

VI

SYNTHESIS AND PROPERTIES OF SOAPS

I. OBJECTIVES AND BACKGROUND

You will synthesize soap by saponification of a triacylglycerol, and then study the properties of the soap in water.

Fatty Acids

Fatty acids are long, straight-chain carboxylic acids; those found in nature usually contain an even number of carbon atoms. Fatty acids with only single bonds between carbon atoms are said to be *saturated*. *Unsaturated* fatty acids have one or more carbon-carbon double bonds. The common names of fatty acids are used more frequently than the IUPAC names.

Some Saturated Fatty Acids

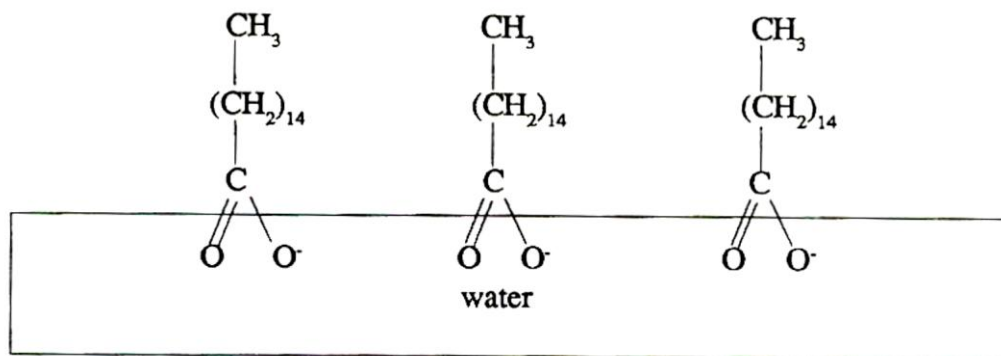
common name	formula
Butyric Acid	$\text{CH}_3(\text{CH}_2)_2\text{COOH}$
Lauric Acid	$\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$
Myristic Acid	$\text{CH}_3(\text{CH}_2)_{12}\text{COOH}$
Palmitic Acid	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$
Stearic Acid	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$
Arachidic Acid	$\text{CH}_3(\text{CH}_2)_{18}\text{COOH}$

Some Unsaturated Fatty Acids

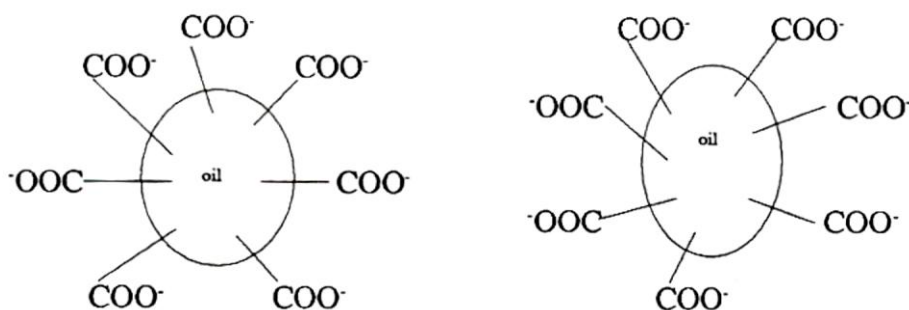
common name	formula
Oleic Acid	$\text{CH}_3\text{CH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$
Linoleic Acid	$\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$
Linolenic Acid	$\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$
Arachidonic Acid	$\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_3\text{COOH}$

Laboratory Experiments for GOB Chemistry

When soap is added to water, the hydrophilic ends of the molecules are attracted to the water and dissolve in it. The hydrophobic ends are repelled by the water molecules. Consequently, a thin film of soap (suds) forms on the water surface, drastically lowering the surface tension.



When a soap solution is brought into contact with oil (most dirt is held to clothes by a thin film of oil), soap molecules become reoriented: the hydrophobic portions dissolve in the oil, and the hydrophilic ends remain dissolved in the aqueous phase. Mechanical action (scrubbing) causes the oil to disperse into tiny droplets, and the soap molecules arrange themselves around the surface of the globules to form micelles. Because the carboxylate ends of the soap molecules project outward, the surface of the micelle is negatively charged; the drops repel one another and do not coalesce (form larger drops). The entire micelle becomes water soluble and can be washed away by a stream of water. The cleansing process involves both the lowering of the surface tension of water and the production of micelles.



Certain metal ions present in "hard water" decrease the cleansing power of soaps. Calcium and magnesium ions will form precipitates with the carboxylate ions of fatty acids. These precipitates are responsible for the bathtub ring.



The various methods for softening hard water all involve the removal of the calcium and magnesium ions.

II. PROCEDURE

A. Preparation of a Soap by Saponification of a Triacylglycerol

1. Place 6 mL of corn oil into a 125-mL Erlenmeyer flask. Add 5 mL of ethanol (as a solvent) and 5 mL of 25% sodium hydroxide solution.
2. Gently heat the flask in a boiling water bath, stirring the mixture frequently. After heating for twenty minutes, a pasty mass containing a mixture of the soap, glycerol, and excess sodium hydroxide is obtained.
3. Use an ice-water bath to cool the flask and its contents.

B. Investigation of the Properties of Soap

Part 1. Separation of the Soap by Salting-Out

To precipitate or "salt out" the soap, add 35 mL of a saturated sodium chloride solution to the soap mixture while stirring. The soap will float to the top of the mixture. Isolate the soap by vacuum filtration, washing it with ice-cold water. Record your observations of the soap. Attempt to form suds by shaking a small piece of the soap with water in a medium test tube. Record your observations.

Part 2. Effect of Hard Water on Soap

Place a small amount (1/2 of a spatula) of the soap you have prepared in a 50-mL beaker containing 25 mL of water. Warm the beaker and its contents to dissolve the soap. Pour 5 mL of the soap solution into each of two medium test tubes. Add "hard water" solutions to two of the tubes as described below.

Laboratory Experiments for GOB Chemistry

Tube 1

Add several drops of 0.2 M calcium chloride solution.

Tube 2

Add several drops of 0.2 M magnesium chloride solution.

Record your observations for each test tube.

Repeat this procedure using 5 ml portions of a clear, 5-10% solution of a synthetic detergent. Dispose of the contents of the test tubes down the sink

Part 3. Effect of Soap on Oil

Place 10 mL of water in a 50 mL beaker. Add one drop of corn oil and agitate the flask. Record your observations. Add 1 mL of your soap solution and agitate again. Record your observations.

Report Sheet: Experiment 6

Name _____

Date _____

Partner's Name _____

Instructor's Initials _____

A. Preparation of Soap by Saponification of a Triacylglycerol

Describe the appearance of the soap.

Give the equation for the reaction of sodium hydroxide and glyceryl trioleate (structure is on p.3). Give the names of all products.

B. Investigation of the Properties of Soap

Part 1. Separation of the Soap by Salting Out

Describe the appearance of the resulting material.

Did the collected soap form suds with distilled water?

Question: This salting out process is used commercially. Using this process, what substance could be separated from the prepared soap? (Consider the equation for the formation of the soap by saponification.)

Part 2. Effect of Hard Water on Soap

Describe the result when solutions of Mg^{2+} and Ca^{2+} are added to:

Solutions of your soap.

Solutions of a synthetic detergent.

Write an equation for the reaction of the soap sodium oleate with calcium chloride solution.

Part 3. Effect of Soap on Oil

Describe the appearance of the mixture containing one drop of corn oil in water.

Describe what happened to the corn oil/water mixture after adding your soap solution.

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