

# Soap

Soap is a mixture of sodium salts of various naturally occurring fatty acids. Air bubbles added to a molten soap will decrease the density of the soap and thus it will float on water. If the fatty acid salt has potassium rather than sodium, a softer lather is the result. Soap is produced by a saponification or basic hydrolysis reaction of a fat or oil. Currently, sodium carbonate or sodium hydroxide is used to neutralize the fatty acid and convert it to the salt.

## Introduction

General overall hydrolysis reaction:

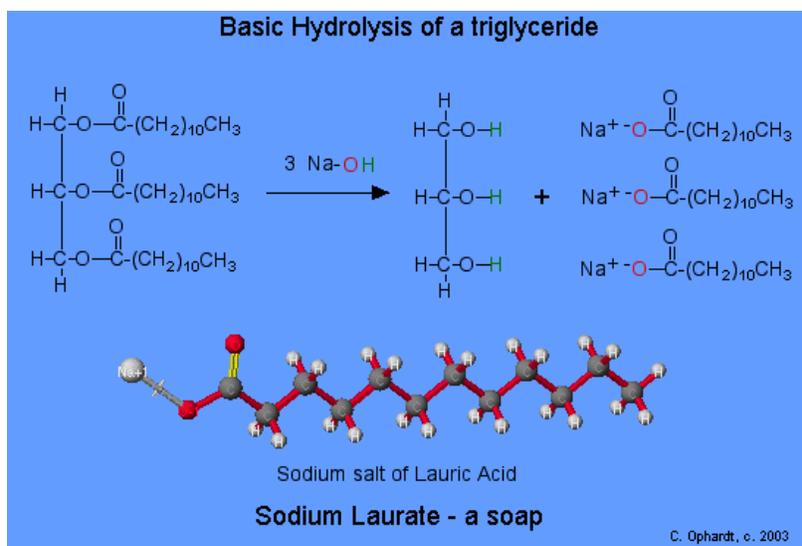


Although the reaction is shown as a one step reaction, it is in fact two steps. The net effect is that the ester bonds are broken. The glycerol turns back into an alcohol (addition of the green H's). The fatty acid portion is turned into a salt because of the presence of a basic solution of the NaOH. In the carboxyl group, one oxygen (red) now has a negative charge that attracts the positive sodium ion.

## Types of Soap

The type of fatty acid and length of the carbon chain determines the unique properties of various soaps. Tallow or animal fats give primarily sodium stearate (18 carbons) a very hard, insoluble soap. Fatty acids with longer chains are even more insoluble. As a matter of fact, zinc stearate is used in talcum powders because it is water repellent.

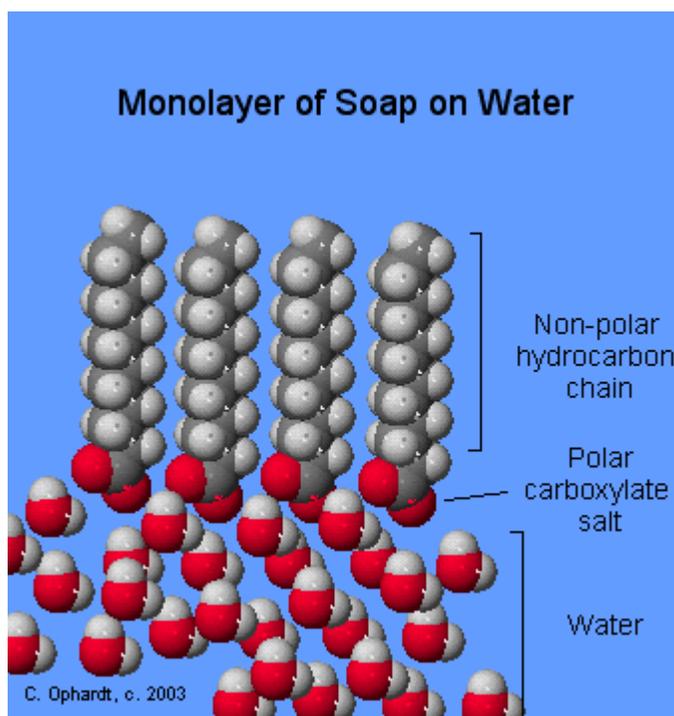
Coconut oil is a source of lauric acid (12 carbons) which can be made into sodium laurate. This soap is very soluble and will lather easily even in sea water. Fatty acids with only 10 or fewer carbons are not used in soaps because they irritate the skin and have objectionable odors.



