitty litter, Oil Dry® or dirt, to pick up the spill
5. If the spill has reached soil or gravel, excavate the affected material using vision and smell to determine the extent of excavation
6. Place the materials used to pick up the spill and any excavated soil and gravel in the provided garbage bags, seal them and label as hazardous waste
7. Place waste material tag on the bag and note the bag's contents. Give the bag to Richard Ryoo in Stores for the disposal
8. Contact CHBE safety officer Ivan Leversage (leversag@mail.ubc.ca)
9. If the spill has entered the sewer drain, cannot be excavated, or exceeds 100L, call 1-800-663-3456 (Emergency Management BC) to report the spill and its details
    1. the reporting person's name and telephone number,
    2. the name and telephone number of the person who caused the spill,
    3. the location and time of the spill,
    4. the type and quantity of the substance spilled,
    5. the cause and effect of the spill,
    6. details of action taken or proposed to comply with section 3 of the Provincial Spill Reporting Regulations
    7. a description of the spill location and of the area surrounding the spill,
    8. the details of further action contemplated or required,
    9. the names of agencies on the scene, and
    10. the names of other persons or agencies advised concerning the spill.

6.4 Spill kit

- fuel absorbent gravel (kitty litter)
- waste bags and ties
- resistant gloves
- mobile container (to hold everything)
- broom and dust pan

7. Quality testing procedures

7.1 Methanol Content

1. Weigh 250mL erlenmeyer flask
2. Pour 200ml of biodiesel product into the flask
3. Weigh the flask with the biodiesel
4. Heat the biodiesel to 70 degrees C using a magnetic stirrer, a temperature control, and a thermometer to ensure temperature of the biodiesel does not exceed 90 degrees C
5. Leave at 70 degrees C for 15 mins
6. Take the flask off the heat and reweigh. Record weight
7. Repeat steps 5 and 6 until the weight no longer changes
8. Calculate methanol weight percentage

7.2 Water Content - use of autotitrator to be determined

1. Weigh 250mL erlenmeyer flask
2. Pour 200ml of biodiesel product into the flask
3. Weigh the flask with the biodiesel
4. Heat the biodiesel to 110 degrees C using a magnetic stirrer, a temperature control, and a thermometer to ensure temperature of the biodiesel does not exceed 120 degrees C
5. Leave at 110 degrees C for 15 mins
6. Take the flask off the heat and reweigh. Record weight
7. Repeat steps 5 and 6 until the weight no longer changes
8. Calculate water weight percentage

7.3 3/27 Conversion Test

(done in fume hood)

1. Pipette 27mL of room temperature methanol into a clear vial with a lid
2. Add 3mL of room temperature biodiesel product
3. Shake well, and allow to settle for 30 mins
    - If an oily material settles out, then the fuel contains more than trace amounts of triglycerides (unreacted oil), diglycerides, and monoglycerides - may need further reaction
    - If nothing settles out, it is highly converted!

7.4 Water Separation Test

(to tell whether further washing is required)

1. During the process
    a. Drain 50mL of wet biodiesel (a hazy orange juice colour) into a clear vial with a lid
    b. Gently warm the vial for 10 mins
    c. If it takes longer than 10 mins to become translucent, more washing is needed
2. After Process
    a. To a clear vial with a lid, add 50mL of dry biodiesel
    b. Add 50mL of water

c. Shake well, and allow to settle
    - If the water is dirty (not completely clear), needs more washingIf water is clear and the separation line is clean, no further washing is required

7.5 Viscosity

(use of viscometer to be determined)

7.6 Acid Number

(see titration in appendix A)

7.7 Cloud Point

(Use cloud point tester in 5.18)

7.8 Glycerol Content

(free and total glycerol can be determined in the GC-MS)

8. Appendix A: Titration

Excerpt from www.journeytoforever.com

8.1 Basic titration

For processing used oil, it's essential to titrate the oil to determine the Free Fatty Acid (FFA) content and calculate how much extra lye will be required to neutralise it.

An electronic pH tester is best, but you can also use phenolphthalein solution (from a chemicals supplier).

Dissolve 1 gram of pure sodium hydroxide lye (NaOH) in 1 litre of distilled or de-ionized water (0.1% w/v NaOH solution) (weight to volume).

In a smaller beaker, dissolve 1 ml of dewatered WVO in 10 ml of pure isopropyl alcohol (isopropanol).

Warm the beaker gently by standing it in some hot water, stir until all the oil dissolves in the alcohol and the mixture turns clear. If you're using phenolphthalein, add 2 drops of phenolphthalein solution.

Using a graduated syringe, add the 0.1% NaOH solution drop by drop to the oil-alcohol-phenolphthalein solution, stirring all the time. It might turn a bit cloudy, keep stirring. Keep on carefully adding the lye solution until the solution stays pink (actually magenta) for 15 seconds.

Take the number of millilitres of 0.1% lye solution you used and add 3.5 (the basic amount of lye needed for fresh oil). This is the number of grams of lye you'll need per litre of oil to process the WVO.

Potassium hydroxide (KOH) can also be used for titration, see **Using KOH**, below.

Duda's Alternative Energy Online Store supplies phenolphthalein solution in convenient 18-ml dropper bottles, enough for about 180 titrations, as well as a variety of syringes, beakers, chemicals for titration, and gloves, sold separately and as part of their **WVO Titration Kit**, buy online: http://dudadiesel.com/

8.1.1 Electronic pH testers

With an electronic pH tester, use the same procedure as above but without the phenolphthalein. Dip the pH tester electrode in the oil-alcohol mixture, add 0.1% sodium hydroxide (NaOH) solution drop by drop while stirring until the pH tester reads 8.5.

Take the number of millilitres of NaOH solution you used and add 3.5 (the basic amount of lye needed for fresh oil). This is the number of grams of lye you'll need per litre of oil to process the WVO. For potassium hydroxide, see **Using KOH**, below.

Do a few practice runs first to get used to the pH tester. Sometimes they can be a little slow to register. Stop adding the NaOH solution and stirring the mixture for half a minute or so to see if the tester needs time to catch up.

To be accurate, pH testers need regular calibration using buffer solutions, normally supplied with the tester, along with directions for use. See:

pH meters

pH testing > Techtips

8.2 Better titration

Unless you have a very accurate scale, it's not easy to measure exactly 1 gram of lye. It's much easier to measure 5 g accurately than 1 g. So mix 5 g of NaOH (or KOH) with 500 millilitres of distilled or de-ionized water to make a stock solution.

Before titration measure out 5 ml of the stock solution, add 45 ml of distilled or de-ionized water. This makes a 0.1% w/v lye solution (weight/volume).

It's also not easy to measure exactly 1 millilitre of oil. Instead of the usual 1 ml of oil and 10 ml of isopropyl alcohol, mix 4 ml of oil in 40 ml of isopropyl alcohol in a glass beaker.

Warm the mixture gently by standing the beaker in hot water, stir until all the oil disperses and it becomes a clear mixture.

If you're using phenolphthalein, add 2 drops as usual -- no need to add four times as much, 8 drops gives the same result as 2 drops.

Titrate as usual, measuring millilitres of 0.1% lye solution used. When it reaches pH8.5 count up the number of millilitres used as usual and divide by 4. This will give a much more precise measurement.

To save on isopropyl alcohol, use 2 ml of oil in 20 ml of isopropyl and divide the results by two -- still twice as accurate.

8.3 Using KOH

KOH is not as strong as NaOH -- use 1.4 times as much KOH (actually 1.4025 times).

Titration is basically the same.

You can use either KOH solution or NaOH solution for titration. Unlike NaOH, your KOH probably won't be pure, but as long as you use the same strength of KOH for both the titration solution and the reaction it won't make any difference.

Mix the KOH solution the same as for NaOH: add 1 g of KOH to 1 litre of distilled water to make 0.1% KOH solution. Or do it the **Better titration** way. For each 1 millilitre of solution used in the titration add 1 g of KOH to the basic amount.

You can also use the usual 0.1% w/v NaOH solution and convert the end result for KOH, see below.

Instead of the basic 3.5 grams of NaOH per litre of oil, use 3.5 x 1.4 = 4.9 grams of KOH (4.90875). So, if your titration was 3 ml of 0.1% KOH solution, use 3 + 4.9 = 7.9 g KOH per litre of oil.

One more complication: KOH is generally not as pure as NaOH. KOH is usually 92%, 90% or 85% pure -- check the label. We use half-pearls assayed at 85%, with good and reliable results. KOH is available at 99% strength, but it's hard to find and it's expensive, and anyway 92% or 85% work just fine.

Adjust the basic lye quantity according to the strength of the KOH: the basic 4.9 grams of KOH at 100% strength would be:

- 85% KOH -- 5.8 (5.775) grams
- 90% KOH -- 5.5 (5.454) grams
- 92% KOH -- 5.3 (5.336) grams

To substitute KOH for the 3.1 grams of NaOH per litre of oil used in the acid-base process:

- 85% KOH -- 5.1 (5.115) grams

- 90% KOH -- 4.8 (4.831) grams
- 92% KOH -- 4.7 (4.726) grams

To convert NaOH quantities for KOH:

- For 85% KOH use 165% of the NaOH amount (x 1.65).
- For 90% KOH use 155.83% of the NaOH amount (x 1.56).
- For 92% KOH use 152.45% of the NaOH amount (x 1.52).

Example: You're using 85% KOH and the titration needed 3 ml of KOH solution to bring the pH to 8.5.

Number of grams of KOH required for the reaction:

- Basic amount: 5.8 g KOH (5.775)
- Titration result: 3 ml
- Add: 3 g KOH
- Total: 8.8 g (8.775) of 85% KOH required per litre of WVO.

Using 0.1% NaOH solution for titration and the same WVO as above: the titration result is lower, it only needs 1.8 ml to reach pH8.5. (Actually 1.82 ml, according to the calculation.)

- Basic amount: 3.5 g NaOH
- Titration result: 1.8 ml (1.82)
- Add: 1.8 g NaOH (1.82)
- Total: 5.3 g NaOH (5.32)
- Convert for 85% KOH:
- 5.3 (5.32) x 1.65 = 8.8 g (8.778) of 85% KOH per litre of WVO.

We usually use NaOH solution for titration and convert the result for our 85% KOH, but in practice NaOH solution and KOH solution both work equally well.

One reason for preferring NaOH solution is that it's usually the standard used in describing FFA content of different oils -- 2 ml titration WVO or 5 ml titration WVO invariably refers to ml of 0.1% NaOH solution, unless otherwise specified. In the example above, the WVO would be described as 1.8 ml titration WVO.

KOH dissolves in methanol much faster and more easily than NaOH does, and doesn't "clump" together as NaOH can do. When you use KOH the glycerine by-product is liquid and won't solidify.

KOH is easier to use than NaOH. It's more flexible and adaptible and it gives generally better results -- all round it's a better catalyst than NaOH. We seldom use NaOH (except for titration).

Note Don't mix KOH and NaOH in the same batch. If you use KOH as the catalyst, you must also use KOH if you make soap from the glycerin by-product, and again you must use KOH if you **deacidify the WVO** as a pre-processing step.

9. Appendix B: Water Wash Test

Excerpt from www.journeytoforever.com

9.1 Wash test

This is the most useful all-round test, and it's very simple: Put 150 ml of unwashed biodiesel (settled for 12 hours or more, with the glycerine layer removed) in a half-litre glass jar or PET bottle. Add 150 ml of water (at room temperature), screw the lid on tight and shake it up and down violently for 10 seconds. Then let it settle.

The biodiesel should separate from the water in half an hour or less, with amber (and cloudy) biodiesel on top and milky water below, and no more than a paper-thin white interface layer between the oil and water.

This is quality fuel, a completed product with minimal contaminants. Wash it and use it with confidence.

