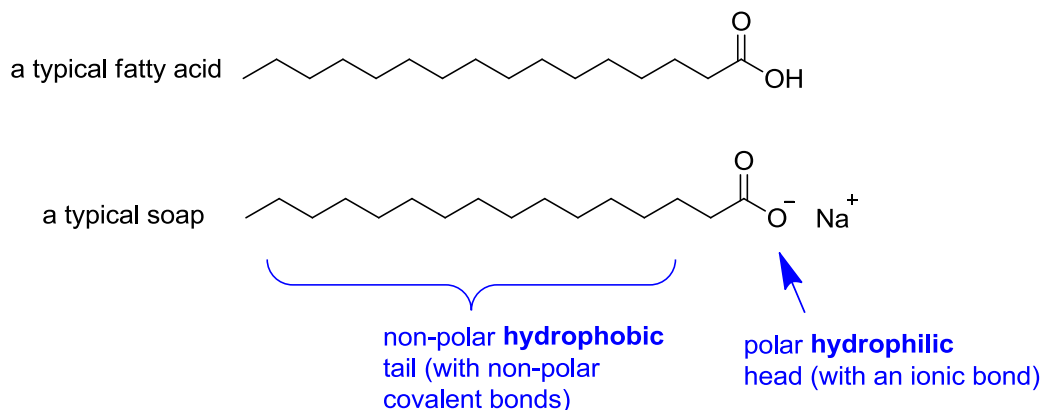


Synthesis of Soap from Olive Oil

Introduction

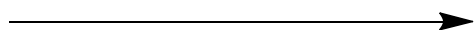
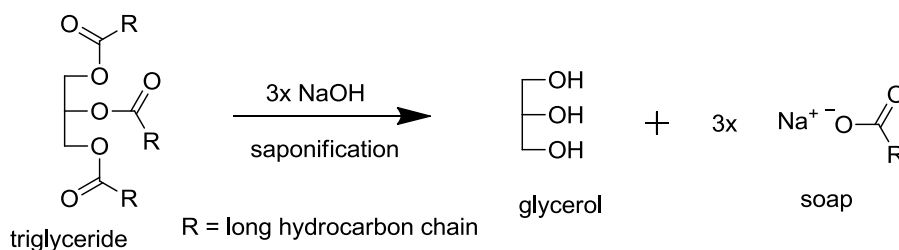
A soap is a salt of a fatty acid. Fatty acids are carboxylic acids with a long unbranched hydrocarbon (aliphatic) chains.



The ionic (highly polar, charged) nature of salts typically makes them water soluble. The non-polar hydrocarbon (aliphatic) tail of soap molecules allows them to be miscible with non-polar (greasy) substances and ‘help’ these substances dissolve in water. Successful bathing is all about improving the water solubility of ‘dirt’ 😊

Soap can be prepared from certain esters by a process known as saponification. Historically, soaps were made by boiling the fat of an animal in a solution containing potash (various potassium containing minerals). This was done long before anyone had a good understanding of the chemical transformations taking place. We now know that this process is the reaction of **triglycerides** (which are esters) with a **strong base** such as potassium hydroxide (or sodium hydroxide in today’s experiment).

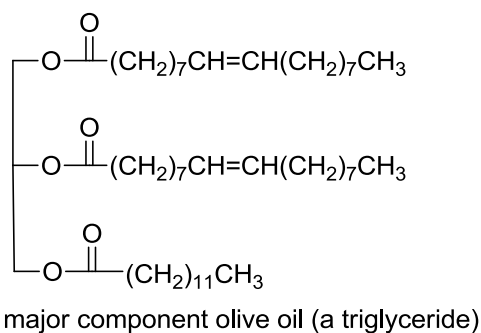
Triglycerides are the main constituents of vegetable oil and animal fats. A triglyceride is a tri-ester with three long fatty-acid-like hydrocarbon chains. When a triglyceride reacts with three equivalents of a strong aqueous base such as NaOH, the three ester bonds are hydrolyzed to yield three fatty acid salts (soap molecules) and one molecule of glycerol as shown below. This ‘saponification’ can also be referred to as base hydrolysis.



Industrially, soap is made by reaction of sodium hydroxide with vegetable fat or a form of beef or mutton fat called 'tallow'. It is important to use enough NaOH to ensure complete saponification of triglycerides. If insufficient base, time, heat is provided the result is incomplete saponification and a soap product that can be very brittle. Once the saponification reaction is complete, sodium chloride is added to precipitate the soap. The aqueous portion is decanted off (taking with it the glycerol byproduct). The remaining substance is crude soap which contains some impurities such as sodium chloride, sodium hydroxide and residual glycerol.

Although you will not have time to purify your crude soap in this lab, usually this purification would consist of re-dissolving the soap in boiling water and then cooling and precipitating it once again by adding sodium chloride. After purification, commercial soaps get other ingredients such as sand (to produce a soap that can scour), or compounds that add fragrance or color.

In this experiment you will make soap from olive oil. The chemical structure of the major constituent of olive oil is as follows ($C_{52}H_{96}O_6$)



IMPORTANT SAFETY CAUTION: 6M aqueous NaOH is a very strongly basic reagent and **can cause severe chemical burns and injury upon skin contact**. If this substance contacts your skin, the initial soapy feeling is a consequence of saponification of skin oils. Should this happen tell your TA immediately and treat your skin immediately with a large amount of running tap water to avoid serious burns.

Experimental Procedure

Part A: Saponification Reaction

1. Fill a 600 mL beaker with water and heat to boiling on a hot plate.
2. While your water bath is heating, clean a large test tube and rinse with deionized water.
3. To your test tube add:
 - 5 grams of olive oil
 - 10 mL of 95% ethanol
4. Place your test tube in your boiling water bath.
5. Slowly add 8 mL of 6 M NaOH to your solution.
6. Stir and keep hot for 15 minutes.
7. Add 95% ethanol periodically to replace the ethanol that has boiled off.

Part B: Isolation of soap product.

8. Remove test tube and allow the solution to cool to room temperature
9. Add 25 mL of saturated NaCl solution.
10. Thoroughly mix the contents of your test tube and cool in an ice bath for 10 minutes. Your soap should now precipitate out of solution.
11. Vacuum filter your solution thru your Hirsch funnel to isolate the solid soap.
12. Allow air to pull through funnel for 5 minutes to dry your solid.
13. Weigh your product.

Part C: Characterization of your product

14. Dissolve some of your soap in deionized water.
15. Determine the pH using pH paper.

Results and Discussion:

1. Write a balanced chemical equation for this saponification reaction:

2. Mass of olive oil used:

Molar mass of triglyceride (g/mol):

Moles of triglyceride starting material used:

Mass of crude soap obtained:

Molar masses of the two soap salt products (g/mol):

Theoretical yield of soap (g):

Percentage yield of this saponification reaction:

pH of soap in deionized water:

Discussion Questions:

1. Describe your crude product. Do you expect it to be pure soap? Why or why not?
2. Why are sufficient base, heat, and time important in saponification chemistry?
3. What would occur if your soap was treated with a strong acid like HCl?