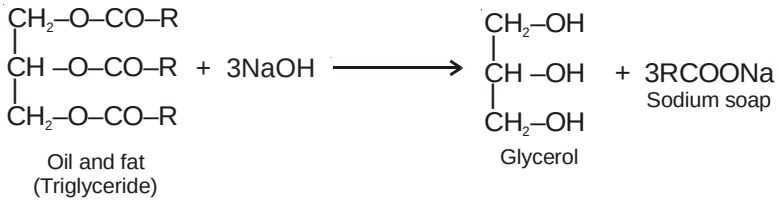
Soaps & Detergents

1. SOAPS :

Sodium and potassium salt of higher fatty acids are called soaps. Saturated and unsaturated monocarboxylic acids are called fatty acids. Stearic acid ($C_{17}H_{35}COOH$). Palmitic acid ($C_{15}H_{31}COOH$) and Oleic acid ($C_{17}H_{33}COOH$) are main examples of fatty acids, which are found in nature. Sodium salt of fatty acids are called sodium soaps or hard soaps or washing soaps, whereas potassium soap is called bathing soap of soft soap.

Saponification :

Oils and fats are chemically triesters of glycerol and fatty acids. Therefore, they are called triglycerides or triacylglycerol. They give glycerol and soaps on hydrolysis by a caustic alkali.



The quality of soap containing eight to eighteen carbon atoms is very good. Solubility in water decreases on having more number of carbon atoms and cleansing power decreases on having less number of carbon atoms.

1.1 Methods of Preparation of Soaps :

Soap can be prepared by the following methods.

[1] Cold Process :

In this method some starch is mixed with the oil or fat and the whole content is stirred with caustic alkali at ordinary temperature. This slowly hardens on leaving in moulds.

[2] Hot Process :

The follwing are the steps in hot process

[a] Saponfication : The oil or the fat is taken in an iron tub and heated with lye (10% solution of the caustic alkali). The reaction takes place on stirring.

Oil or fat + Lye $\longrightarrow$ Glycerol + Soap

[b] Precipitation of soap by salt : When common salt is added to the above mixture, the crude soap gets separated out due to common ion effect of sodium ion and float on the surface. It is removed from the solution and the solution left behind is called spent lye, which contains glycerol

[c] Purification : The curde soap obtained above is again heated with caustic alkali solution. when the amount of oil or fat that remained unreacted also undergoes complete saponification. Excess amount of alkali is removed by washing by hot water. The mass is then transferred into the moulds after mixing with sodium silicate, colours, perfumes, etc.

[3] Modern Method :

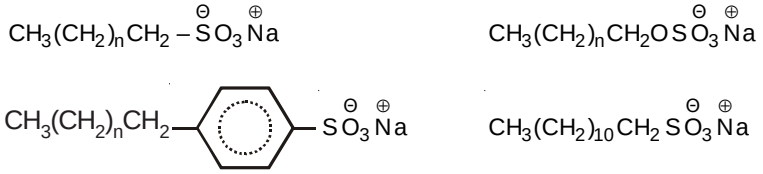
Non–a–days, glycerol and fatty acids are preapred on industiral scale by hydrolysis of oils and fats under high pressure and high temperature in the presnece of catalysts. Glycerol is removed from the aqueous solution, called sweet lye, after saparating the fatty acids are neutralised by caustic alkali solution by which soaps are prepared.

Oil or fat + Steam $\xrightarrow[\text{Catalyst}]{\text{High pressure and temperature}}$ Glycerol Solution (sweet lye) + Fatty acids (Precipitate)

Fatty acis + Alkali $\longrightarrow$ Soaps + Water

2. Detergents :

Chemically detergents are not soaps, but they have cleansing action similar to that of the soap. Therefore, these are sometimes referred to as soapless soaps. They are genrally sodium slats of sulphate or sulphonates of higher alkanes. Some detergents are sodium aralkylsulphonates or sulphates also For example



Sodium p–alkylbenzenesulphonate Sodium laurlysulphonate

2.1 Synthesis of Detergents :

[i] Oil or fat $\xrightarrow[\text{or by } H_2 \text{ at high pressure and temperature catalyst (a copper compound)}]{Na+C_2H_5OH}$ Glycerol + Primary alcohol (RCH_2OH)

$$R–CH_2OH \xrightarrow{H_2SO_4} R–CH_2OSO_3H \xrightarrow{NaOH} RCH_2O\,S\overset{\ominus}{O}_3\overset{\oplus}{N}a$$

A detergent (sodium alkylsulphate)