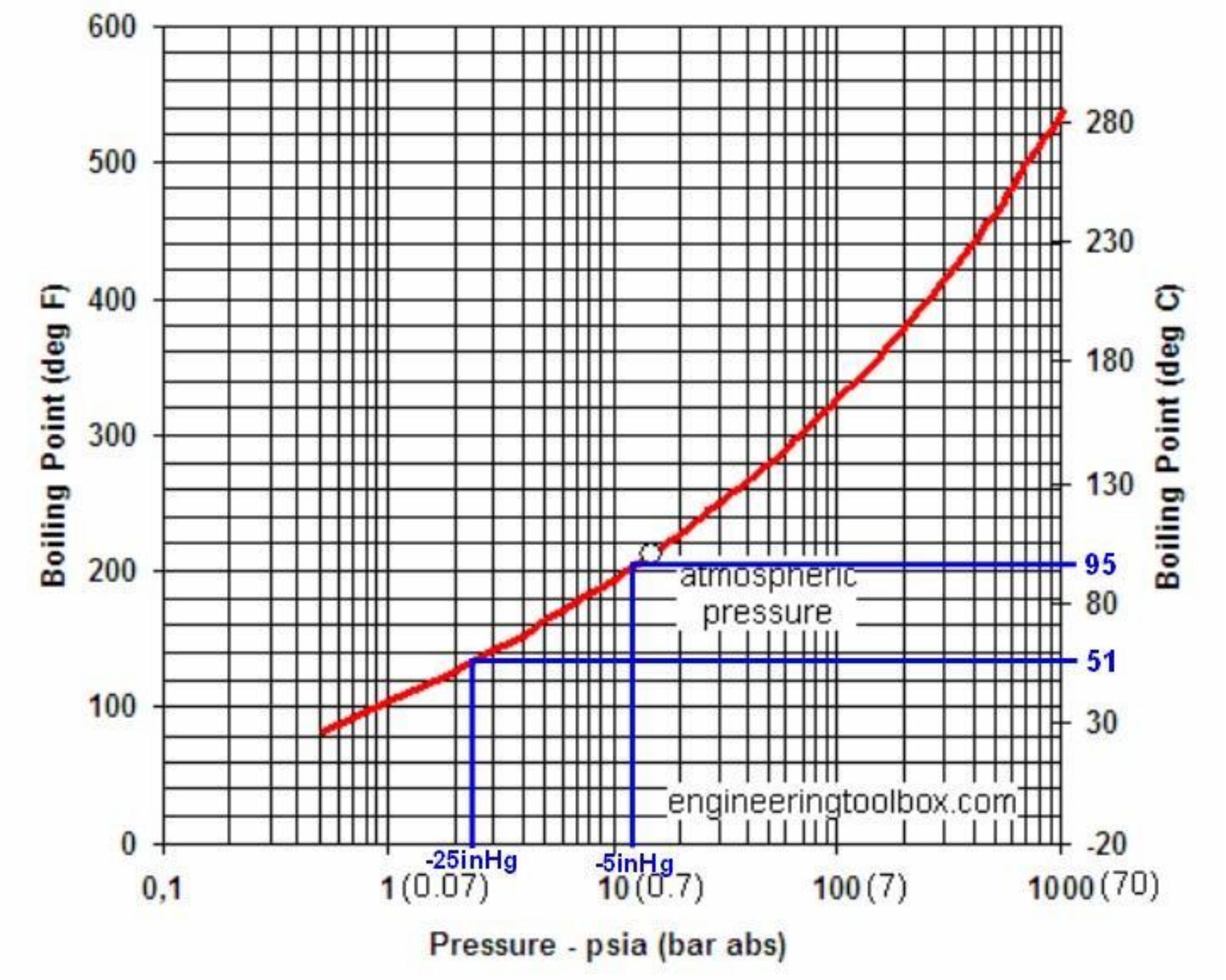
But if it turns into something that looks like mayonaisse and won't separate, or if it only separates very slowly, with a thick, creamy white layer sandwiched between the water and the biodiesel, it's not quality fuel and your process needs improvement.

Either you've used too much catalyst and made excess soap (solution: more accurate measurements, better titration), or an incomplete reaction with poor conversion has left you with half-processed monoglycerides and diglycerides, fuel contaminants that also act as emulsifiers. Emulsifiers are used to make stable mixtures of oil and water, such as, indeed, mayonnaise (solution: more accurate measurements, better titration; longer processing time, better temperature control, also try using more methanol), or both -- too much catalyst as well as poor conversion.

◄ Wash-test with unwashed biodiesel -- left, after a violent 10-second shaking; right, biodiesel and water separated cleanly within minutes. The biodiesel will be cloudy, and the water can be milkier than this, but as long as it separates quickly and cleanly, it passes the test.

Poor conversion is much more likely to cause a severe emulsion that won't separate than excess soap is. See Emulsions. Either way you're headed for washing problems. Using super-gentle washing techniques like bubble-washing or mist-washing might avoid the washing problems, but you'll still be left with poor-quality fuel laced with contaminants that can cause injector coking and engine damage and they can't be washed out.

10. Appendix C: Water boiling point



11. Appendix D: NREL procedure for high FFA oils

11.1 Procedure for High FFA Feedstocks

1. Measure FFA level
2. Add 2.25 g methanol and 0.05 g sulfuric acid for each gram of free fatty acid in the oil or fat. Sulfuric acid and methanol should be mixed first and then added slowly to the oil.
3. Agitate for one hour at 60-65ºC.
4. Let mixture settle. Methanol-water mixture will rise to the top. Decant the methanol, water, and sulfuric acid layer.
5. Take bottom fraction and measure new FFA level.
6. If FFA is > 0.5%, return to step 2 with new FFA level. If FFA is < 0.5%, proceed to step
7. Add an amount of methanol equal to 0.217 x [grams of unreacted triglycerides] and an amount of sodium methoxide equal to [0.25 + (%FFA)0.190]/100 x [grams of unreacted triglycerides]. Mix the sodium methoxide with the methanol and then add to the oil. This corresponds to a 6:1 molar ratio of methanol to oil for the unreacted triglycerides. It ignores any methanol that may have carried over from the pretreatment.
8. Agitate for 1 hour at 60ºC.

11.1.1 Example: 100 g of 12% FFA animal fat

1. Pretreatment
   - 2.25 x 12 g = 27.0 g methanol
   - 0.05 x 12 g = 0.6 g H2SO4 (sulfuric acid)
2. Mix acid with methanol. Then add mixture to fat. Agitate for one hour at 60ºC. Let settle and separate bottom phase. Acid value should decrease substantially, to at least 5-6 mg KOH/g. Therefore, FFA = 2.5%
3. Second step of pretreatment:
   - 2.25 x 2.5 g = 5.6 g of methanol
   - 0.05 x 2.5 g = 0.13 g H2SO4
4. Mix with oil, agitate at 60ºC for 1 hour. FFA should be < 0.5%. Removal of upper phase is usually optional at this point.
5. Then add 0.217 x (88) = 19.1 g methanol
   - [0.25 + (0.5)(0.190)]/100 x 88 = 0.30 g sodium methoxide
6. Agitate at 60ºC for one hour. If glycerol and ester do not separate, add 50 g of warm distilled water to encourage separation. Wash 3-4 times.

12. Appendix E: Biodiesel Production Scheduling - Fresh Vegetable Oil

Complete form and ensure each person has a copy

Supervising Grad Student: **Phone #:**

Team Members:

Day	Date	Task	Duration (hrs)	Personal			Start Time	End Time
				Req'd	Team Members	SGS		
1		Waste Oil Procurement	1	1		Initiate		
2		Oil Transfer to R1	2	4		Initiate / Available		
		Heating of R1	2	4		On-Site		
		Methoxide Production						
		Transesterification	1	2		Initiate / Available		
3		Methanol Removal 1	2	1		Initiate		
		Methanol Removal 1	2	1		Available		
		Methanol Removal 1	2	1		Available		
4		First Water Wash	1	2		Initiate		
5		Second Water Wash	1	2		Initiate		
6		Third Water Wash	1	2		Initiate		
7		Water Removal	2	1		Available		
		Water Removal	2	1		Available		
		Biodiesel Removal	1.5	2		Initiate		
		Waste Disposal						
		Lab Clean-Up						
8		Quality Control	2	1		Initiate		

13. Appendix F: Biodiesel Production Scheduling - Waste Vegetable Oil

Complete form and ensure each person has a copy

Supervising Grad Student: **Phone #:**

Team Members:

Day	Date	Task	Duration (hrs)	Personal			Start Time	End Time
				Req'd	Team Members	SGS		
1		Waste Oil Titration	1	1		Initiate		
1		Waste Oil Filtration	0.5	2		Available		
		Oil Transfer to PT1	0.5	2		Available		
		Heating of PT1	1	2		Initiate / Available		
		Water Removal	2	1		Available		
3		Oil Transfer to R1	2	2		Initiate / Available		
		Heating of R1	2	2		On-Site		
		Methoxide Production						
		Transesterification	1	2		Initiate / Available		
3		Methanol Removal 1	2	1		Initiate		
		Methanol Removal 1	2	1		Available		
		Methanol Removal 1	2	1		Available		
4		First Water Wash	1	2		Initiate		
5		Second Water Wash	1	2		Initiate		
6		Third Water Wash	1	2		Initiate		
7		Water Removal	2	1		Available		
		Water Removal	2	1		Available		
		Biodiesel Removal	1.5	2		Available		
		Waste Disposal						
		Lab Clean-Up						
8		Quality Control	2	1		Initiate		

14. Appendix G: Basics of Biodiesel Production

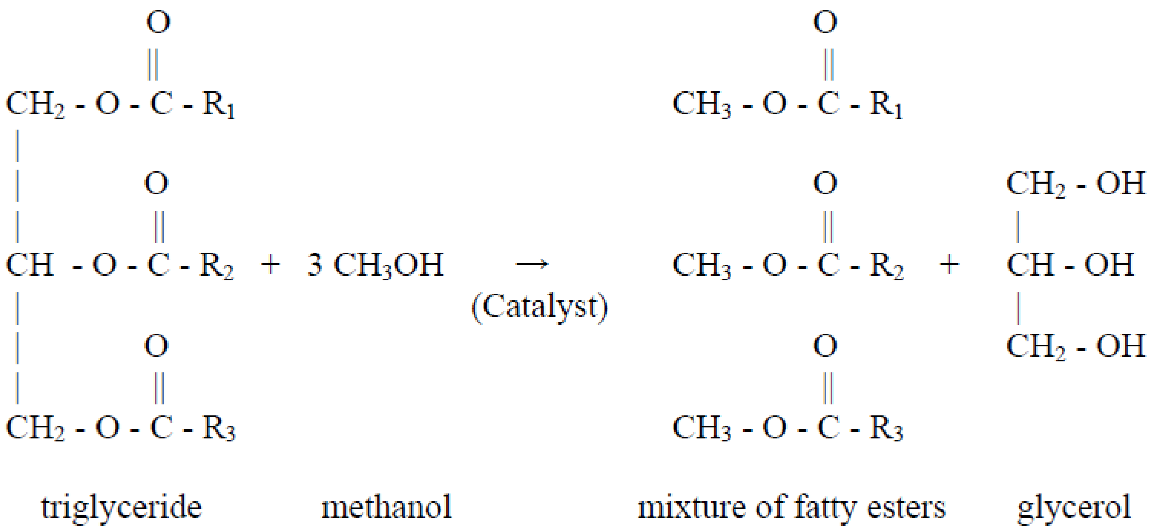
(Excerpt from NREL's Production Handbook)

Biodiesel is an alternative fuel for diesel engines that is gaining attention in the United States after reaching a considerable level of success in Europe. Its primary advantages are that it is one of the most renewable fuels currently available and it is also non-toxic and biodegradable. It can also be used directly in most diesel engines without requiring extensive engine modifications. The purpose of this book is to describe and explain the processes and issues involved in producing this new fuel.

The most cursory look at the literature relating to biodiesel will soon reveal the following relationship for prediction of biodiesel from fats and oils.

