FE 132 ORGANIC CHEMISTRY LABORATORY

EXPERIMENT 8: SOAPS

Theory

Fats and oils of animal or vegetable origin are called glycerides. They are triesters of glycerol with long chain carboxylic acids. The R group (see the formula below) may vary in length and degree of unsaturation. The most common acids that occur in fats and oils have 11 to 12 carbon atoms. If the R groups are saturated, or nearly so, the glycerides are solids at room temperature and are called fats. Double bonds in the R groups lower the melting point; thus, oils are highly unsaturated glycerides. Vegetable oils, such as cottonseed or peanut oil, can be converted to fats, such as margarines by hydrogenation of some of the double bonds.

The hydrolysis of a fat or an oil in alkaline solution is called “saponification” and this process produces glycerol and a mixture of long chain carboxylic acid salts.

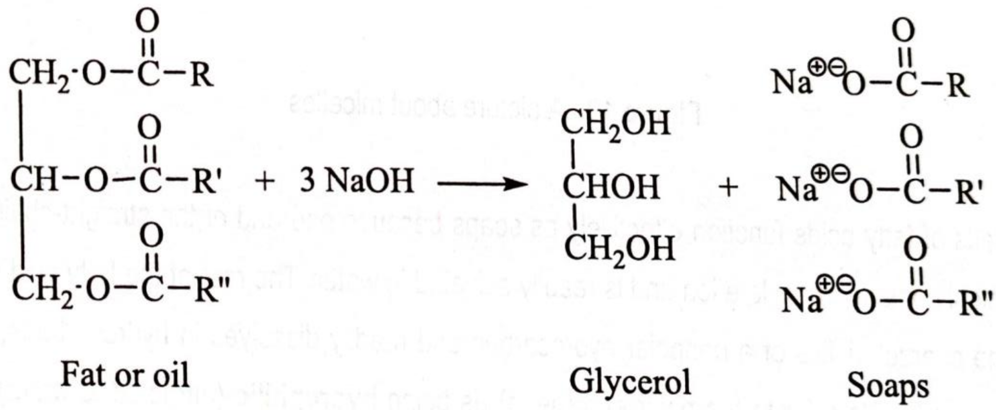

Figure 1. Soap formation reaction

When sodium hydroxide is used as the saponifying agent, the sodium salts of the fatty acids are formed along with glycerol. These salts can be separated from the glycerol and from most of the water by the process known as *salting out.* Soap is soluble in water but insoluble in salt solution; hence, addition of salt solution causes separation of the soap as a curdy precipitate.

Hydrolysis of fats by means of potassium hydroxide gives potassium salts. The potassium salts are more soluble than sodium salts and for that reason are used in the preparation of liquid soaps.

The glycerol produced as a by-product is isolated from the aqueous solution after the salting out process; by concentration and distillation, it is obtained as a viscous sweet liquid.

