

Name _____

Date _____

Partners _____

Section _____

Chemical Reactions: Soap Making

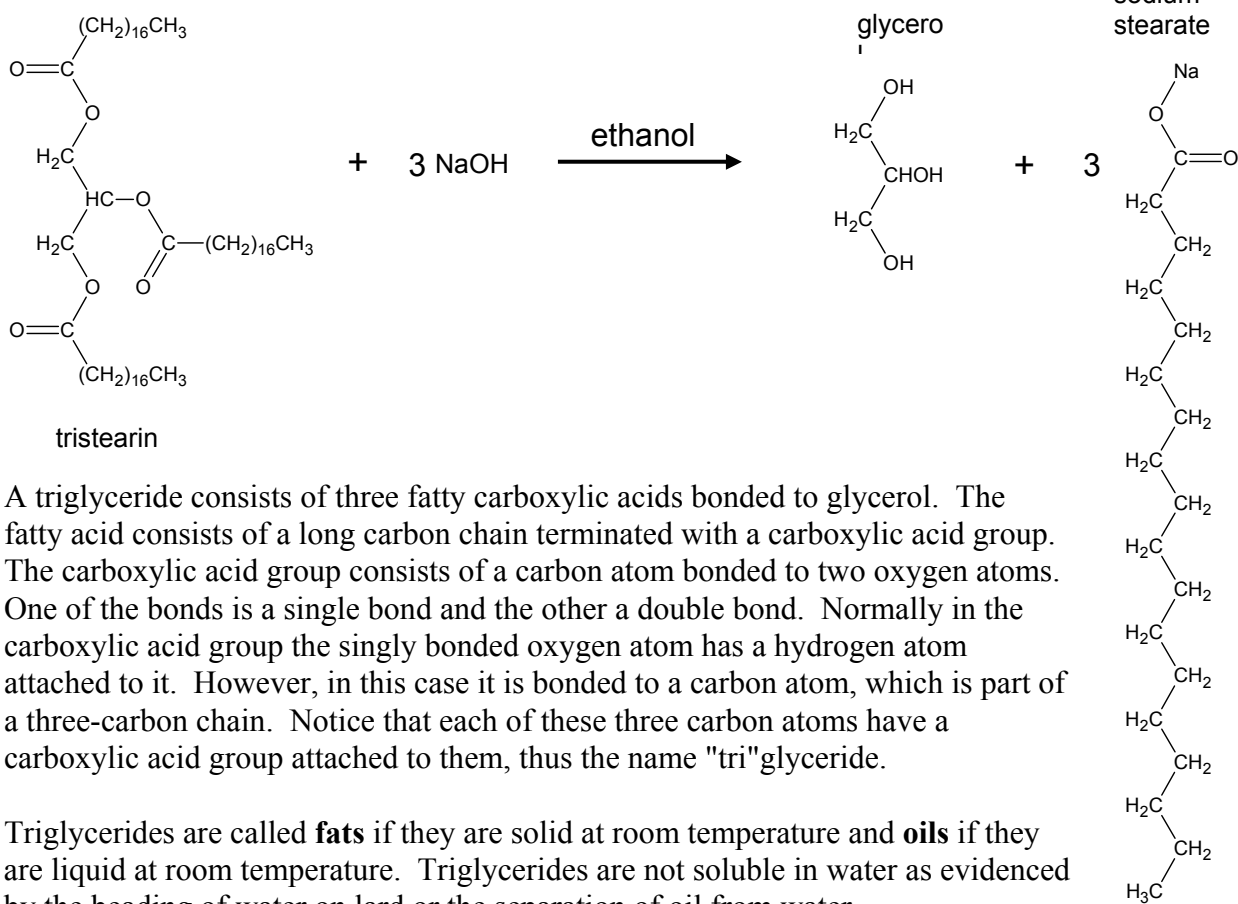
Purpose:

To understand why soap is useful in cleaning and understand the chemistry behind the making of soap.

Equipment:

- Material Safety Data Sheets (MSDS) for Sodium Hydroxide and Ethyl Alcohol
- Latex gloves
- 100 mL graduated cylinder
- 30 g fat or oil
- 30 mL ethyl alcohol
- 200 mL saturated NaCl solution
- 400 mL beaker
- hot plate
- 15 mL of 50% NaOH solution
- 100 mL distilled water

Theory:



A triglyceride consists of three fatty carboxylic acids bonded to glycerol. The fatty acid consists of a long carbon chain terminated with a carboxylic acid group. The carboxylic acid group consists of a carbon atom bonded to two oxygen atoms. One of the bonds is a single bond and the other a double bond. Normally in the carboxylic acid group the singly bonded oxygen atom has a hydrogen atom attached to it. However, in this case it is bonded to a carbon atom, which is part of a three-carbon chain. Notice that each of these three carbon atoms have a carboxylic acid group attached to them, thus the name "tri"glyceride.