[ii] By Reed Reaction :

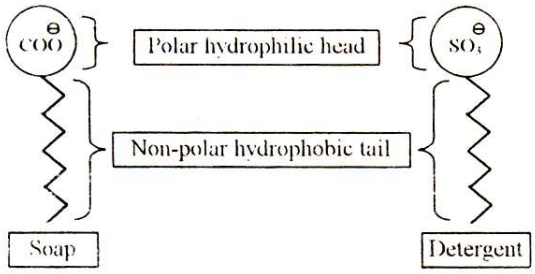
$$R–H + SO_2 + Cl_2 \longrightarrow R–SO_2Cl + HCl$$

$$R–SO_2Cl + 2NaOH \longrightarrow R–SO_2O^- \overset{+}{N}a + NaCl + H_2O$$

Sodium alkylsulphonate

3. Similarities between Soaps and Detergents :

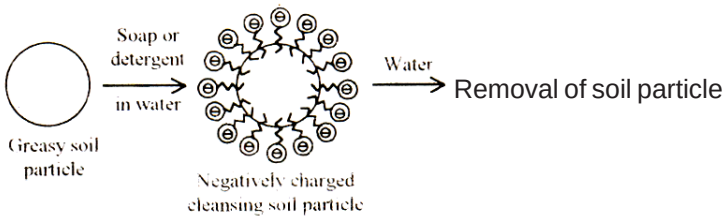
Sopas as well as detergents have cleasing action due to formation of lather in water, because the molecules of both have structural similties. They have a long hydrocarbon chain, on which a polar group is attahced at the terminal. The terminal group is called polar hydrophilic head and the long hydrocarbon chain is called nonpolar hydrophobic tail.



Soaps and detergents both the surface active and reduce the surface tenstion of water.

4. Cleansing Action of Soaps and Detergents :

The dirt attached to a fabric is actually the soil particles entangled in the grease or fat. When the fabric is soaked in the soap solution, the non–polar tails of a large number of molecules of soap or detergent get into the soily grease and the polar heads are oriented outwards all around the soild particle. Thus, the whole particle becomes polar. That is why the soil particle comes out of the fabric and goes into water.



5. Difference between Soaps and Detergents :

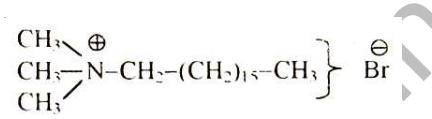
Sodium or potassium salts of higher monocarboxylic aliphatic acids are called soaps, whereas sodium salts of higher alkanesulphonic acids of alkane hydrogensulphates are called detergents. Therefore, there is a chemical difference between polar heads of soaps and detergents. Second difference is that soaps are the salts of RCOOH (which are weaker acids) and NaOH (which is a strong base), wherease detergents are the salts of stronger acid (RSO_3H or RSO_4H) and strong base, NaOH. This is the reason why the Ca^{++} or Mg^{++} ions present in hard water form insoluble calcium and magnesium salts on reacting with soap, because these are basically covalent in nature. Therefore soaps initially form precipitates of calcium and magnesium soaps. When all the Ca and Mg ions are removed, then only lather is given by soaps. Detergents give lather even in hard water, because their Ca and Mg salts are ionic in nature and therefore soluble in water.

Soaps give alkaline solutions in water due to hydrolysis, where as aqueous solutions of detergents are neutral. This is the reson why the detergents are used to wash woollen silk and other delicate clother, whereas soaps are not.

Some Other Examples of Detergents :

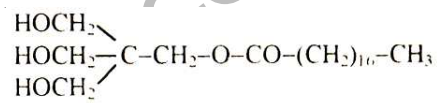
[i] Quaternary Ammonium Salts :

In trimethylstearylammonium bromide three small sized methyl groups and one long heptadecyl ($C_{17}H_{35}$) alkyl radical having an unbranached chain of seventeen carbon atoms are bonded to the positively charged nitrogen atom.



[ii] Monoesters of Polyhydroxy Compounds :

Pentaerthirtol monostearate is a nonoinic detergent because its polar head is not ionic yet it is hydrophilic due to the presence of hydroxy groups.



Chemistry in Action

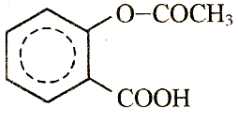
1. Drugs :

Discovery of many drugs for the treatment of many diseases is the greatest achievement of chemistry for the modern life of human being. Discovery of quinine for the treatment of malaria and synthesis of chloroquine, antibiotics to kill the germs, for example, discovery of penicillin, streptomycin, chloromycetin, terramycin and aureomycin and synthesis of sulpha drugs is regarded as greatest achievements of tIus chain.