100 lbs of oil + 10 lbs of methanol → 100 lbs of biodiesel + 10 lbs of glycerol

This equation is a simplified form of the following ***transesterfication*** reaction.



$$\begin{array}{llcll} CH_2-O-\overset{\overset{O}{\|}}{C}-R_1 & & & CH_3-O-\overset{\overset{O}{\|}}{C}-R_1 & \\ | & & & & \\ CH\ -O-\overset{\overset{O}{\|}}{C}-R_2 & +\ 3\ CH_3OH & \xrightarrow[\text{(Catalyst)}]{} & CH_3-O-\overset{\overset{O}{\|}}{C}-R_2\ \ + & \begin{array}{l} CH_2-OH \\ | \\ CH-OH \\ | \\ CH_2-OH \end{array} \\ | & & & & \\ CH_2-O-\overset{\overset{O}{\|}}{C}-R_3 & & & CH_3-O-\overset{\overset{O}{\|}}{C}-R_3 & \\ \text{triglyceride} & \text{methanol} & & \text{mixture of fatty esters} & \text{glycerol} \end{array}$$

Figure 1. Transesterification Reaction

where R_1, R_2, and R_3 are long chains of carbons and hydrogen atoms, sometimes called fatty acid chains. There are five types of chains that are common in soybean oil and animal fats (others are present in small amounts):

Palmitic:	$R = -(CH_2)_{14}-CH_3$	16 carbons, (including the one that R is attached to.) (16:0)
Stearic:	$R = -(CH_2)_{16}-CH_3$	18 carbons, 0 double bonds (18:0)
Oleic:	$R = -(CH_2)_7\,CH{=}CH(CH_2)_7CH_3$	18 carbons, 1 double bond (18:1)

Table 1. Composition of Various Oils and Fats.

Oil or fat	14:0	16:0	18:0	18:1	18:2	18:3	20:0	22:1
Soybean		6-10	2-5	20-30	50-60	5-11		
Corn	1-2	8-12	2-5	19-49	34-62	trace		
Peanut		8-9	2-3	50-65	20-30			
Olive		9-10	2-3	73-84	10-12	trace		
Cottonseed	0-2	20-25	1-2	23-35	40-50	trace		
Hi linoleic Safflower		5.9	1.5	8.8	83.8			
Hi Oleic Safflower		4.8	1.4	74.1	19.7			
Hi Oleic Rapeseed		4.3	1.3	59.9	21.1	13.2		
Hi Erucic Rapeseed		3.0	0.8	13.1	14.1	9.7	7.4	50.7
Butter	7-10	24-26	10-13	28-31	1-2.5	.2-.5		
Lard	1-2	28-30	12-18	40-50	7-13	0-1		
Tallow	3-6	24-32	20-25	37-43	2-3			
Linseed Oil		4-7	2-4	25-40	35-40	25-60		
Yellow grease (Typical)	2.43	23.24 16:1=3.79	12.96	44.32	6.97	0.67		

Data derived from *Organic Chemistry*, W.W. Linstromberg, D.C. Heath and Co., Lexington, MA, 1970.

Linoleic: R = $-(CH_2)_7\,CH{=}CH{-}CH_2{-}CH{=}CH(CH_2)_4CH_3$

18 carbons, 2 double bonds (18:2)

Linolenic: R = $-(CH_2)_7\,CH{=}CH{-}CH_2{-}CH{=}CH{-}CH_2{-}CH{=}CH{-}CH_2{-}CH_3$

18 carbons, 3 double bonds (18:3)

These chains are designated by two numbers separated by a colon. The first number designates the number of carbon atoms in the chain and the second number designates the number of double bonds. Note that the number of carbon atoms includes the carbon that is double bonded to the oxygen atom at one end of the fatty acid (called the carboxylic carbon). This is the end that the methanol attaches to when methyl esters are produced. Table 1 shows the percentages of each fatty acid chain present in common oils and fats.

For simplicity, consider an oil such as soybean oil to consist of pure triolein. Triolein is a triglyceride in which all three fatty acid chains are oleic acid. This is near the actual number of carbons and hydrogens and gives a molecular weight that is near the value for soybean oil. If triolein is reacted with methanol, the reaction will be that shown in Figure 2. Note that weights for each of the compounds in the reaction are given. These are based on the fact that one molecule of triolein reacts with 3 molecules of methanol to produce 3 molecules of methyl oleate, the biodiesel product, and one mole of glycerol. Chemists typically multiply all the terms of this equation by a large number that corresponds to the number of molecules in a quantity equal to the molecular weight of the substance. This quantity is called a *mole* of the substance. To calculate the molecular weight of triolein, we count the number of carbons in the molecule (57) and multiply

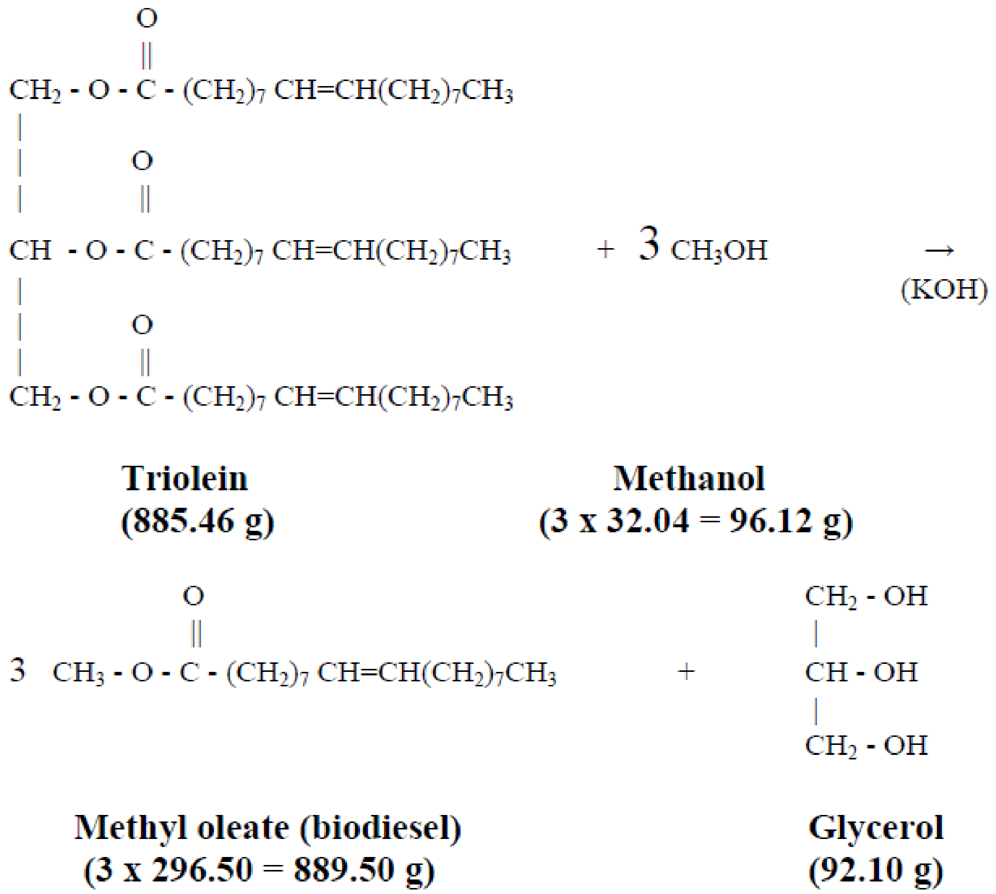


Figure 2. Transesterification of Triolein

this by 12.0111, the molecular weight of carbon. Doing the same thing for hydrogen and oxygen gives:

57 x 12.0111 = 684.63
104 x 1.00797 = 104.83
6 x 16.000 = 96.00
Total = 885.46 grams per mole

Therefore, the molecular weight of triolein is 885.46 and one mole of triolein weighs 885.46 grams. Three moles of methanol weigh 96.12 g, 3 moles of methyl oleate weigh 889.50 g, and 1 mole of glycerol weighs 92.10 g.

We do not actually conduct the reaction this way. We usually add 60% to 100% excess methanol to ensure that the reaction goes to completion. In general, reactions can be encouraged to progress by adding an excess of one of the reactants or by removing one of the products. The reaction of triolein with 100% excess (XS) methanol is shown in Figure 3.

Triolein + 2X Methanol
(885.46 g) (6 x 32.04 = 192.24 g)

→ Methyl oleate + Glycerol + XS Methanol
(Catalyst) (3 x 296.50 = 889.50 g) (92.10 g) (96.12 g)

Figure 3. Transesterification of Triolein with 100% Excess Methanol

On the basis of 100 lb of oil, the reaction mass balance with 100% XS methanol becomes:

100 lb oil + 21.71 lb methanol → 100.45 lb biodiesel + 10.40 lb glycerol + 10.86 lb XS methanol

The reaction also requires about 1% (based on the weight of oil) of sodium hydroxide or a similar catalyst that mostly ends up in the glycerol. These quantities can be converted to volumes by including the densities of the reactants and products given in Table 2.

Table 2. Densities of Biodiesel Reactants (kg/liter)
(from the Handbook of Chemistry and Physics, 51st Edition, CRC, 1970-1971.)

Triolein:	0.8988
Methanol	0.7914
Methyl Oleate	0.8739
Glycerol	1.2613

On a volume basis, the reaction becomes:

100 liters of oil + 24.65 liters methanol
→ 103.3 liters methyl oleate + 7.42 liters glycerol + 12.33 liters XS methanol

Product Quality

The standard for biodiesel allows 0.24% total glycerol in the final product. What does this actually mean? It is clear that a molecule of a triglyceride can be considered to contain a molecule of glycerol, sometimes called the glycerol backbone. In the case of triolein, the mole of glycerol would weigh 92.10 g and the mole of triolein weighs 885.46 g. Therefore, triolein can be considered to consist of 92.10/885.46 = 0.104, or 10.4% glycerol. This glycerol is called *bound glycerol* because it is chemically bound to the triolein molecule. Bound glycerol can also be associated with monoglycerides and diglycerides, the partial reaction products of the conversion of triglycerides to alkyl esters. The structures of these molecules are shown in Figure 4.

Diglyceride **Monoglyceride**

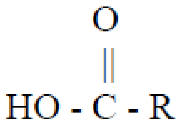
Figure 4. Chemical Structure of Diglyceride and Monoglyceride

Bound glycerol is added to any fully reacted glycerol, or *free glycerol*, that may still be in the biodiesel, to get the *total glycerol*. If the original oil contains 10.4% glycerol, and the final biodiesel can only contain a total glycerol level of 0.24%, then the transesterification reaction must be

$$\frac{10.4 - 0.24}{10.4} x100 = 97.7\% \qquad \text{or } 97.7\% \text{ complete.}$$

Competing Reactions

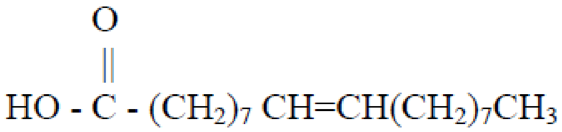
It is common for oils and fats to contain small amounts of water and free fatty acids. Free fatty acids consist of the long carbon chains described that are disconnected from the glycerol backbone. They are sometimes called carboxylic acids.



$$HO-\overset{\overset{O}{\|}}{C}-R$$

Figure 5. Carboxylic Acid (R is a carbon chain)

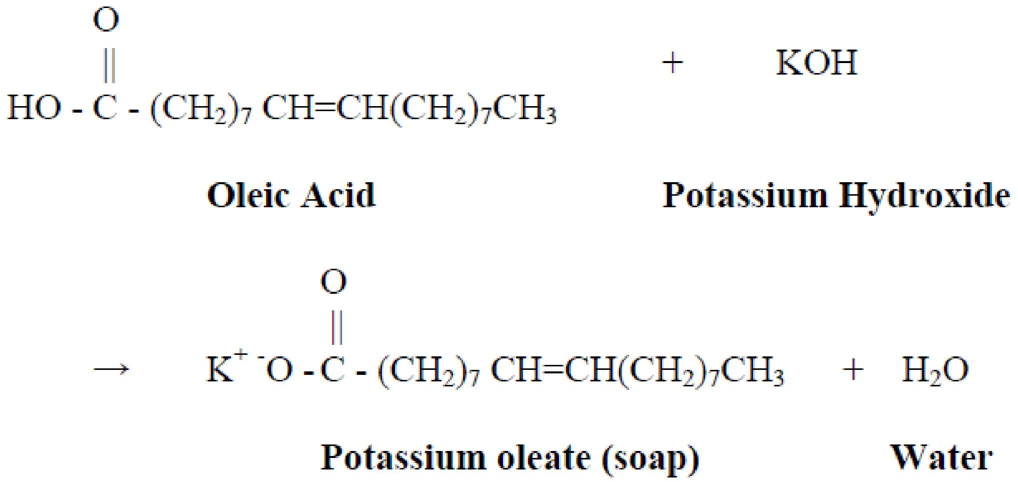
The oleic group we have used earlier gives oleic acid, one of the free fatty acids that can be found in unrefined vegetable oils and animal fats.



$$HO-\overset{\overset{O}{\|}}{C}-(CH_2)_7\,CH{=}CH(CH_2)_7CH_3$$

Figure 6. Oleic Acid

If an oil or fat containing a free fatty acid such as oleic acid is used to produce biodiesel, the alkali catalyst typically used to encourage the reaction will react with this acid to form soap. Figure 7 shows this reaction when the catalyst is potassium hydroxide (KOH).



