Making Soap

Introduction:
The exact date when soap was first made is not really known. One legend places the time at around 1000 B.C. on Sapo Hill near Rome. It was on this hill that people burnt animals as sacrifices to the Roman Gods. Fats from the animals dripped down through wood ashes and eventually reached the nearby Tiber River. Some observant person noticed that the Tiber River had remarkable cleaning power below Sapo Hill. Actually soap was formed by the reaction of animal fat with alkali in the ashes. The word “soap” is derived from Sapo Hill where conditions were right for this accidental discovery.

Soap is a reaction product of a fat with an alkali. A fat is a rather complex ester of long-chain acids with glycerol. Soap-making can be summarized by the following equation:

\[
\begin{align*}
\text{fat (tripalmitin)} & \quad \text{base} \\
\begin{array}{c}
\text{CH}_2\text{O}-(\text{CH}_2)_{14}\text{CH}_3 \\
\text{CH}_2\text{O}-(\text{CH}_2)_{14}\text{CH}_3 \\
\text{CH}_2\text{O}-(\text{CH}_2)_{14}\text{CH}_3
\end{array} & + 3 \text{NaOH} & \quad \begin{array}{c}
\text{CH}_2\text{OH} \\
\text{CH}_2\text{OH} \\
\text{CH}_2\text{OH}
\end{array} + 3 \text{Na} \quad \begin{array}{c}
\text{O}-(\text{CH}_2)_{14}\text{CH}_3 \\
\text{O}-(\text{CH}_2)_{14}\text{CH}_3 \\
\text{O}-(\text{CH}_2)_{14}\text{CH}_3
\end{array}
\end{align*}
\]

This soap could be better visualized as:

\[
\begin{align*}
\text{nonpolar tail (hydrophobic)} & \quad \text{polar head (hydrophilic)} \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{C} \quad \text{O} & \quad \text{Na}
\end{align*}
\]

By writing it this way, the long, nonpolar chain of carbon atoms which is a necessary part of the soap action, can be seen. Also on the right end above, the necessary polar grouping of the sodium salt is seen.

When soap is added to a greasy substance, the hydrophobic tails are embedded in the nonpolar fats and oils. The polar heads are attracted to the polar water molecules. Clusters of soap particles called micelles form with the nonpolar oil droplet in the center surrounded by many polar heads that extend into the water. Eventually all of the greasy substance forms micelles, which can be washed away with water. See the figure on the next page.
**Procedure:**

Soap can easily be made at home from fat saved in the kitchen. The fat is simply boiled for awhile with lye or alkali (NaOH) in an iron kettle until it is converted into a solution of the sodium salts of the acids and a layer of glycerol. On cooling, the soap solution solidifies into a cake. This soap will usually have a dark color from impurities in the fat and some excess alkali which makes it rather harsh. A softer soap can be made by dispersing the glycerol in the soap solution as it cools. If you want to be completely self-sufficient, you can make your own alkali. Save the wood ashes from your fireplace and strain hot water through them. This water will contain large amounts of Na₂CO₃ and K₂CO₃ and will serve quite well to hydrolyze fat.

In this experiment, you may choose to make your soap from any number of fatty acids sources. Two methods are given below. If you wish, you can devise your own recipe. A softer soap results when KOH is used instead of NaOH. You may want to add perfume to make the soap smell better. You will be making small amounts of soap in this experiment. If you wish to do it on a large scale at some later time, just increase all the ingredients by the same factor.

**Procedure A:**

Fill a beaker about two-thirds full of water and place on a hot plate and heat the water to boiling. Dissolve 2.5 grams of NaOH in 5 mL of distilled water and 10 mL 95% ethanol. Add this alkaline solution to 5 grams of lard (Crisco can be substitute for lard) in a 150 mL beaker. Cover the beaker with a watch glass and heat the mixture on the water bath. Stir the mixture frequently to prevent spattering. Keep the volume of the mixture fairly constant by adding small amounts of 50% ethanol. If the mixture foams to much, add a small amount of 95% ethanol.

The reaction is complete when the melted fat has dissolved and gives a clear homogeneous solution (about 30 minutes). Dilute your soap solution by adding 15 mL of water then pour into a brine made by dissolving 30 grams of NaCl in 100 mL of distilled water. Stir the mixture...
thoroughly and collect the precipitated soap by filtration. Wash the soap twice with 10 mL portions of cold distilled water.

Place the soap in an evaporating dish, heat it on the water bath, and stir into the soap just enough water to form a thick solution. Allow the soap solution to cool. Unless the amount of water added was excessive, the soap will solidify into a cake somewhat resembling commercial soap.

**Procedure B:**
This is an easy but expensive method you can try. It results in a floating soap and was developed by John Hill. Slowly add 14 grams of sodium carbonate decahydrate (washing soda) with stirring to 28 grams of oleic acid. Let stand overnight or until hard.

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Here is a recipe to prepare soap at home. This comes from Asta Kalmann, a chemistry student in my buddy Ellis Adler’s class at PCC back in the 70’s. She says this produces a soap that can be grated into flakes to be used in washing clothes and dishes as well as a firm bar suitable for the bath.

**Ingredients:**
- 5 lbs grease (dripping, tallow, etc.)
- 1 can lye (NaOH), 13 ounces
- ½ cup household ammonia solution
- ½ cup ground borax
- 1 tablespoon sugar
- cheesecloth
- empty milk cartons

**Procedure:**
- The day before, carefully dissolve the lye in one quart of water. Let cool overnight.
- Melt the grease and strain through cheesecloth to obtain a clarified grease. Stir the lye solution in slowly. Mix well. Add the borax, dissolved in 2 cups water, and ammonia.
- Stir 5 to 10 minutes. The mixture begins to thicken. Then stir in the sugar. Pour the mixture into milk cartons. Cover the cartons with cloth for a day or two, then the cartons may be stapled shut.
- Allow the soap to stand for 3 weeks. The blocks of soap are best cut with a thin wire.
Report for Soap Experiment:

1. Describe the appearance of your two soaps.

2. How are soaps made from vegetable oils different from those soaps made from animal fat?

3. Why are soaps more soluble than fatty acids in water?

4. How does soap remove an oil spot?