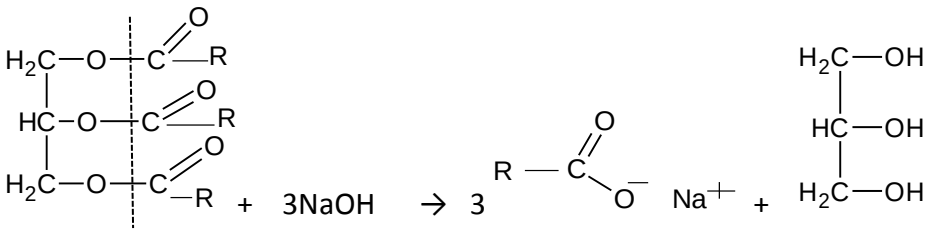
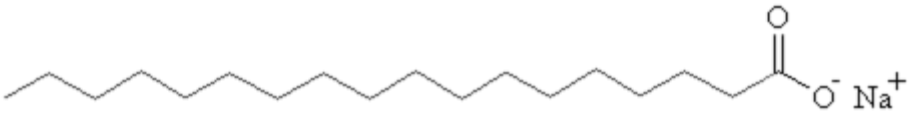
AS 90730 Describe selected organic compounds and their uses

ADDITIOAL NOTES ON SOAPS AND DETERGENTS

Soaps are made by boiling fats/oils (triglycerides) with a strong base, usually sodium hydroxide in a reaction called saponification. The triglyceride breaks up into sodium salts of the fatty acid (the soap) and glycerol.

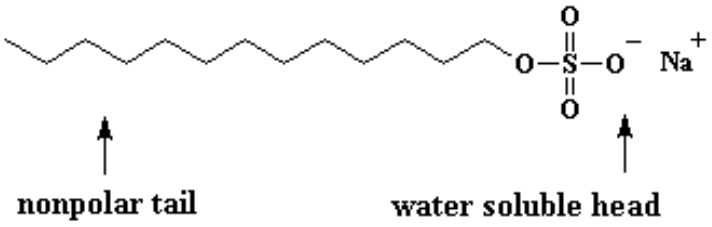


The soap molecules are soluble Na^+ salts of long-chain fatty acids, e.g. sodium stearate.



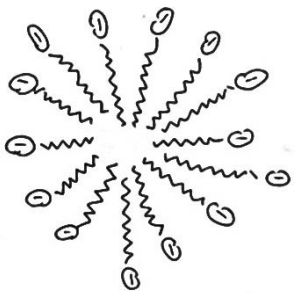
$C_{17}H_{35}COONa$

Detergents are produced by reacting a triglyceride with concentrated sulfuric acid.



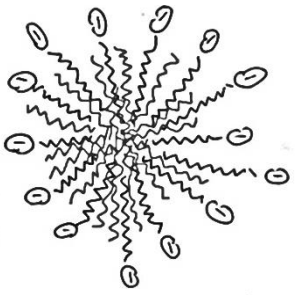
Sodium lauryl sulfate

Soap micelle



The head ends of both of these two molecules are attracted to water (hydrophilic – water loving) because there is an ionic charge due to O^- and Na^+ The long tail of both molecules are considered non-polar because all bonds are either C-C or C-H, which have no (or no significant) dipole. These tails are repelled by water. The tail is said to be hydrophobic (water-hating). Both detergent and soap have the same action on grease. Their non-polar tails bond with the non-polar grease creating a micelle with the polar heads exposed. This polar surface micelle mixes easily with water and the grease can be removed.

Soap micelle removing grease



When a soap or detergent is added to water that contains oil or other water-insoluble materials (e.g. when doing the washing up, washing clothes or at bath time, etc), the soap or detergent molecules surround the oil droplets. The oil or grease is "dissolved" in the alkyl groups of the soap molecules (the oil and dirt are dragged off the dirty dishes, clothes or people) collected together into clumps (micelles) while the ionic end allows the micelle to dissolve in water, and be washed down the drain.

Soaps & detergents act as a surfactants (gets water to wet the fibres) and as emulsifiers (separates the dirt from the fibres and suspends it so the water can rinse it away).

Soaps and detergents form micelles – spherical particles with a hydrophobic interior and a hydrophilic exterior, that dissolves in the water causing a lather.