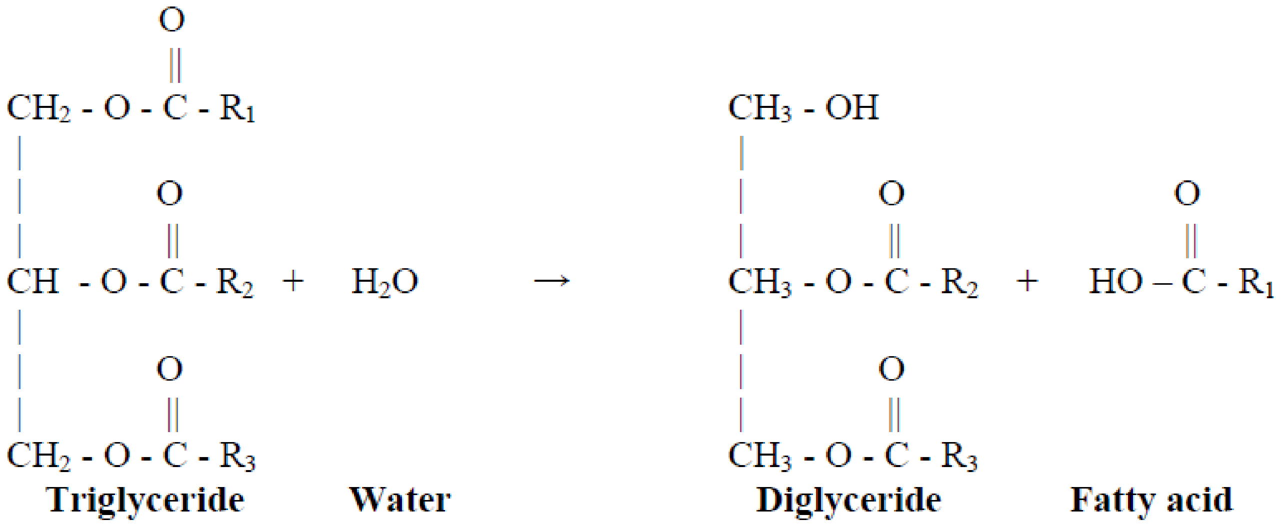
$$HO-\overset{\overset{O}{\|}}{C}-(CH_2)_7\,CH=CH(CH_2)_7CH_3 + KOH \rightarrow K^+\,{}^-O-\overset{\overset{O}{\|}}{C}-(CH_2)_7\,CH=CH(CH_2)_7CH_3 + H_2O$$

Figure 7. Formation of Soap

This reaction is undesirable because it binds the catalyst into a form that does not contribute to accelerating the reaction. Excessive soap in the products can inhibit later processing of the biodiesel, including glycerol separation and water washing.

Water in the oil or fat can also be problem. When water is present, particularly at high temperatures, it can hydrolyze the triglycerides to diglycerides and form a free fatty acid. Figure 8 shows a typical hydrolysis reaction.

When an alkali catalyst is present, the free fatty acid will react to form soap following the reaction given earlier (Figure 7). When water is present in the reaction it generally manifests itself through excessive soap production. The soaps of saturated fatty acids tend to solidify at ambient temperatures so a reaction mixture with excessive soap may gel and form a semi-solid mass that is very difficult to recover.



$$\begin{array}{l} CH_2-O-\overset{\overset{O}{\|}}{C}-R_1 \\ | \\ CH-O-\overset{\overset{O}{\|}}{C}-R_2 \\ | \\ CH_2-O-\overset{\overset{O}{\|}}{C}-R_3 \end{array} + H_2O \rightarrow \begin{array}{l} CH_3-OH \\ | \\ CH_3-O-\overset{\overset{O}{\|}}{C}-R_2 \\ | \\ CH_3-O-\overset{\overset{O}{\|}}{C}-R_3 \end{array} + HO-\overset{\overset{O}{\|}}{C}-R_1$$

Figure 8. Hydrolysis of a Triglyceride to Form Free Fatty Acids

15. Appendix H: Soap Production

15.1 Procedure

1) Filter glycerin: Remove any unwanted impurities – any vegetable strainer will do

2) Quantities: Amount of water should be approx. 25% volume of glycerin being processed. 38.5grams of lye (NaOH) per litre of glycerin.

3) Methanol Removal: Heat glycerin to 65 degrees Celsius to remove all left-over methanol.

4) Water/Lye: Heat water to 38 degrees Celsius and add lye. Stir until all lye is dissolved. Add this mixture to the glycerin and keep heating for 10 minutes. Reduce stir speed and continue heating for another 10 minutes (20 minutes total).

5) Container: Use any Tupperware container (Wal-Mart especially) and pour in soap at desired thickness. Cover with cardboard/plywood to keep in heat and let it cool for 24 hours.

6) Removal: Use a butter knife to slide soap out of container, cut into desired sizes and let sit in a cool are for 4 -7 days. Note: the colour will lighten over this period.

15.2 Making Glycerin Soap from Biodiesel By-Products

by Terry McGleish

A byproduct from making bio-diesel is glycerin. In a process called transesterification, waste vegetable oil (WVO) is broken down into esters (bio-diesel) and glycerin. This glycerin can be filtered to remove any food particles or impurities, and used as an industrial degreaser in its raw form, composted and used as a fertilizer, or made into bar soap. Bar soap made from your glycerin byproduct is excellent for use in the shop because of its degreasing abilities, but can also be used as a household soap for everyday use. Adding fragrances and dyes will make household use more appealing to other members of the household.

The soap lathers well and cuts grease and dirt easily.

Ingredients used in making bar soap from glycerin are, glycerin, water and lye. The amounts of water and lye used will effect the lathering abilities of the soap. I have found that the more water used, the more lather the soap will produce. And using more lye will produce a soap which is very strong and cuts grease well, but also dries out the skin.

To begin, filter the glycerin to remove any unwanted impurities, you may have to heat the glycerin back to a liquid state in order to strain it. A good strainer is a restaurant type strainer used for vegetable oil or an old pair of panty hose works well.

The amount of lye and water used will depend on the amount of glycerin you are processing. I have found that one quart of water per gallon of glycerin (or 25%) works well, producing a soap with good lathering and cleansing abilities. On the lye, I use 38.5 grams per liter or 5.5 oz. per gallon of glycerin. I have used these quantities on several batches of glycerin, even when the glycerin is from WVO from different sources.

Heat the glycerin in a stainless steel or aluminum pot (or your bio processor) to 150 degrees F. to remove any excess methanol (if you used ethanol, heat to 175 F.). Measure the proper amounts of water and lye to be used, heat the water to 100 degrees F., add the lye and mix until all the lye is dissolved. Be sure not to breathe the fumes. Pour the water/lye mixture into the glycerin. Continue to heat the glycerin for another ten minutes while mixing. Allow to mix for an additional ten minutes (20 mins. total) at slow speed. The mixture may foam up slightly and form soap bubbles. After mixing is complete, the soap can be poured into a container and allowed to cool.

A good container to use is a Tupperware type container available at any Wal-mart for a couple dollars. You do not need to add any type of release agent using these type of containers, and removal is simple. You will need two 28 qt. containers for 3 gallons of soap at 1 1/2" thick. Pour the soap into the containers at the desired thickness and cover with a piece of cardboard or plywood to help hold the heat in, and let set for 24 hrs. As the soap cools, it will start to solidify.

Plastic "Tupperware" sweater box used to hold soap while cooling.

After the 24 hr cooling period, the soap should be ready to be removed and cut into bars. Using a butter knife or putty knife, slice around the inside edge of the container to release the soap from the sides. Quickly turn the container upside down over a piece of newspaper or cardboard. You may have to tap lightly on the bottom of the container to help it release and drop out. You now have a nice evenly shaped "slab" of soap which can be cut into individual bars. Each slap will produce about 45 bars of soap measuring 2" X 3" each.

The hardend soap easily is removed from the container and is ready to be cut into individual bars.

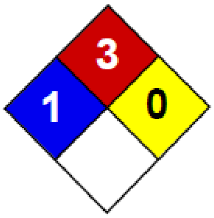
Allow soap to set in a cool area for approximately 4 - 7 days before using. When first cut the soap will appear dark in color, but will lighten to a tan color as drying progresses. The resulting soap is a long lasting bar with good cleansing abilities leaving no greasy residues.

Soap can be stored in plastic zip lock bags or placed in plastic tubs in layers with waxed paper in between each layer and kept in a cool place.

Lay the bars of soap on a piece of waxed paper or newspaper to allow for further drying.

16. Appendix I: Material Safety and Data Sheets

16.1 Methanol MSDS



Health	2
Fire	3
Reactivity	0
Personal Protection	H

Section 1: Chemical Product and Company Identification

Product Name: Methyl alcohol

Catalog Codes: SLM3064, SLM3952

CAS#: 67-56-1

RTECS: PC1400000

TSCA: TSCA 8(b) inventory: Methyl alcohol

CI#: Not applicable.

Synonym: Wood alcohol, Methanol; Methylol; Wood Spirit; Carbinol

Chemical Name: Methanol

Chemical Formula: CH3OH

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Methyl alcohol	67-56-1	100

Toxicological Data on Ingredients: Methyl alcohol: ORAL (LD50): Acute: 5628 mg/kg [Rat]. DERMAL (LD50): Acute: 15800 mg/kg [Rabbit]. VAPOR (LC50): Acute: 64000 ppm 4 hours [Rat].

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator). Severe over-exposure can result in death.

Potential Chronic Health Effects:
Slightly hazardous in case of skin contact (sensitizer). CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/or yeast. TERATOGENIC EFFECTS: Classified POSSIBLE for human. DEVELOPMENTAL TOXICITY: Not available. The substance is toxic to eyes. The substance may be toxic to blood, kidneys, liver, brain, peripheral nervous system, upper respiratory tract, skin, central nervous system (CNS), optic nerve. Repeated or prolonged exposure to the substance can produce target organs damage. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Get medical attention.

Skin Contact:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used.Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.

Ingestion:
If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Flammable.

Auto-Ignition Temperature: 464°C (867.2°F)

Flash Points: CLOSED CUP: 12°C (53.6°F). OPEN CUP: 16°C (60.8°F).

Flammable Limits: LOWER: 6% UPPER: 36.5%

Products of Combustion: These products are carbon oxides (CO, CO2).

Fire Hazards in Presence of Various Substances:
Highly flammable in presence of open flames and sparks, of heat. Non-flammable in presence of shocks.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Explosive in presence of open flames and sparks, of heat.

Fire Fighting Media and Instructions:
Flammable liquid, soluble or dispersed in water. SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use alcohol foam, water spray or fog.

Special Remarks on Fire Hazards:
Explosive in the form of vapor when exposed to heat or flame. Vapor may travel considerable distance to source of ignition and flash back. When heated to decomposition, it emits acrid smoke and irritating fumes. CAUTION: MAY BURN WITH NEAR INVISIBLE FLAME

Special Remarks on Explosion Hazards:
Forms an explosive mixture with air due to its low flash point. Explosive when mixed with Choroform + sodium methoxide and diethyl zinc. It boils violently and explodes.

