Making Liquid Soap: Teacher Manual

Learning Goals:

- Students will understand how to produce liquid soap from glycerin.
- Students will understand how to adjust variables to alter the physical properties of a product.
- Students will understand the distinction between reagents and products.

Objectives:

- Students will make liquid soap from glycerin they made in a biodiesel reaction.
- Students will record actions, calculations, and observations in a laboratory notebook.

Extended Background:

Making biodiesel can be a simple, effective way to produce liquid transportation fuel that has both financial and environmental benefits. Another advantage of biodiesel is that is can be made from waste cooking oil after it has already been used for cooking foods in the kitchen, cafeteria, or restaurant. The oil molecule is still suitable for biodiesel production so this waste can be utilized to make fuel. Unfortunately, the chemical process of making biodiesel, transesterification, results in two products: biodiesel and glycerin. The biodiesel is the primary product, but the glycerin is very useful as well. Additionally, we don't want to take one waste product (cooking oil) and create another waste product (glycerin). Therefore we refer to the glycerin produced during the biodiesel reaction as a "by-product".

By-products retain both financial and environmental value that we can capture through other chemical processes. Glycerin has hundreds of uses from food sweetener to heart medication depending on the quality. Glycerin derived from biodiesel production is a low quality product because it contains many contaminants from the biodiesel reaction. Biodiesel glycerin is actually a mixture of free fatty acids (FFA) that were neutralized during transesterification, soaps, water, catalyst (NaOH or KOH depending on what was used to make the biodiesel), methanol, and glycerin. The only contaminant that poses a risk is the methanol. To obtain a high conversion of oil into biodiesel we use a purposeful excess of methanol. The excess methanol settles into the glycerin layer and must be removed to make the glycerin safe to handle.

All residual methanol must be removed before the glycerin can be used for making soap. Methanol will boil off at temperatures above 68°C. The methanol can be distilled out of the glycerin to capture the methanol or simply heated under a fume hood to remove methanol. Allow 45 minutes of boiling at temperature to ensure all methanol is driven off.

Once the methanol is removed, the glycerin is safe to handle and is suitable for making soap. The remaining contaminates are all ingredients in soap. Producing soap is the easiest way to capture the value of the glycerin at the small scale. The following lab is designed to show how glycerin, from biodiesel made with KOH, can be turned into a liquid soap with a multitude of uses from hand soap to glass cleaner.

Materials:

- Glycerin, Methanol Removed (200 grams per pair of students)
- Essential Oil (optional)
- Coconut Oil (25 g per pair of students)
- Citric Acid
- 250 mL graduated cylinder
- Scale or balance
- Potassium Hydroxide (KOH)
- 1,000 mL beaker
- 250 mL beaker x 2
- Water (DI or Distilled if available)
- Hot Plates
- Thermometer
- pH Strips or Meter

Preparation:

Ensure all residual methanol is removed from glycerin. Methanol will boil off at temperatures above 68°C. Allow 45 minutes of boiling at temperature to ensure all methanol is driven off.

Procedure:

1. Prepare glycerin
    a. Measure 200 grams of glycerin into a 1,000 mL beaker
    b. Heat glycerin to 60°C
    c. Stir glycerin gently and check temperature with thermometer
2. Prepare coconut oil
    a. Weigh 25 grams of coconut oil in a 250 mL beaker
    b. Heat coconut oil enough to melt the oil
    c. Add to glycerin
3. Prepare potassium hydroxide (KOH) solution
    a. Measure 75 mL of water into a 250 mL beaker
        i. Use DI or distilled water if available
        ii. Fewer impurities in water, especially if you have hard water, will improve the quality and clarity (color) of the soap.
    b. Measure 25 grams of KOH
        i. KOH is hydroscopic. It will absorb moisture from the air causing it to weigh more and be less effective. Keep KOH covered.
        ii. KOH dust can irritate the nostrils and throat. Avoid breathing the dust or fumes when mixing KOH solutions.
    c. Add the measured KOH to the water and swirl to dissolve
        i. If available, perform this step under a fume hood
4. Mix Soap
    a. Gently pour KOH/Water solution into the hot glycerin
    b. Heat soap and maintain temperature of 60-70°C
    c. Stir soap constantly
        i. Mix for 5 minutes
        ii. The soap will start to thicken as the glycerin and coconut oil are saponified

d. Add 250 mL of dilution water to the soap
    i. Use DI or distilled water if available
    ii. Fewer impurities in water, especially if you have hard water, will improve the quality and clarity (color) of the soap.
e. Continue to heat and stir soap for an additional 20 minutes
f. After 20 minutes:
    i. Take soap off of the heat
    ii. Allow to cool to room temperature
    iii. Let soap rest overnight if possible

5. pH Balance Soap
    a. Test the pH of your soap
        i. Use pH test strips and/or a pH meter
        ii. Target pH is 9.75
    b. The pH is likely to be too high, but this was done purposefully to ensure that all of the glycerin and coconut oil were saponified.
    c. Lower pH by adding 20% citric acid solution
        i. Dissolve 20 grams of citric acid in 80 grams of water
        ii. Slowly add small amounts to the soap
        iii. Stir
        iv. Retest pH
        v. Continue this until you reach your target pH of 9.75
6. OPTIONAL:
    a. At this point you can add a few grams of essential oil to scent the soap
    b. Concentrated essential oil is very strong and a little goes a long way
7. Test
    a. Test the soap on your hands, floors, tables...almost anything can be cleaned with this universal soap!
    b. Observe the soap over the next couple days and weeks. The soap should not form any layers and the pH should remain stable.