# Cleansing Action of Soap

The cleansing action of soap is determined by its polar and non-polar structures in conjunction with an application of solubility principles. The long hydrocarbon chain is of course non-polar and hydrophobic (repelled by water). The "salt" end of the soap molecule is ionic and hydrophilic (water soluble).

**Monolayer:** When soap is added to water, the ionic-salt end of the molecule is attracted to water and dissolved in it. The non-polar hydrocarbon end of the soap molecule is repelled by water. A drop or two of soap in water forms a monolayer on the water surface as shown in the graphics on the left. The soap molecules "stand up" on the surface as the polar carboxyl salt end is attracted to the polar water. The non-polar hydrocarbon tails are repelled by the water, which makes them appear to stand up.

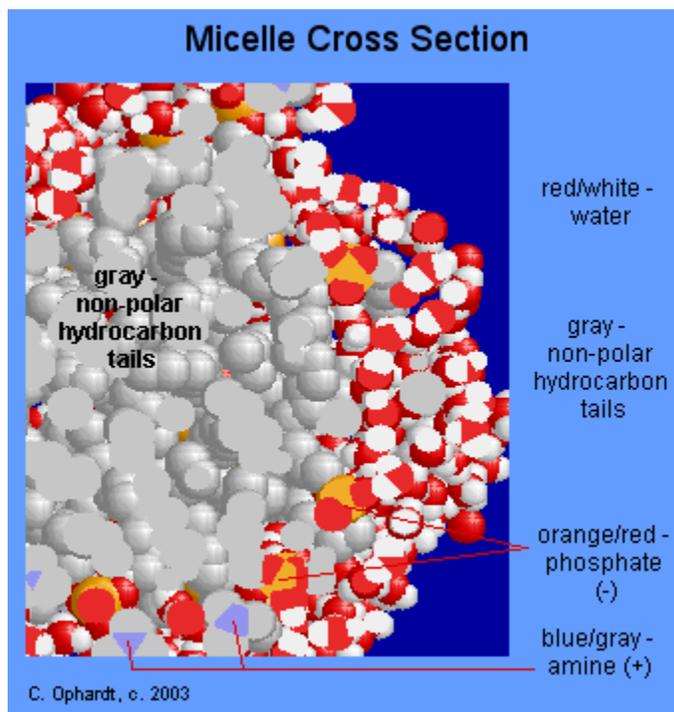


## Soap vs. oil vs. water

Water alone is not able to penetrate grease or oil because they are of opposite polarity. When grease or oil (non-polar hydrocarbons) are mixed with a soap-water solution, the soap molecules work as a "bridge" between polar water molecules and non-polar oil molecules. Soap molecules have both properties of non-polar and polar at opposite ends of the molecule.

The oil is a pure hydrocarbon so it is non-polar. The non-polar hydrocarbon tail of the soap dissolves into the oil. That leaves the polar carboxylate ion of the soap molecules are sticking out of the oil droplets, the surface of each oil droplet is negatively charged. As a result, the oil droplets repel each other and remain suspended in solution (this is called an emulsion) to be washed away by a stream of water. The outside of the droplet is also coated with a layer of water molecules.

The graphic on the left although not strictly a representation of the above description is a micelle that works in much the same fashion. The oil would be at the center of the micelle. Click for more information on a micelle.



## Effect of Hard Water

If soap is used in "hard" water, the soap will be precipitated as "bath-tub ring" by calcium or magnesium ions present in "hard" water. The effects of "hard" water calcium or magnesium ions are minimized by the addition of "builders". The most common "builder" used to be sodium trimetaphosphate. The phosphates react with the calcium or magnesium ions and keeps them in solution but away from the soap molecule. The soap molecule can then do its job without interference from calcium or magnesium ions. Other "builders" include sodium carbonate, borax, and sodium silicate are currently in detergents.

Source: [http://chemwiki.ucdavis.edu/Biological\\_Chemistry/Lipids/Case\\_Studies/Case\\_Study%3a\\_Soap](http://chemwiki.ucdavis.edu/Biological_Chemistry/Lipids/Case_Studies/Case_Study%3a_Soap)