Section 6: Accidental Release Measures

Small Spill:
Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container.

Large Spill:
Flammable liquid. Poisonous liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, metals, acids.

Storage:
Store in a segregated and approved area. Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:
Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
TWA: 200 from OSHA (PEL) [United States] TWA: 200 STEL: 250 (ppm) from ACGIH (TLV) [United States] [1999] STEL: 250 from NIOSH [United States] TWA: 200 STEL: 250 (ppm) from NIOSH SKIN TWA: 200 STEL: 250 (ppm) [Canada] Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid.

Odor: Alcohol like. Pungent when crude.

Taste: Not available.

Molecular Weight: 32.04 g/mole

Color: Colorless.

pH (1% soln/water): Not available.

Boiling Point: 64.5°C (148.1°F)

Melting Point: -97.8°C (-144°F)

Critical Temperature: 240°C (464°F)

Specific Gravity: 0.7915 (Water = 1)

Vapor Pressure: 12.3 kPa (@ 20°C)

Vapor Density: 1.11 (Air = 1)

Volatility: Not available.

Odor Threshold: 100 ppm

Water/Oil Dist. Coeff.: The product is more soluble in water; log(oil/water) = -0.8

Ionicity (in Water): Non-ionic.

Dispersion Properties: See solubility in water.

Solubility: Easily soluble in cold water, hot water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Heat, ingnition sources, incompatible materials

Incompatibility with various substances: Reactive with oxidizing agents, metals, acids.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Can react vigorously with oxidizers. Violent reaction with alkyl aluminum salts, acetyl bromide, chloroform + sodium methoxide, chromic anhydride, cyanuirc chlorite, lead perchlorate, phosphorous trioxide, nitric acid. Exothermic reaction with sodium hydroxide + chloroform. Incompatible with beryllium dihydride, metals (potassium and magnesium), oxidants (barium perchlorate, bromine, sodium hypochlorite, chlorine, hydrogen peroxide), potassium tert-butoxide, carbon tetrachloride, alkali metals, metals (aluminum, potassium magnesium, zinc), and dichlormethane. Rapid autocatalytic dissolution of aluminum, magnesium or zinc in 9:1 methanol + carbon tetrachloride - sufficiently vigorous to be rated as potentially hazardous. May attack some plastics, rubber, and coatings.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Eye contact. Inhalation. Ingestion.

Toxicity to Animals:
WARNING: THE LC50 VALUES HEREUNDER ARE ESTIMATED ON THE BASIS OF A 4-HOUR EXPOSURE. Acute oral toxicity (LD50): 5628 mg/kg [Rat]. Acute dermal toxicity (LD50): 15800 mg/kg [Rabbit]. Acute toxicity of the vapor (LC50): 64000 4 hours [Rat].

Chronic Effects on Humans:
MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/or yeast. TERATOGENIC EFFECTS: Classified POSSIBLE for human. Causes damage to the following organs: eyes. May cause damage to the following organs: blood, kidneys, liver, brain, peripheral nervous system, upper respiratory tract, skin, central nervous system (CNS), optic nerve.

Other Toxic Effects on Humans:
Hazardous in case of skin contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans:

Passes through the placental barrier. May affect genetic material. May cause birth defects and adverse reproductive effects(paternal and maternal effects and fetotoxicity) based on animal studies.

Special Remarks on other Toxic Effects on Humans:

Section 12: Ecological Information

Ecotoxicity: Ecotoxicity in water (LC50): 29400 mg/l 96 hours [Fathead Minnow].

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are less toxic than the product itself.

Special Remarks on the Products of Biodegradation:
Methanol in water is rapidly biodegraded and volatilized. Aquatic hydrolysis, oxidation, photolysis, adsorption to sediment, and bioconcentration are not significant fate processes. The half-life of methanol in surfact water ranges from 24 hrs. to 168 hrs. Based on its vapor pressure, methanol exists almost entirely in the vapor phase in the ambient atmosphere. It is degraded by reaction with photochemically produced hydroxyl radicals and has an estimated half-life of 17.8 days. Methanol is physically removed from air by rain due to its solubility. Methanol can react with NO2 in pollulted to form methyl nitrate. The half-life of methanol in air ranges from 71 hrs. (3 days) to 713 hrs. (29.7 days) based on photooxidation half-life in air.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: CLASS 3: Flammable liquid.

Identification: : Methyl alcohol UNNA: 1230 PG: II

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
Connecticut hazardous material survey.: Methyl alcohol Illinois toxic substances disclosure to employee act: Methyl alcohol Illinois chemical safety act: Methyl alcohol New York release reporting list: Methyl alcohol Rhode Island RTK hazardous substances: Methyl alcohol Pennsylvania RTK: Methyl alcohol Minnesota: Methyl alcohol Massachusetts RTK: Methyl alcohol Massachusetts spill list: Methyl alcohol New Jersey: Methyl alcohol New Jersey spill list: Methyl alcohol Louisiana spill reporting: Methyl alcohol California Directors List of Hazardous Substances (8CCR 339): Methyl alcohol Tennesse Hazardous Right to Know : Methyl alcohol TSCA 8(b) inventory: Methyl alcohol SARA 313 toxic chemical notification and release reporting: Methyl alcohol CERCLA: Hazardous substances.: Methyl alcohol: 5000 lbs. (2268 kg)

Other Regulations:
OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):
CLASS B-2: Flammable liquid with a flash point lower than 37.8°C (100°F). CLASS D-1B: Material causing immediate and serious toxic effects (TOXIC). CLASS D-2A: Material causing other toxic effects (VERY TOXIC). Class D-2B: Material causing other toxic effects (TOXIC).

DSCL (EEC):
R11- Highly flammable. R23/24/25- Toxic by inhalation, in contact with skin and if swallowed. R39- Danger of very serious irreversible effects. R39/23/24/25- Toxic: danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed. S7- Keep container tightly closed. S16- Keep away from sources of ignition - No smoking. S36/37- Wear suitable protective clothing and gloves. S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 3

Reactivity: 0

Personal Protection: h

National Fire Protection Association (U.S.A.):

Health: 1

Flammability: 3

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

References:
-SAX, N.I. Dangerous Properties of Indutrial Materials. Toronto, Van Nostrand Reinold, 6e ed. 1984. -Material safety data sheet emitted by: la Commission de la SantÃ© et de la SÃ©curitÃ© du Travail du QuÃ©bec. -Hawley, G.G.. The Condensed Chemical Dictionary, 11e ed., New York N.Y., Van Nostrand Reinold, 1987. LOLI, HSDB, RTECS, HAZARDTEXT, REPROTOX databases

Other Special Considerations: Not available.

Created: 10/10/2005 08:23 PM

Last Updated: 05/21/2013 12:00 PM

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16.2 KOH MSDS

1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	Potassium hydroxide		
Product Number	:	484016		
Brand	:	Sigma-Aldrich		
Product Use	:	For laboratory research purposes.		
Supplier	:	Sigma-Aldrich Canada Co. 2149 Winston Park Drive OAKVILLE ON L6H 6J8 CANADA	Manufacturer :	Sigma-Aldrich Corporation 3050 Spruce St. St. Louis, Missouri 63103 USA
Telephone	:	+1 9058299500		
Fax	:	+1 9058299292		
Emergency Phone # (For both supplier and manufacturer)	:	1-800-424-9300		
Preparation Information	:	Sigma-Aldrich Corporation Product Safety - Americas Region 1-800-521-8956		

2. HAZARDS IDENTIFICATION

Emergency Overview

WHMIS Classification

D1B	Toxic Material Causing Immediate and Serious Toxic Effects	Toxic by ingestion
E	Corrosive Material	Corrosive to metals Corrosive

GHS Classification

Corrosive to metals (Category 1)
Acute toxicity, Oral (Category 4)
Skin corrosion (Category 1A)
Serious eye damage (Category 1)
Acute aquatic toxicity (Category 3)

GHS Label elements, including precautionary statements

Pictogram

Signal word: Danger

Hazard statement(s)

H290	May be corrosive to metals.
H302	Harmful if swallowed.
H314	Causes severe skin burns and eye damage.
H402	Harmful to aquatic life.

Precautionary statement(s)

P280	Wear protective gloves/ protective clothing/ eye protection/ face protection.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P310	Immediately call a POISON CENTER or doctor/ physician.

HMIS Classification

Health hazard:	3
Flammability:	0
Physical hazards:	0

Potential Health Effects

Inhalation	May be harmful if inhaled. Material is extremely destructive to the tissue of the mucous membranes and upper respiratory tract.
Skin	May be harmful if absorbed through skin. Causes skin burns.
Eyes	Causes eye burns. Causes severe eye burns.
Ingestion	Toxic if swallowed.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Synonyms : Caustic potash

Formula : HKO
Molecular Weight : 56.11 g/mol

CAS-No.	EC-No.	Index-No.	Concentration
Potassium hydroxide			
1310-58-3	215-181-3	019-002-00-8	<=100%

4. FIRST AID MEASURES

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Take off contaminated clothing and shoes immediately. Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.Continue rinsing eyes during transport to hospital.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

5. FIREFIGHTING MEASURES

Conditions of flammability
Not flammable or combustible.

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Special protective equipment for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

Hazardous combustion products
Hazardous decomposition products formed under fire conditions. - Potassium oxides

Explosion data - sensitivity to mechanical impact
no data available

Explosion data - sensitivity to static discharge
no data available

Further information
Gives off hydrogen by reaction with metals.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Wear respiratory protection. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust.

Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

Methods and materials for containment and cleaning up
Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

7. HANDLING AND STORAGE

Precautions for safe handling
Avoid contact with skin and eyes. Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed.

Conditions for safe storage
Keep container tightly closed in a dry and well-ventilated place.
Absorbs carbon dioxide (CO2) from air.

Air sensitive. strongly hygroscopic

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value	Control parameters	Basis
Potassium hydroxide	1310-58-3	C	2 mg/m3	Canada. British Columbia OEL
		(c)	2 mg/m3	Canada. Alberta, Occupational Health and Safety Code (table 2: OEL)
Remarks	Occupational exposure limit is based on irritation effects and its adjustment to compensate for unusual work schedules is not required			
		C	2 mg/m3	Québec. Regulation respecting occupational health and safety, Schedule 1, Part 1: Permissible exposure values for airborne contaminants
	A substance which may not be recirculated in accordance with section 108			
		C	2 mg/m3	USA. ACGIH Threshold Limit Values (TLV)

Personal protective equipment

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face particle respirator type N100 (US) or type P3 (EN 143) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Hand protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Eye protection
Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin and body protection
Complete suit protecting against chemicals, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Hygiene measures
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Specific engineering controls
Use mechanical exhaust or laboratory fumehood to avoid exposure.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form	flakes
Colour	no data available

Safety data

pH	13.5
Melting point/freezing point	Melting point/range: 361 °C (682 °F) - lit.
Boiling point	1,320 °C (2,408 °F)
Flash point	no data available
Ignition temperature	no data available
Auto-ignition temperature	no data available
Lower explosion limit	no data available
Upper explosion limit	no data available
Vapour pressure	1 hPa (1 mmHg) at 719 °C (1,326 °F) 1 hPa (1 mmHg) at 714 °C (1,317 °F)
Density	2.044 g/cm3
Water solubility	soluble
Partition coefficient: n-octanol/water	no data available
Relative vapour density	no data available
Odour	no data available
Odour Threshold	no data available
Evapouration rate	no data available

10. STABILITY AND REACTIVITY

Chemical stability
Heat of solution is very high, and with limited amounts of water, violent boiling may occur Stable under recommended storage conditions.

Possibility of hazardous reactions
no data available

Conditions to avoid
Do not heat above melting point.