Questions:

What is the purpose of adding glycerin to the soap? Essential oil?

What would happen if we dissolved the soap paste in more/less water?

What could this soap be used for?

How does making soap fit in with making biodiesel?

Making Liquid Soap: Student Lab

Learning Goals:

- Students will understand how to produce liquid soap from glycerin.
- Students will understand how to adjust variables to alter the physical properties of a product.
- Students will understand the distinction between reagents and products.

Objectives:

- Students will make liquid soap from cooking oil and glycerin they made in a biodiesel reaction
- Students will record actions, calculations, and observations in a laboratory notebook.

Extended Background:

Making biodiesel can be a simple, effective way to produce liquid transportation fuel that has both financial and environmental benefits. Biodiesel can be made from waste cooking oil, but we don't want to take one waste product (cooking oil) and create another waste product (glycerin). Therefore we refer to the glycerin produced during the biodiesel reaction as a "by-product".

By-products retain both financial and environmental value that we can capture through other chemical processes. Biodiesel glycerin is actually a mixture of free fatty acids (FFA) that were neutralized during transesterification, soaps, water, catalyst (NaOH or KOH depending on what was used to make the biodiesel), methanol, and glycerin.

Once the methanol is removed, the glycerin is safe to handle and is suitable for making soap. The remaining contaminates are all ingredients in soap making soap production the easiest way to capture the value of the glycerin. The following lab is designed to show how glycerin, from biodiesel made with KOH, can be turned into a liquid soap with a multitude of uses from hand soap to stainless steel cleaner.

Materials:

- Glycerin, Methanol Removed (200 grams per pair of students)
- Essential Oil (optional)
- Coconut Oil (25 g per pair of students)
- Citric Acid
- 250 mL graduated cylinder
- Scale or balance
- Potassium Hydroxide (KOH)
- 1,000 mL beaker
- 250 mL beaker x 2
- Water (DI or Distilled if available)
- Hot Plate
- Thermometer
- pH Strips or Meter

Procedure:

1. Prepare glycerin
    a. Measure 200 grams of glycerin into a 1,000 mL beaker
    b. Heat glycerin to 60°C
    c. Stir glycerin gently and check temperature with thermometer
2. Prepare coconut oil
    a. Weigh 25 grams of coconut oil in a 250 mL beaker
    b. Heat coconut oil enough to melt the oil
    c. Add to glycerin
3. Prepare potassium hydroxide (KOH) solution
    a. Measure 75 mL of water into a 250 mL beaker
        i. Use DI or distilled water if available
        ii. Fewer impurities in water, especially if you have hard water, will improve the quality and clarity (color) of the soap.
    b. Measure 25 grams of KOH
        i. KOH is hydroscopic. It will absorb moisture from the air causing it to weigh more and be less effective. Keep KOH covered.
        ii. KOH dust can irritate the nostrils and throat. Avoid breathing the dust or fumes when mixing KOH solutions.
    c. Add the measured KOH to the water and swirl to dissolve
        i. If available, perform this step under a fume hood
4. Mix Soap
    a. Gently pour KOH/Water solution into the hot glycerin
    b. Heat soap and maintain temperature of 60-70°C
    c. Stir soap constantly
        i. Mix for 5 minutes
        ii. The soap will start to thicken as the glycerin and coconut oil are saponified
    d. Add 250 mL of dilution water to the soap
        i. Use DI or distilled water if available
        ii. Fewer impurities in water, especially if you have hard water, will improve the quality and clarity (color) of the soap.
    e. Continue to heat and stir soap for an additional 20 minutes
    f. After 20 minutes:
        i. Take soap off of the heat
        ii. Allow to cool to room temperature
        iii. Let soap rest overnight if possible
5. pH Balance Soap
    a. Test the pH of your soap

i. Use pH test strips and/or a pH meter
ii. Target pH is 9.75

b. The pH is likely to be too high, but this was done purposefully to ensure that all of the glycerin and coconut oil were saponified.
c. Lower pH by adding 20% citric acid solution
    i. Dissolve 20 grams of citric acid in 80 grams of water
    ii. Slowly add small amounts to the soap
    iii. Stir
    iv. Retest pH
    v. Continue this until you reach your target pH of 9.75

6. OPTIONAL:
    a. At this point you can add a few grams of essential oil to scent the soap
    b. Concentrated essential oil is very strong and a little goes a long way
7. Test
    a. Test the soap on your hands, floors, tables...almost anything can be cleaned with this universal soap!
    b. Observe the soap over the next couple days and weeks. The soap should not form any layers and the pH should remain stable.

Questions:

What is the purpose of adding glycerin to the soap? Essential oil?

What would happen if we dissolved the soap paste in more/less water?

What could this soap be used for?

How does making soap fit in with making biodiesel?