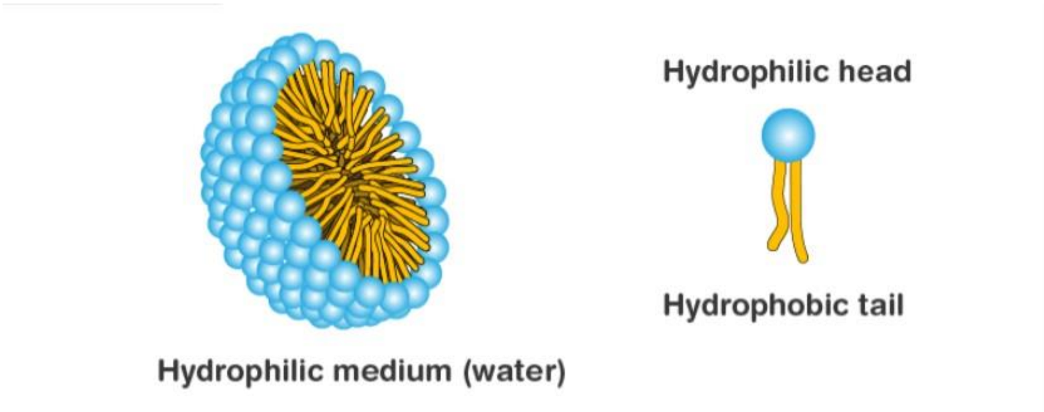

Figure 2. Structure of a micelle

Salts of fatty acids function effectively as soaps because one end of the straight-chain system has the highly polar carboxylate ion and is readily solvated in water. The rest of the fatty acid molecule has all the characteristics of a nonpolar hydrocarbon and readily dissolves in hydrocarbons, such as greases and oils. We refer to the polar end (head) as being **hydrophilic** (attracted to water) and the hydrocarbon end (tail) as being **lipophilic** (attracted to oils). When dispersed in an aqueous solution, fatty acids tend to form **micelles** (spherical clusters of molecules). The lipophilic ends of the fatty acids occupy the interior of the cluster, while the polar ends, which are heavily solvated by water molecules, form the outer surface of the spherical micelle. Micelles absorb the hydrocarbon chains of the triglycerides, and thus soaps break up and help to dissolve fats and oils that tend to coat skin, clothes, and surfaces of eating and cooking utensils. Most dirt on clothing or skin adheres to a thin film of oil. If the oil film can be removed, the dirt particles can be washed away. In ordinary soaps, the outer part of each micelle is negatively charged, and the positively charged sodium ions congregate near the periphery of each micelle.

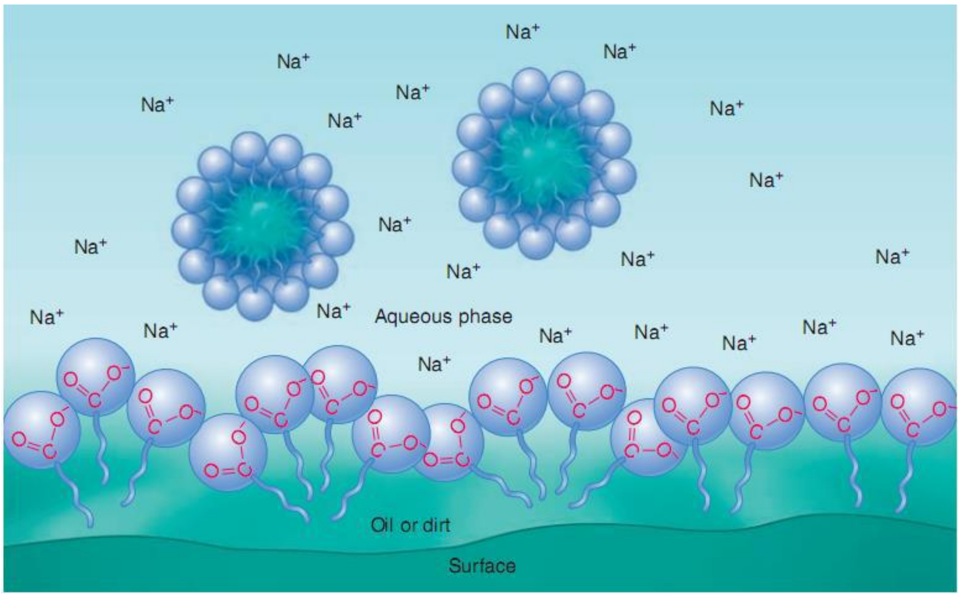

Figure 3. Interaction of soap with oil/dirt

Procedure

1. Place 5 mL of oil, 10 mL of 50% NaOH solution and 10 mL of ethanol into a 400 mL beaker.
2. Vigorously stir the mixture with glass rod. Saponification is complete when you obtain a homogeneous solution. (35-40 min.)
3. While the saponification is in progress, prepare a concentrated NaCl solution by dissolving 25 g salt in 75 mL water in a 250 mL beaker.
4. When saponification is complete pour the saturated salt solution into the reaction mixture. Stir the mixture thoroughly for 5 minutes.
5. Filter the mixture.
6. Wash the soap twice with 15 mL of cold distilled water and dry it.

Post Lab questions

1. What is triglyceride?
2. What is soap? How do soaps work? How do soaps clean the dirts?
3. What is micelle?
4. What are the differences between soaps and detergents?