Materials to avoid
Nitro compounds, Organic materials, Magnesium, Copper, Water, reacts violently with:, Metals, Light metals, Contact with aluminum, tin and zinc liberates hydrogen gas. Contact with nitromethane and other similar nitro compounds causes formation of shock-sensitive salts., vigorous reaction with:, Alkali metals, Halogens, Azides, Anhydrides

Hazardous decomposition products
Other decomposition products - no data available
Hazardous decomposition products formed under fire conditions. - Potassium oxides

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Oral LD50
LD50 Oral - rat - 333 mg/kg

Inhalation LC50
no data available

Dermal LD50
no data available

Other information on acute toxicity
no data available

Skin corrosion/irritation
Skin - rabbit - Severe skin irritation - 24 h

Serious eye damage/eye irritation
Eyes - rabbit - Corrosive to eyes - OECD Test Guideline 405

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

IARC:	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
ACGIH:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

Reproductive toxicity

no data available

Teratogenicity

no data available

Specific target organ toxicity - single exposure (Globally Harmonized System)
no data available

Specific target organ toxicity - repeated exposure (Globally Harmonized System)
no data available

Aspiration hazard
no data available

Potential health effects

Inhalation	May be harmful if inhaled. Material is extremely destructive to the tissue of the mucous membranes and upper respiratory tract.
Ingestion	Toxic if swallowed.
Skin	May be harmful if absorbed through skin. Causes skin burns.
Eyes	Causes eye burns. Causes severe eye burns.

Synergistic effects
no data available

Additional Information
RTECS: TT2100000

12. ECOLOGICAL INFORMATION

Toxicity

Toxicity to fish	LC50 - Gambusia affinis (Mosquito fish) - 80 mg/l - 96 h

Persistence and degradability
The methods for determining the biological degradability are not applicable to inorganic substances.

Bioaccumulative potential
no data available

Mobility in soil
no data available

PBT and vPvB assessment
no data available

Other adverse effects

An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.

Harmful to aquatic life.

no data available

13. DISPOSAL CONSIDERATIONS

Product
Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN number: 1813 Class: 8 Packing group: II
Proper shipping name: Potassium hydroxide, solid
Reportable Quantity (RQ): 1000 lbs
Marine pollutant: No
Poison Inhalation Hazard: No

IMDG
UN number: 1813 Class: 8 Packing group: II EMS-No: F-A, S-B
Proper shipping name: POTASSIUM HYDROXIDE, SOLID
Marine pollutant: No

IATA
UN number: 1813 Class: 8 Packing group: II
Proper shipping name: Potassium hydroxide, solid

15. REGULATORY INFORMATION

WHMIS Classification

D1B	Toxic Material Causing Immediate and Serious Toxic Effects	Toxic by ingestion
E	Corrosive Material	Corrosive to metals Corrosive

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all the information required by the Controlled Products Regulations.

16. OTHER INFORMATION

Text of H-code(s) and R-phrase(s) mentioned in Section 3

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

16.3 NaOH Flakes MSDS

1. PRODUCT AND COMPANY IDENTIFICATION

Product name : Sodium hydroxide

Product Number : 484024
Brand : Sigma-Aldrich
Product Use : For laboratory research purposes.

Supplier : Sigma-Aldrich Canada Co.
2149 Winston Park Drive
OAKVILLE ON L6H 6J8
CANADA

Manufacturer : Sigma-Aldrich Corporation
3050 Spruce St.
St. Louis, Missouri 63103
USA

Telephone : +1 9058299500
Fax : +1 9058299292
Emergency Phone # (For both supplier and manufacturer) : 1-800-424-9300
Preparation Information : Sigma-Aldrich Corporation
Product Safety - Americas Region
1-800-521-8956

2. HAZARDS IDENTIFICATION

Emergency Overview

WHMIS Classification

E	Corrosive Material	Corrosive to metals Corrosive

GHS Classification
Skin corrosion (Category 1)
Serious eye damage (Category 1)
Acute aquatic toxicity (Category 3)

GHS Label elements, including precautionary statements

Pictogram

Signal word Danger

Hazard statement(s)	
H314	Causes severe skin burns and eye damage.
H402	Harmful to aquatic life.

Precautionary statement(s)	
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P310	Immediately call a POISON CENTER or doctor/ physician.

HMIS Classification

Health hazard:	3
Flammability:	0
Physical hazards:	1

Potential Health Effects

Inhalation May be harmful if inhaled. Material is extremely destructive to the tissue of the mucous

	membranes and upper respiratory tract.
Skin	May be harmful if absorbed through skin. Causes skin burns.
Eyes	Causes eye burns. Causes severe eye burns.
Ingestion	May be harmful if swallowed.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Synonyms : 'Caustic soda'

Formula : HNaO
Molecular Weight : 40.00 g/mol

CAS-No.	EC-No.	Index-No.	Concentration
Sodium hydroxide			
1310-73-2	215-185-5	011-002-00-6	-

4. FIRST AID MEASURES

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Take off contaminated clothing and shoes immediately. Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.Continue rinsing eyes during transport to hospital.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

5. FIREFIGHTING MEASURES

Conditions of flammability
Not flammable or combustible.

Suitable extinguishing media
Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

Special protective equipment for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

Hazardous combustion products
Hazardous decomposition products formed under fire conditions. - Sodium oxides

Explosion data - sensitivity to mechanical impact
no data available

Explosion data - sensitivity to static discharge
no data available

Further information
The product itself does not burn.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Use personal protective equipment. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust.

Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

Methods and materials for containment and cleaning up
Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

7. HANDLING AND STORAGE

Precautions for safe handling
Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed.

Conditions for safe storage
Keep container tightly closed in a dry and well-ventilated place.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value	Control parameters	Basis
Sodium hydroxide	1310-73-2	C	2 mg/m3	Canada. British Columbia OEL
		(c)	2 mg/m3	Canada. Alberta, Occupational Health and Safety Code (table 2: OEL)
Remarks	Occupational exposure limit is based on irritation effects and its adjustment to compensate for unusual work schedules is not required			
		C	2 mg/m3	Québec. Regulation respecting occupational health and safety, Schedule 1, Part 1: Permissible exposure values for airborne contaminants
	A substance which may not be recirculated in accordance with section 108			
		CEIL	2 mg/m3	USA. ACGIH Threshold Limit Values (TLV)

Personal protective equipment

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face particle respirator type N100 (US) or type P3 (EN 143) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Hand protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Eye protection
Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin and body protection
Complete suit protecting against chemicals, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Hygiene measures
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Specific engineering controls
Use mechanical exhaust or laboratory fumehood to avoid exposure.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form	flakes
Colour	white

Safety data

pH	13.0 - 14
Melting point/freezing point	Melting point/range: 318 °C (604 °F)
Boiling point	1,390 °C (2,534 °F)
Flash point	not applicable
Ignition temperature	no data available
Auto-ignition temperature	no data available
Lower explosion limit	no data available
Upper explosion limit	no data available
Vapour pressure	< 24.00 hPa (< 18.00 mmHg) at 20 °C (68 °F) 4.00 hPa (3.00 mmHg) at 37 °C (99 °F)
Density	2.1300 g/cm3
Water solubility	no data available
Partition coefficient: n-octanol/water	no data available
Relative vapour density	1.38 - (Air = 1.0)
Odour	no data available
Odour Threshold	no data available
Evapouration rate	no data available

10. STABILITY AND REACTIVITY

Chemical stability
Stable under recommended storage conditions.

Possibility of hazardous reactions
no data available

Conditions to avoid
no data available

Materials to avoid
Strong oxidizing agents, Strong acids, Organic materials

Hazardous decomposition products
Hazardous decomposition products formed under fire conditions. - Sodium oxides
Other decomposition products - no data available

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11. TOXICOLOGICAL INFORMATION

Acute toxicity

Oral LD50
no data available

Inhalation LC50
no data available

Dermal LD50
no data available

Other information on acute toxicity
no data available

Skin corrosion/irritation
Skin - rabbit - Causes severe burns. - 24 h

Serious eye damage/eye irritation
Eyes - rabbit - Corrosive - 24 h

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

IARC:	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
ACGIH:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

Reproductive toxicity

no data available

Teratogenicity

no data available

Specific target organ toxicity - single exposure (Globally Harmonized System)
no data available

Specific target organ toxicity - repeated exposure (Globally Harmonized System)
no data available

Aspiration hazard
no data available

Potential health effects

Inhalation	May be harmful if inhaled. Material is extremely destructive to the tissue of the mucous membranes and upper respiratory tract.
Ingestion	May be harmful if swallowed.
Skin	May be harmful if absorbed through skin. Causes skin burns.
Eyes	Causes eye burns. Causes severe eye burns.

Signs and Symptoms of Exposure
spasm, inflammation and edema of the larynx, spasm, inflammation and edema of the bronchi, pneumonitis, pulmonary edema, burning sensation, Cough, wheezing, laryngitis, Shortness of breath, Headache, Nausea, Vomiting, Material is extremely destructive to tissue of the mucous membranes and upper respiratory tract, eyes, and skin.

Synergistic effects
no data available

Additional Information
RTECS: WB4900000

12. ECOLOGICAL INFORMATION

Toxicity

Toxicity to fish	LC50 - Gambusia affinis (Mosquito fish) - 125 mg/l - 96 h
Toxicity to daphnia and other aquatic invertebrates	Immobilization EC50 - Daphnia - 40.38 mg/l - 48 h

Persistence and degradability
no data available

Bioaccumulative potential
no data available

Mobility in soil
no data available

PBT and vPvB assessment
no data available

Other adverse effects

An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.

Harmful to aquatic life.

13. DISPOSAL CONSIDERATIONS

Product
Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN number: 1823 Class: 8 Packing group: II
Proper shipping name: Sodium hydroxide, solid
Reportable Quantity (RQ): 1000 lbs
Marine pollutant: No
Poison Inhalation Hazard: No

IMDG
UN number: 1823 Class: 8 Packing group: II EMS-No: F-A, S-B
Proper shipping name: SODIUM HYDROXIDE, SOLID
Marine pollutant: No

IATA
UN number: 1823 Class: 8 Packing group: II
Proper shipping name: Sodium hydroxide, solid

15. REGULATORY INFORMATION

WHMIS Classification

E	Corrosive Material	Corrosive to metals Corrosive

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all the information required by the Controlled Products Regulations.

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16. OTHER INFORMATION

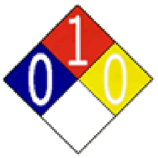
Text of H-code(s) and R-phrase(s) mentioned in Section 3

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

16.4 Biodiesel MSDS

SAMPLE MATERIAL SAFETY DATA SHEET



1. CHEMICAL PRODUCT

General Product Name:	**Biodiesel (B100)**
Synonyms:	Methyl Soyate, Rapeseed Methyl Ester (RME)
Product Description:	Methyl esters from lipid sources
CAS Number:	Methyl Soyate: 67784-80-9; RME: 73891-99-3;

2. COMPOSITION/INFORMATION ON INGREDIENTS

This product contains no hazardous materials.

3. HAZARDS IDENTIFICATION

Potential Health Effects:

INHALATION:

Negligible unless heated to produce vapors. Vapors or finely misted materials may irritate the mucous membranes and cause irritation, dizziness, and nausea. Remove to fresh air.

EYE CONTACT:

May cause irritation. Irrigate eye with water for at least 15 to 20 minutes. Seek medical attention if symptoms persist.

SKIN CONTACT:

Prolonged or repeated contact is not likely to cause significant skin irritation. Material is sometimes encountered at elevated temperatures. Thermal burns are possible.

INGESTION:

No hazards anticipated from ingestion incidental to industrial exposure.

4. FIRST AID MEASURES

EYES:

Irrigate eyes with a heavy stream of water for at least 15 to 20 minutes.

SKIN:

Wash exposed areas of the body with soap and water.

INHALATION:

Remove from area of exposure; seek medical attention if symptoms persist.

INGESTION:

Give one or two glasses of water to drink. If gastro-intestinal symptoms develop, consult medical personnel. (Never give anything by mouth to an unconscious person.)

5. FIRE FIGHTING MEASURES

Flash Point (Method Used): 130.0 C or 266.0 F min (ASTM 93)

Flammability Limits: None known

EXTINGUISHING MEDIA:

Dry chemical, foam, halon (may not be permissible in some countries), CO_2, 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.