Triglycerides are called **fats** if they are solid at room temperature and **oils** if they are liquid at room temperature. Triglycerides are not soluble in water as evidenced by the beading of water on lard or the separation of oil from water.

When triglycerides are reacted with sodium hydroxide, the bond between the oxygen atom of the carboxylic acid group and the carbon atom of the glycerol is broken. This

process is called **saponification**. The oxygen atom picks up the sodium atom from the sodium hydroxide and thus makes this end of the fatty acid chain soluble in water. This sodium salt of a fatty acid is called **soap**. The hydroxide group (OH) from sodium hydroxide then attaches to the glycerol molecule. When all three fatty acids are removed, the reaction is complete. The presence of ethanol during this process allows the reaction to take place at medium heat.

While heating the mixture, ethanol and water will evaporate away. When the reaction is complete, the glycerol needs to be separated from the soap. This is done by adding water to the mixture to make it more liquid in texture and then by adding a saturated solution of salt water. The glycerol is more soluble in the salt water than the soap and, therefore, allows these two chemicals to be separated. This process is referred to as "salting out" the soap.

The unique properties of soap lie in the fact that one end of the chain is water soluble (hydrophilic) and the other end is not (hydrophobic). In the process of washing with soap, a particle of grease is surrounded by soap molecules. The hydrophobic ends attach to the grease particle, thus leaving the hydrophilic end exposed to the water. This allows the grease particle to freely move around in the water and, therefore, be washed away.

The fats and oils used in making soap consist mainly of seven different fatty acids. If all of the carbon bonds in the fatty acid chain are single bonds, we have a saturated fatty acid. If any of the carbon bonds are double bonds, we have an unsaturated fatty acid. Unsaturated fats can be converted to saturated fats by adding hydrogen atoms at the locations of the double bonds. The amount of unsaturated fatty acids in the soap can affect the firmness of the soap.

CAUTION: *Sodium hydroxide is a strong base and corrosive. Ethyl alcohol is flammable. Read the appropriate MSDS in the lab for further information. Wear latex gloves and goggles during the lab to protect yourself from the sodium hydroxide.*

Procedure:

1. Weigh 30 g of fat or oil into a 400 mL beaker. Record the exact amounts on the data sheet.
2. Add 30 mL of ethyl alcohol and 15 mL of 50% NaOH solution.
3. Stir the mixture constantly with a glass stirring rod and heat gently (medium heat) on a hot plate until the alcohol evaporates. (~30 min.).
4. Add 100 mL of distilled water and heat with gentle stirring until a smooth texture is obtained. **Do not** allow your soap to boil.
5. Fill the beaker with a saturated salt solution and stir vigorously to "salt out" the soap.
6. Label your beaker with your names and place it on the shelf until the next lab period. Clean up your lab station.

(This lab was provided by Dr. Mark McClain.)

DATA SHEET -- SOAP MAKING

Date _____ Your Name _____

Lab Section: #1 #2 #3 #4 Partner _____

Mass of beaker	
Mass of beaker w/ fat	
Mass of fat	
Volume of ethyl alcohol	
Volume of 50% NaOH	
Volume of distilled water	
Time to evaporate ethyl alcohol	
Time to mix in distilled water	

Safety Information:

1. From the MSDS, what are the effects of ingestion of 50% NaOH?
2. How should you help a person who has swallowed 50% NaOH?
3. From the MSDS reactivity information, what conditions for ethyl alcohol should be avoided?
4. What are the acute and chronic health hazards for ethyl alcohol?
5. What is the appropriate emergency first aid treatment for ethyl alcohol exposure?

Conclusions:

1. What are the reactants in this reaction and what are the products in this reaction?
2. If sodium (Na) has a mass of 23, oxygen (O) has a mass of 16, carbon (C) has a mass of 12, and hydrogen (H) has a mass of 1, what is the total weight of the soap molecule sodium stearate?
3. Using the result from question 2, find the percentage by weight of each type of atom in the molecule. For carbon add up the total weight of all the carbon molecules and divide this by the total weight of the soap molecule. Do the same for hydrogen, oxygen and sodium.

%C = _____

%H = _____

%O = _____

%Na = _____

4. How would you guess that lye works to unclog grease (fats and oils) in household drains?
5. Search the World Wide Web for a history of soap. How long ago has soap making been around?
6. Search the World Wide Web for pollution hazards of soap. How dangerous is soap to our environment?