- **Surfactants** - water wets the fibres by altering the surface tension. Molecules are strongly attracted to each other, soap molecules make the water droplet collapse so it wets more fabric.
- **Emulsifiers -** separate dirt from the fibres and suspends it in the water so it can be washed away. Hydrophilic polar end of the soap or detergent dissolves in the water, the hydrocarbon chain dissolves in the oil forming a 'bridge' which enables the dirt to be washed away with the water.
- **Micelles** - spherical particles with a hydrophobic interior and a hydrophilic exterior. They pick up the dirt (known as "soil"), are repelled from each other due to the charges and then wash away with the water.

Hard and soft water

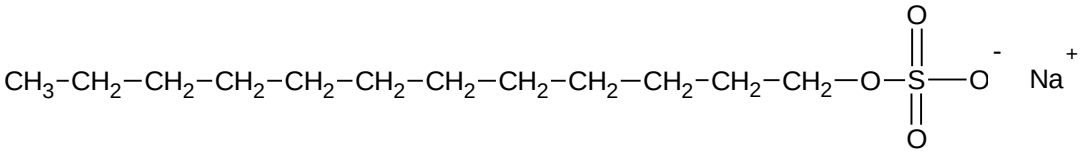
Soap produces a good lather in "soft" water. Soft water does not contain any dissolved calcium or magnesium ions.

Soap does not produce a good lather in "hard" water. Hard water contains dissolved calcium, or magnesium ions. These react with sodium stearate (soap) to produce a white or grey scum. If the soap is sodium stearate NaSt the dissolved calcium ions will react with the soap molecule to produce calcium stearate $Ca(St)_2$ (where St represents stearic acid)). The grey insoluble scum of calcium or magnesium stearate wastes soap and minimises the lathering action. This soap scum can form deposits on clothes causing them to be grey in colour. More soap is required to give the same cleaning effect as the detergent.
Once all the dissolved magnesium or calcium ions are have reacted with the sodium stearate the water will lather as normal with the soap.
This does not happen with detergents as their magnesium or calcium salts are soluble.

Hard water can be softened using sodium carbonate (washing soda) or a water softener, or distilled, then the soap can act as a surfactant and emulsifier as usual. (You are not expected to know details of water softening but they all remove calcium or magnesium ions).

Detergents work better in hard water than soaps. Detergents lather in hard water when soaps do not.

Below is a drawing of a molecule of detergent made from palm oil, called **sodium lauryl sulfate**. The two ends of the molecule are **non-polar** & **polar**. This detergent is an ANIONIC detergent.



non-polar tail water soluble head-end

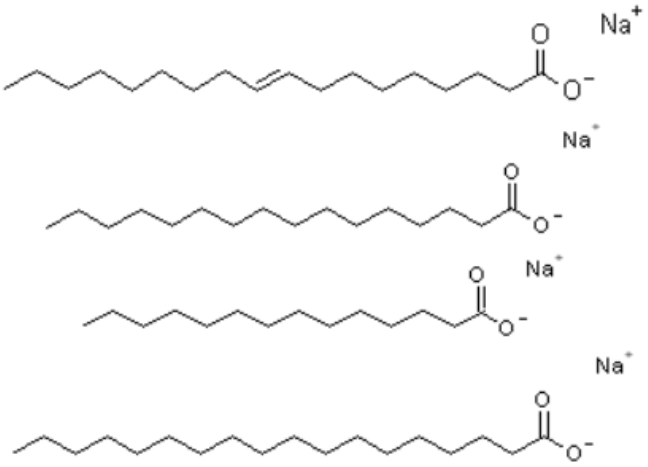
Synthetic detergents such as alkyl sulfonate above do not form insoluble salts in hard water. Their Ca^{2+} and Mg^{2+} salts are soluble in water.

Synthetic detergents can also act in acid environment, soaps cannot as they are converted to free fatty acids.

SUMMARY

	SOAP	DETERGENT
Example	Sodium stearate	Sodium alkyl sulfate
Made by	Heating fat/oil with NaOH	Reacting fat/oil with conc. H_2SO_4
Have	Non-polar (hydrophobic) tail & an ionic (charged) water soluble head (hydrophilic)	
Lather well in	Soft water only; form scum in hard water as their calcium and magnesium salts are insoluble e.g. calcium stearate = scum	Hard and soft water; do NOT form scum in hard water as their calcium and magnesium salts are soluble
Are	Anionic $RCOO^-$	Cationic, anionic (RSO_4^-) or neutral
Can work in acid environment?	No; are converted to free fatty acids RCOOH	Yes; ionic head still remains

Soaps



Detergents