Science of treatement of diseases by chemical compounds is called chemotherapy. The compounds used in chemotherapy are classified on the basis of their use. For example, analgesics reduce pain, antipyretics reduce fever, antibiotics, kill bacteria and other microorganisms, tranquillisers and sedatives calm down the nervous system.

1.1 Analgesics :

Analgesics are used as pain-killers. Aspirin is an important analgesic. Many hyphotic and anaesthetic medicines also have analgesic properties. For example, morphine, heroin, codeine, etc., but human being gets addicted by taking them.

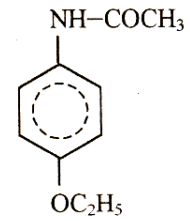


Aspirin
(Acetylsalicylic acid)
(2-Acetoxybenzoic acid)

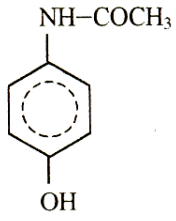
Aspirin should not be taken in empty stomach, because it increases acidity in the stomach, due to which inner membrane can get wounded and starts bleeding.

1.2 Antilpyretics :

Antipyretics are used to prevent fever. Aspirin has antipyretjc property along with analgesic property. Other antipyretic medicines are phenacetin and paracetamol.



Phenacetin

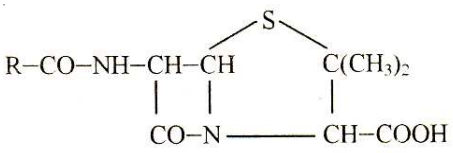


Paracetamol

Antipyretic medicines produce sweat and thereby reduce fever.

1.3 Antibiotics :

AntibiotIcs are the compounds which are prepared by microorganisms and which restrict growth of the other microorganisms or destroy them. In the year 1929. Alexander Fleming first discovered the antibiotic medicine penicillin from Penicillium notatum fungi. General formula of penicillin is as follows.

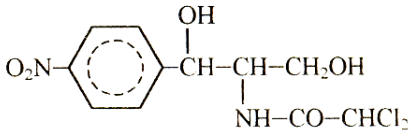


Penicillin

Due to different nature of R, many penicillin medicines are found in the nature.

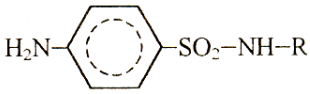
In India, the production of penicillin is carried out by Hindustan Antibiotics Limited, (H.A.L.). in Pimpri and Indian Drugs and Pharmaceuticals Limited, I.D.P.L., Hrishikesh.

Another antibiotic medicine, chloromycetin or chloramphenicol can be given orally. It is very useful in typhoid, dysentery, pneumonia, meningitis, etc. The structural formula of this medicine is as follows.



Chloramphenicol
(Chloromycetin)

Sulpha drugs are synthetic antibiotics whose general formula is as follows.

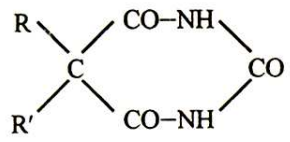


Sulpha drug

Different drugs are possible due to different nature of the group R. For example, sulphadiazine, sulphapyridinc, sulphaguanidine, sulphathiazole. etc.

1.4 Tranquillisers :

These medicines give relief from mental tension. They are main components of hypnotics. Derivatives of barbituric acid (or malonylurea) are important medicines of this family.



Barbituric acid derivative

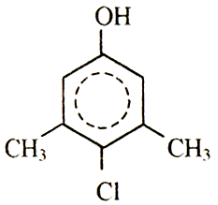
Due to different nature of Rand R', many medicines, called barbiturates or barbitals, have been synthesised.

1.5 Antiseptic and Disinfectants :

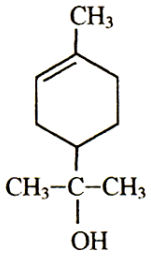
Antiseptic are the compounds, which kill microorganisms or restricts their growth. They can be applied on to skin, wounds, etc. In order to destroy bad smell generated by bacteria, they are also mixed in toothpaste, toothpowder, mouthwash, facewash, soaps, etc.

In inorganic antiseptics, chlorine, iodine and sulphur dioxides are important examples. 2–3% iodine is present in tincture iodine, which is dissolved in aqueous alcohol. Iodoform is also unstable and slowly decomposes to give iodine.