UNUSUAL FIRE AND EXPLOSION HAZARDS:

Biodiesel 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 or spill absorbents in approved safety containers and dispose of properly. Oil soaked rags may be washed with soap and water and allowed to dry in well ventilated area. Firefighters should use self-contained breathing apparatus to avoid exposure to smoke and vapor.

6. ACCIDENTAL RELEASE MEASURES SPILL CLEAN-UP PROCEDURES

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 (see unusual fire and explosion hazards above).

Recover large spills for salvage or disposal. Wash hard surfaces with safety solvent or detergent to remove remaining oil film. Greasy nature will result in a slippery surface.

7. 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 or use near heat, spark, or flame, store out of sun.
Do not puncture, drag, or slide this container.
Drum is not a pressure vessel; never use pressure to empty.

8. EXPOSURE CONTROL /PERSONAL PROTECTION

RESPIRATORY PROTECTION:

If vapors or mists are generated, wear a NIOSH approved organic vapor/mist respirator.

PROTECTIVE CLOTHING:

Safety glasses, goggles, or face shield recommended to protect eyes from mists or splashing. PVC coated gloves recommended to prevent skin contact.

OTHER PROTECTIVE MEASURES:

Employees must practice good personal hygiene, washing exposed areas of skin several times daily and laundering contaminated clothing before re-use.

9. PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point, 760 mm Hg:>200°C
Specific Gravity (H_2O=1): 0.88
Vapor Pressure, mm Hg: <2
Vapor Density, Air=1:>1
Appearance and Odor: pale yellow liquid, mild odor
Volatiles, % by Volume: <2
Solubility in H_2O, % by Volume: insoluble
Evaporation Rate, Butyl Acetate=1: <1

10. STABILITY AND REACTIVITY

GENERAL:

This product is stable and hazardous polymerization will not occur.

INCOMPATIBLE MATERIALS AND CONDITIONS TO AVOID:

Strong oxidizing agents

HAZARDOUS DECOMPOSITION PRODUCTS:

Combustion produces carbon monoxide, carbon dioxide along with thick smoke.

11. DISPOSAL CONSIDERATIONS

WASTE DISPOSAL:

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 regulations.

12. TRANSPORT INFORMATION

UN HAZARD CLASS: N/A

NMFC (National Motor Freight Classification):
PROPER SHIPPING NAME: Fatty acid ester
IDENTIFICATION NUMBER: 144920
SHIPPING CLASSIFICATION: 65

13. REGULATORY INFORMATION:

OSHA STATUS:

This product is not hazardous under the criteria of the Federal OSHA Hazard Communication Standard 29 CFR 1910.1200. However, thermal processing and decomposition fumes from this product may be hazardous as noted in Sections 2 and 3.

TSCA STATUS:

This product is listed on TSCA.

CERCLA (Comprehensive Response Compensation and Liability Act):

NOT reportable.

SARA TITLE III (Superfund Amendments and Reauthorization Act):

Section 312 Extremely Hazardous Substances:
None
Section 311/312 Hazard Categories:
Non-hazardous under Section 311/312
Section 313 Toxic Chemicals:
None

RCRA STATUS:

If discarded in its purchased form, this product would not be a hazardous waste either by listing or by characteristic. However, under RCRA, it is the responsibility of the product user to determine at the time of disposal, whether a material containing the product or derived from the product should be classified as a hazardous waste,
(40 CFR 261.20-24)

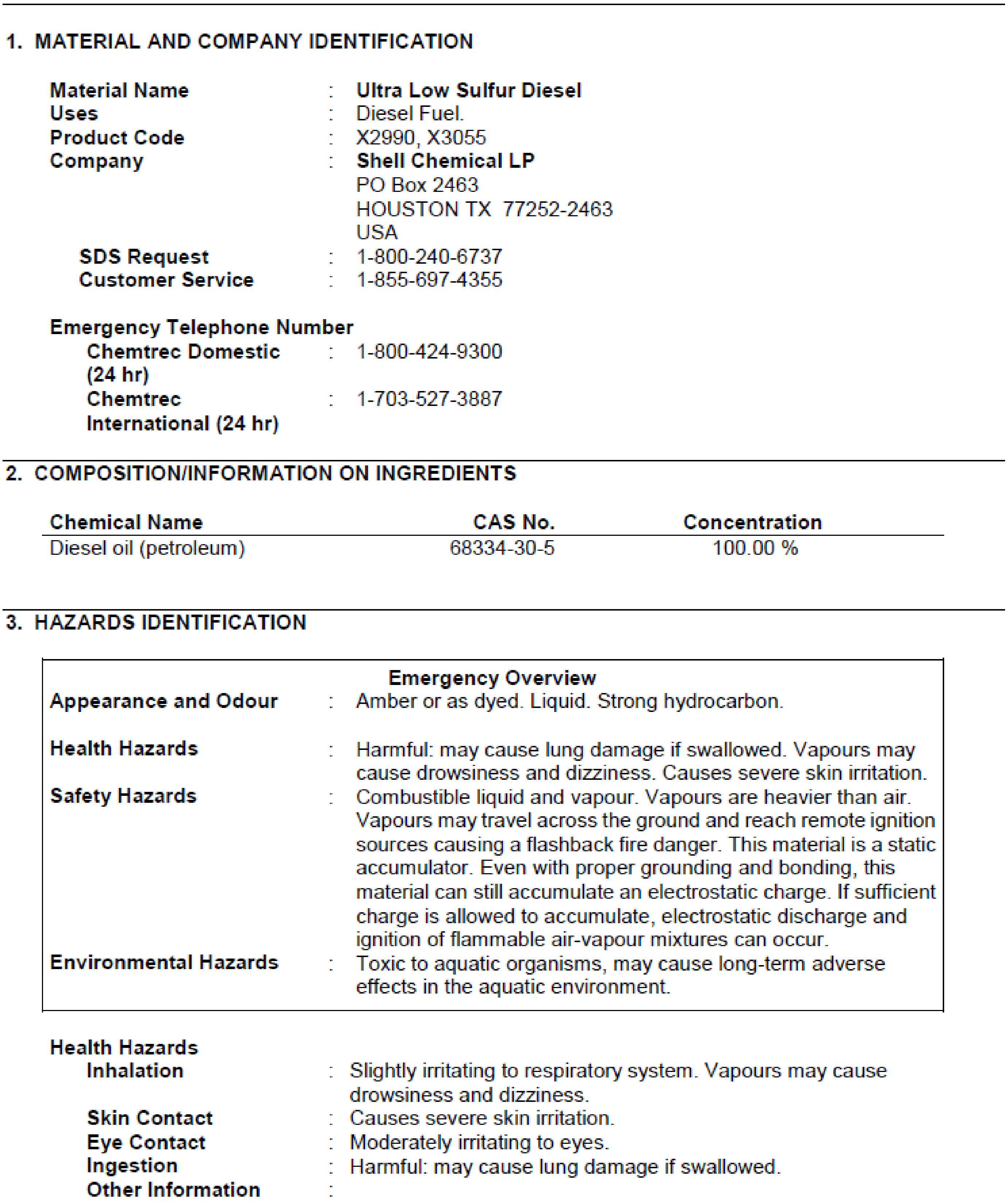
CALIFORNIA PROPOSITION 65:

The following statement is made in order to comply with the California Safe Drinking Water and Toxic Enforcement Act of 1986. This product contains no chemicals known to the state of California to cause cancer.

14. OTHER INFORMATION:

This information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any other process. Such information is to the best of the company's knowledge and believed accurate and reliable as of the date indicated. However, no representation, warranty or guarantee of any kind, express or implied, is made as to its accuracy, reliability or completeness and we assume no responsibility for any loss, damage or expense, direct or consequential, arising out of use. It is the user's responsibility to satisfy himself as to the suitableness and completeness of such information for his own particular use.

16.5 Diesel MSDS



1. MATERIAL AND COMPANY IDENTIFICATION

Material Name : **Ultra Low Sulfur Diesel**
Uses : Diesel Fuel.
Product Code : X2990, X3055
Company : **Shell Chemical LP**
PO Box 2463
HOUSTON TX 77252-2463
USA
SDS Request : 1-800-240-6737
Customer Service : 1-855-697-4355

Emergency Telephone Number
Chemtrec Domestic (24 hr) : 1-800-424-9300
Chemtrec International (24 hr) : 1-703-527-3887

2. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Name	CAS No.	Concentration
Diesel oil (petroleum)	68334-30-5	100.00 %

3. HAZARDS IDENTIFICATION

Emergency Overview
Appearance and Odour : Amber or as dyed. Liquid. Strong hydrocarbon.

Health Hazards : Harmful: may cause lung damage if swallowed. Vapours may cause drowsiness and dizziness. Causes severe skin irritation.
Safety Hazards : Combustible liquid and vapour. Vapours are heavier than air. Vapours may travel across the ground and reach remote ignition sources causing a flashback fire danger. This material is a static accumulator. Even with proper grounding and bonding, this material can still accumulate an electrostatic charge. If sufficient charge is allowed to accumulate, electrostatic discharge and ignition of flammable air-vapour mixtures can occur.
Environmental Hazards : Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Health Hazards
Inhalation : Slightly irritating to respiratory system. Vapours may cause drowsiness and dizziness.
Skin Contact : Causes severe skin irritation.
Eye Contact : Moderately irritating to eyes.
Ingestion : Harmful: may cause lung damage if swallowed.
Other Information :

Diesel exhaust from engines has been associated with cancer.

Signs and Symptoms : Skin irritation signs and symptoms may include a burning sensation, redness, swelling, and/or blisters. Breathing of high vapour concentrations may cause central nervous system (CNS) depression resulting in dizziness, light-headedness, headache, nausea and loss of coordination. Continued inhalation may result in unconsciousness and death. If material enters lungs, signs and symptoms may include coughing, choking, wheezing, difficulty in breathing, chest congestion, shortness of breath, and/or fever. The onset of respiratory symptoms may be delayed for several hours after exposure.

Aggravated Medical Condition : Pre-existing medical conditions of the following organ(s) or organ system(s) may be aggravated by exposure to this material: Skin.

Environmental Hazards : Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

4. FIRST AID MEASURES

Inhalation : Remove to fresh air. If rapid recovery does not occur, transport to nearest medical facility for additional treatment.

Skin Contact : Remove contaminated clothing. Immediately flush skin with large amounts of water for at least 15 minutes, and follow by washing with soap and water if available. If redness, swelling, pain and/or blisters occur, transport to the nearest medical facility for additional treatment.

Eye Contact : Flush eye with copious quantities of water. If persistent irritation occurs, obtain medical attention.

Ingestion : If swallowed, do not induce vomiting: transport to nearest medical facility for additional treatment. If vomiting occurs spontaneously, keep head below hips to prevent aspiration. If any of the following delayed signs and symptoms appear within the next 6 hours, transport to the nearest medical facility: fever greater than 101° F (38.3° C), shortness of breath, chest congestion or continued coughing or wheezing. Give nothing by mouth.

Advice to Physician : Potential for chemical pneumonitis. Call a doctor or poison control center for guidance.

5. FIRE FIGHTING MEASURES

Clear fire area of all non-emergency personnel.

Flash point : 52 °C / 125 °F (Pensky-Martens Closed Cup)

Specific Hazards : Carbon monoxide may be evolved if incomplete combustion occurs. Will float and can be reignited on surface water. The vapour is heavier than air, spreads along the ground and distant ignition is possible.

Extinguishing Media : Foam, water spray or fog. Dry chemical powder, carbon dioxide, sand or earth may be used for small fires only.

Unsuitable Extinguishing Media : Do not use water in a jet.

Protective Equipment for Firefighters : Wear full protective clothing and self-contained breathing apparatus.

Additional Advice : Keep adjacent containers cool by spraying with water.

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6. ACCIDENTAL RELEASE MEASURES

Observe all relevant local and international regulations.