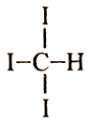
Many organic dyes attach to chromatin present in the nucleus of bacterial cell and make it inactive. Thus, bacteria are rendered ineffective. Methylene blue, mercurochrome, gentian violet, etc., are some important examples of the family of antiseptic dyes.



Chloroxylenol
(4-Chloro-3,5-dimethylphenol)



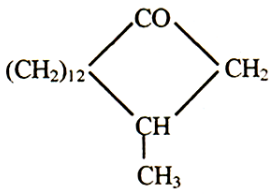
Terpeneol



Iodoform

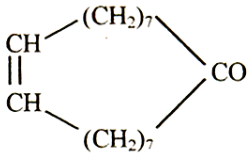
2. Pheromones :

Pheromones are the compounds, which are secreted by the animals and which affect the behaviour of other animal of same species. Pheromones have sharp odour. In many species of insect family, pheromones is secreted for sexual attraction. Presence of similar type of compounds in the tetrapodes is to attract animals of opposite sex. In the reproduction period, a sharp odour of musk comes from the odoriferous gland of the navel of tibetan musk Jeer. This odour is due to a compound called muscone. Its structure is given below.



Muscone

Musk-like odour coming from the civet gland of the civet cat is due to presence of an unsaturated cyclic ketone, civetone.



Civetone

Rocket Propellants :

The propulsion system in most space vehicles improvised with rocket engines powered with chemical propellants called rocket propellants.

"A propellant is a combination of : Fuel and oxidiser."

"When a propellant is ignited, it burns to release large quantities of hot gases which provide necessary thrust for the rocket to move forward following Newton's third law".

Energy of a propellant is measured in terms of specific impulse I_s.

$$I_s = \sqrt{\frac{Tc}{M}}$$

where Tc =Flame temperature inside the rocket motor.

M = Average molecular mass of the product gases coming out of the rocket nozzle.

Classification :

Solid propellants. Liquid propellants

Hybrid propellants

Solid Propellants :

Two types of solid propellants are :

[i] Composite propellants

[ii] Double base propellants

[i] Composite Propellants :

Composite propellant is made up of. Fuel,. Oxidiser and Additives

Fuel : Polyurethane or polybutadiene is used as a fuel.

Oxidiser : Ammonium perchlorate is used as oxidiser.

Additive : Aluminium or magnesium (finely divided form) is used as additive.

[ii] Double base Propellant :

Nitrocellulose gels in nitro glycerine sets as a solid mass acts as a double base propellant.

Note : Main difficulty with the solid propellant is that once ignited these will burn with predetermined rate, and to not have the start and stop capability.

Liquid Propellants :

Two types of liquid propellants are

[i] Monopropellants

[ii] Biliquid propellants

[i] Monopropellants :

Monopropellant is a single chemical compound which acts both as a fuel and oxidiser.

Examples :

Hydrazine, methyl nitrate, nitromethane and hydrogen peroxide.

Biliquid propellants :

Biliquid propellants possess both the fuel as well as oxidiser as liquids.

Examples :

Fuel : Kerosene, alcohol, hydrazine, monomethyl hydrazine, (MMH), unsymmetrical dimethyl hydrazine (UDMH), liquid hydrogen etc.

Oxidiser : N_2O_4, O_2, HNO_3 etc.

Note : Liquid propellants give higher thrust as compared to solid propellants. Further the flow of the liquid propellant can be regulated as such rate of combustion can be easily controlled.

Hybrid propellants :

Hybrid propellants are made of solid fuel and liquid oxidiser.

Example :

Solid fuel — acrylic rubber

Liquid oxidiser — liquid N_2O_4

Application of Propellants :

Space vehicle	Fuel	Oxidiser
• Titanballistic missile	N_2H_4	N_2O_4
• Proton (Russian rocket)	Kerosene	O_2 (liquid)
• Space shuttle	H_2 (liquid)	O_2 (liquid)
• Saturn booster	Kerosene (Initial state)	O_2 (liquid)
rocket	H_2 (liquid) [Upper stage]	O_2 (liquid)
•SLV – 3*	Polyurethane or	Ammonium
and ASLV*	polybutadiene	Perchlorate
• PSLV*	Solid propellant (First state)	N_2O_4
	UDMH (Second stage)	
	Solid propellant	
	(Third state)	
	MMH (Fourth stage)	N_2O_4

SLV–3* (Space Launch Vehicle–3)

ASLV* (Augmented Space Launch Vehicle)

PSLV* (Polar Space Launch Vehicle)