Protective measures : Avoid contact with spilled or released material. Immediately remove all contaminated clothing. For guidance on selection of personal protective equipment see Chapter 8 of this Material Safety Data Sheet. For guidance on disposal of spilled material see Chapter 13 of this Material Safety Data Sheet. Be ready for fire or possible exposure. Stay upwind and keep out of low areas. Shut off leaks, if possible without personal risks. Remove all possible sources of ignition in the surrounding area. Use appropriate containment (of product and fire fighting water) to avoid environmental contamination. Prevent from spreading or entering drains, ditches or rivers by using sand, earth, or other appropriate barriers. Attempt to disperse the vapour or to direct its flow to a safe location for example by using fog sprays. Take precautionary measures against static discharge. Ensure electrical continuity by bonding and grounding (earthing) all equipment.

Clean Up Methods : For small liquid spills (< 1 drum), transfer by mechanical means to a labelled, sealable container for product recovery or safe disposal. Allow residues to evaporate or soak up with an appropriate absorbent material and dispose of safely. Remove contaminated soil and dispose of safely.
For large liquid spills (> 1 drum), transfer by mechanical means such as vacuum truck to a salvage tank for recovery or safe disposal. Do not flush away residues with water. Retain as contaminated waste. Allow residues to evaporate or soak up with an appropriate absorbent material and dispose of safely. Remove contaminated soil and dispose of safely.

Additional Advice : Risk of explosion. Inform the emergency services if liquid enters surface water drains. Vapour may form an explosive mixture with air. Notify authorities if any exposure to the general public or the environment occurs or is likely to occur. Under Section 311 of the Clean Water Act (CWA) this material is considered an oil. As such, spills into surface waters must be reported to the National Response Center at (800) 424-8802. This material is covered by EPA's Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Petroleum Exclusion. Therefore, releases to the environment may not be reportable under CERCLA.

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7. HANDLING AND STORAGE

General Precautions : Avoid breathing vapours or contact with material. Only use in well ventilated areas. Wash thoroughly after handling. On guidance on selection of personal protective equipment see Chapter 8 of this Material Safety Data Sheet.

Handling : Avoid inhaling vapour and/or mists. Avoid contact with skin, eyes and clothing. Extinguish any naked flames. Do not smoke. Remove ignition sources. Avoid sparks. Even with proper grounding and bonding, this material can still accumulate an electrostatic charge. If sufficient charge is allowed to accumulate, electrostatic discharge and ignition of flammable air-vapour mixtures can occur. Be aware of handling operations that may give rise to additional hazards that result from the accumulation of static charges. These include but are not limited to pumping (especially turbulent flow), mixing, filtering, splash filling, cleaning and filling of tanks and containers, sampling, switch loading, gauging, vacuum truck operations, and mechanical movements. These activities may lead to static discharge e.g. spark formation. Restrict line velocity during pumping in order to avoid generation of electrostatic discharge (<= 1 m/s until fill pipe submerged to twice its diameter, then <= 7 m/s). Avoid splash filling. Do NOT use compressed air for filling, discharging, or handling operations. Handling Temperature: Ambient.

Storage : Ambient. Keep away from aerosols, flammables, oxidizing agents, corrosives and from other flammable products which are not harmful or toxic to man or to the environment. Keep container tightly closed. Must be stored in a diked (bunded) well-ventilated area, away from sunlight, ignition sources and other sources of heat. Storage Temperature: Electrostatic charges will be generated during pumping. Electrostatic discharge may cause fire. Ensure electrical continuity by bonding and grounding (earthing) all equipment to reduce the risk. The vapours in the head space of the storage vessel may lie in the flammable/explosive range and hence may be flammable.

Product Transfer : Refer to guidance under Handling section.

Container Advice : Containers, even those that have been emptied, can contain explosive vapours. Do not cut, drill, grind, weld or perform similar operations on or near containers.

Additional Information : Ensure that all local regulations regarding handling and storage facilities are followed.

See additional references that provide safe handling practices for liquids that are determined to be static accumulators: American Petroleum Institute 2003 (Protection Against Ignitions Arising out of Static, Lightning and Stray Currents) or National Fire Protection Agency 77 (Recommended Practices on Static Electricity). CENELEC CLC/TR 50404 (Electrostatics – Code of practice for the avoidance of hazards due to static electricity).

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational Exposure Limits

Material	Source	Type	ppm	mg/m3	Notation
Diesel oil (petroleum)	ACGIH	SKIN_DES			Can be absorbed through the skin.
	as total hydrocarbons				
	Inhalable fraction and vapor.				
	ACGIH	TWA		100 mg/m3	
	as total hydrocarbons				
	Inhalable fraction and vapor.				

Biological Exposure Index (BEI)

Biological Limit Values (BLV) have not been established for this material.

Additional Information : Skin notation means that significant exposure can also occur by absorption of liquid through the skin and of vapour through the eyes or mucous membranes.

Exposure Controls : The level of protection and types of controls necessary will vary depending upon potential exposure conditions. Select controls based on a risk assessment of local circumstances. Appropriate measures include: Adequate explosion-proof ventilation to control airborne concentrations below the exposure guidelines/limits. Eye washes and showers for emergency use.

Personal Protective Equipment : Personal protective equipment (PPE) should meet recommended national standards. Check with PPE suppliers.

Respiratory Protection : If engineering controls do not maintain airborne concentrations to a level which is adequate to protect worker health, select respiratory protection equipment suitable for the specific conditions of use and meeting relevant legislation. Check with respiratory protective equipment suppliers. Where air-filtering respirators are unsuitable (e.g., airborne concentrations are high, risk of oxygen deficiency, confined space) use appropriate positive pressure breathing apparatus. Where respiratory protective equipment is required, use a full-face mask. If air-filtering respirators are suitable for conditions of use: Select a filter suitable for combined particulate/organic gases and vapours [boiling point >65 °C (149 °F)].

Hand Protection : Where hand contact with the product may occur the use of gloves approved to relevant standards (e.g. Europe: EN374, US: F739, AS/NZS:2161) made from the following materials may provide suitable chemical protection: Longer term protection - Viton. Incidental contact/Splash protection - Nitrile rubber. Suitability and durability of a glove is dependent on usage, e.g. frequency and duration of contact, chemical resistance of glove material, glove thickness, dexterity. Always seek advice from glove suppliers. Contaminated gloves should be replaced.
Personal hygiene is a key element of effective hand care.

Gloves must only be worn on clean hands. After using gloves, hands should be washed and dried thoroughly. Application of a non-perfumed moisturizer is recommended.

Eye Protection : Chemical splash goggles (chemical monogoggles).

Protective Clothing : Where risk of splashing or in spillage clean up, use chemical resistant one-piece overall with integral hood and chemical resistant gloves. Otherwise use chemical resistant apron and gauntlets. Wear antistatic and flame retardant clothing.

Monitoring Methods : Monitoring of the concentration of substances in the breathing zone of workers or in the general workplace may be required to confirm compliance with an OEL and adequacy of exposure controls. For some substances biological monitoring may also be appropriate. Examples of sources of recommended exposure measurement methods are given below or contact the supplier. Further national methods may be available. National Institute of Occupational Safety and Health (NIOSH), USA: Manual of Analytical Methods http://www.cdc.gov/niosh/ Occupational Safety and Health Administration (OSHA), USA: Sampling and Analytical Methods http://www.osha.gov/ Health and Safety Executive (HSE), UK: Methods for the Determination of Hazardous Substances, http://www.hse.gov.uk/ Institut für Arbeitsschutz Deutschen Gesetzlichen Unfallversicherung (IFA), Germany. http://www.dguv.de/inhalt/index.jsp L'Institut National de Recherche et de Securité, (INRS), France http://www.inrs.fr/accueil

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9. PHYSICAL AND CHEMICAL PROPERTIES

The physical and chemical property data are typical values and do not constitute a specification.

Appearance	Amber or as dyed. Liquid.
Odour	Strong hydrocarbon.
Boiling point	282 °C / 540 °F
Flash point	52 °C / 125 °F (Pensky-Martens Closed Cup)
Specific gravity	0.8762
Water solubility	0.05 g/l Negligible.
Vapour density (air=1)	> 1
Electrical conductivity	Low conductivity: < 100 pS/m, The conductivity of this material makes it a static accumulator., A liquid is typically considered nonconductive if its conductivity is below 100 pS/m and is considered semi-conductive if its conductivity is below 10 000 pS/m., Whether a liquid is nonconductive or semi-conductive, the precautions are the same., A number of factors, for example liquid temperature, presence of contaminants, and anti-static additives can greatly influence the conductivity of a liquid.
Viscosity	2 cst at 40 °C / 104 °F

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10. STABILITY AND REACTIVITY

Stability : Stable under normal conditions of use.

Conditions to Avoid : Heat, flames, and sparks.

11. TOXICOLOGICAL INFORMATION

Basis for Assessment : Information given is based on product testing.

Acute Oral Toxicity : Low toxicity: LD50 >2000 mg/kg , Rat
Aspiration into the lungs when swallowed or vomited may cause chemical pneumonitis which can be fatal.

Acute Dermal Toxicity : Low toxicity: LD50 >2000 mg/kg , Rabbit

Acute Inhalation Toxicity : High concentrations may cause central nervous system depression resulting in headaches, dizziness and nausea; continued inhalation may result in unconsciousness and/or death.

Skin corrosion/irritation : Causes severe skin irritation.

Serious eye damage/irritation : Moderately irritating to eyes (but insufficient to classify).

Respiratory Irritation : Inhalation of vapours or mists may cause irritation to the respiratory system.

Sensitisation : Not a skin sensitiser.

Germ cell mutagenicity : Not considered a mutagenic hazard.

Carcinogenicity : Limited evidence of carcinogenic effect. (Diesel Fuel)
Repeated skin contact may result in irritation and skin cancer.
Causes cancer in laboratory animals. (Diesel Engine Exhaust)

Material	:	**Carcinogenicity Classification**
Diesel oil (petroleum)	:	ACGIH Group A3: Confirmed animal carcinogen with unknown relevance to humans.
Diesel oil (petroleum)	:	GHS / CLP: Carcinogenicity Category 2
Diesel Engine Exhaust	:	NTP: Reasonably Anticipated to be a Human Carcinogen.
Diesel Engine Exhaust	:	IARC 2A: Probably carcinogenic to humans.
Diesel Engine Exhaust	:	GHS / CLP: No carcinogenicity classification

12. ECOLOGICAL INFORMATION

Acute Toxicity

- **Fish** : Expected to be harmful: LL/EL/IL50 10-100 mg/l
- **Aquatic crustacea** : Expected to be harmful: LL/EL/IL50 1-10 mg/l
- **Algae/aquatic plants** : Expected to be harmful: LL/EL/IL50 10-100 mg/l

Mobility : If product enters soil, one or more constituents will be highly mobile and may contaminate groundwater. Floats on water.

Persistence/degradability : Oxidises rapidly by photo-chemical reactions in air. Expected to be inherently biodegradable.

Bioaccumulation : Contains components with the potential to bioaccumulate.

13. DISPOSAL CONSIDERATIONS

Material Disposal	:	Recover or recycle if possible. It is the responsibility of the waste generator to determine the toxicity and physical properties of the material generated to determine the proper waste classification and disposal methods in compliance with applicable regulations. Do not dispose into the environment, in drains or in water courses. Waste product should not be allowed to contaminate soil or water.
Local Legislation	:	Disposal should be in accordance with applicable regional, national, and local laws and regulations. Local regulations may be more stringent than regional or national requirements and must be in compliance.

14. TRANSPORT INFORMATION

US Department of Transportation Classification (49CFR)

Identification number	NA 1993
UN proper shipping name	Diesel fuel
Class / Division	Combustible liquid
Packing group	III
Contains	OIL
Emergency Response Guide No. .	128
Additional Information	This material is not regulated under 49 CFR if in a container of 119 gallon capacity or less. This material is an 'OIL' under 49 CFR Part 130 when transported in a container of 3500 gallon capacity or greater. Reclassified as combustible liquid for land transportation within the US per 49CFR 173.120(b)(2).

IMDG

Identification number	UN 1202
UN proper shipping name	DIESEL FUEL
Class / Division	3
Packing group	III
Marine Pollutant:	Yes

IATA (Country variations may apply)

Identification number	UN 1202
UN proper shipping name	Diesel fuel
Class / Division	3
Packing group	III