16. Chemistry in Everyday Life

Can you recall?

1. What are the components of balanced diet ?
2. Why is food cooked ? what is the difference in the physical states of uncooked and cooked food?
3. What are the chemicals that we come across in everyday life ?

The life, the atmosphere, the earth and the universe, all have evolved over billions of years to the present state. The evolution continues progress and accompanied by a variety of chemical changes. Natural phenomena such as weathering, lightening, irruption of volcanoes, photosynthesis, ripening of fruit, fermentation, release of fragrance by blooming flowers and many others take around us involve intricate chemistry. Chemistry is involved in a variety of life processes those occur within and across our body. Human civilization in different regions of the world discovered uses of various plant, animal and mineral products for benefits of human life. With the advent of modern science, scientist discovered structures of various constituent chemicals in natural materials. Synthetic organic chemistry has led to advancement in science. Synthesis of natural molecules and new molecules with structural variation revolutionalized materials are used in all the walks of human life. This influence is seen in all aspects of the basic needs, such as food, clothing, shelter and beyond.

In this chapter, we consider some aspects of **food chemistry**, **medicinal chemistry** and **chemistry of cleansing materials** with reference to compounds having simple structural features.

16.1 Basics of food chemistry

Food provides **nutrients** these are used by the body as the source of energy. These nutrients also regulate growth, maintain and repair body tissues. The nutrients comprise carbohydrates, lipids, proteins, vitamins, minerals and water. Grains, fruits and vegetables provide carbohydrates and vitamins; meat, fish, eggs, dairy products and pulses provide proteins and vitamins. Lipids are provided by vegetable oils, dairy products and animal fats.

Most nutrients are organic macromolecules. **Proteins** and **carbohydrates** are **polymeric** materials. As a result of food **digestion,** the polymeric proteins and carbohydrates ultimately break down into monomers, namely, α- **amino acids** and **glucose,** respectively, under the influence of **enzymes**. Cooking makes food easy to digest. During the cooking process, high polymers of carbohydrates or proteins are hydrolysed to smaller polymers. The uncooked food mixture, described as heterogeneous suspension, becomes a colloidal matter on cooking. Because of smaller size of the resulting constituent nutrient molecules, **cooked food** is easier to digest than the uncooked food.

16.1.2 Food quality chemistry :

Just think

1. Why is food stored for a long time ?
2. What methods are used for preservation of food ?
3. What is meant by quality of food ?

Quality of food is an important aspect of food chemistry. Food quality is described in terms of parameters such as flavour, smell, texture, colour and microbial spoilage. Enzymes are present naturally in all foods.

Quality of foods changes on shelving mostly due to enzyme action, chemical reactions with the environment and the action of microorganisms. Some of these effects are beneficial. For example, setting of milk into curd and raising flour dough to make bread is brought about by deliberate action of microorganisms. Most changes brought about by microorganisms and interaction with the environment however, adversely affect the food quality.

Problem 16.1

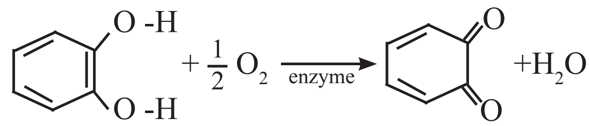
How are the chemical reactions of food stuff with the environment controlled during storage ?

Solution :

Primarily the oxygen and microorganisms in air are responsible for adverse effects on stored food. The exposure of stored food to atmosphere is minimized by storing them in air tight container, evacuation or filling the container with N_2 gas. Rate of a chemical reaction decreases with the lowering of temperature. Thus refregeration is useful for controlling chemical reaction of food stuff with envrionment. The reactions of food stuff with environment are catalyzed by enzymes. Due to boiling, the enzymes become denatured and the reactions are controlled.

Food preservation and food processing methods aim at prevention of undesirable changes and attempt about desirable changes in food. The following cases illustrate some aspects of food quality and the underlying chemisty.

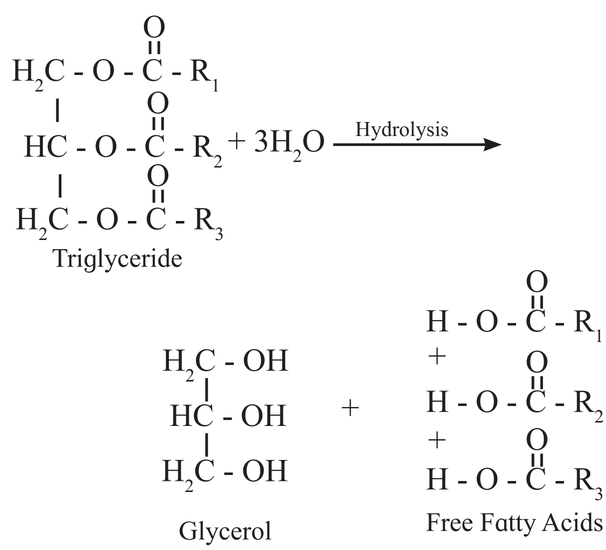
i. Browning of cut fruit/vegetables : When fruits such as banana, apple or vegetables such as potato, bottelgourd are peeled and sliced, sooner or later they turn brown. Cutting action damage the cells resulting in release of chemicals. With the pH prevailing in fruit/vegetables, the polyphenols released are oxidised with oxygen in air owing to action from an enzyme to form quinones.



a poly phenol a quinone

Quinones undergo further reactions including polymerization giving brown coloured products named **tannins**. This browning reaction can be slowed down using reducing agents such as SO_2, ascorbic acid (vitamin C) or by change of pH by adding edible acid such as lemon juice (citric acid) or vinegar.

ii. Rancidity of oils and fats : On keeping for long time, oils and fats develop an unpleasant or **rancid** smell and disagreeable taste. Fats are triesters of fatty acids (long chain carboxylic acids) and glycerol (propane - 1, 2, 3 - triol). One cause of rancidity is release of fatty acids produced during hydrolysis of fats brought about by water present in food.



The hydrolysis of fats occurs rapidly in the presence of certain microorganisms and is an enzyme catalysed reaction. Rancidity of milk and butter is due to the release of four, six and eight carbon fatty acids (butanoic, hexanoic and octanoic acids) on hydrolysis. Chocolate develops oily or fatty flavour due to release of palmitic, stearic and oleic acids on hydrolysis. Lauric acid on hydrolysis gives a soapy flavour to coconut oil.

The second cause of rancidity of oils and fats is **oxidation** by molecular oxygen in the air. Many vegetable oils have one or more C=C double bonds in the fatty acid part of their structure. These are called mono or poly unsaturated fats. The unsaturated fat molecules break down during the oxidation and form **volatile aldehydes** and **carboxylic acids** which give the unpleasent rancid taste.This is called **oxidative rancidity.** It is caused by **free radical** reaction initiated by light (photo oxidation) or catalysed by either enzymes or metal ions. Polyunsaturated oils containing greater number of C=C double bonds and usually become rancid very quickly. High temperature increases the rate of air oxidation of unsaturated fats. Extensive oxidation can leads to some **polymerization** with consequent increase in viscosity and browning.

iii. Saturated, unsaturated and trans fats :

Can you recall?

1. How is Vanaspati Ghee made ?
2. What are the physical states of peanut oil, butter, animal fat, vanaspati ghee at room temperature ?

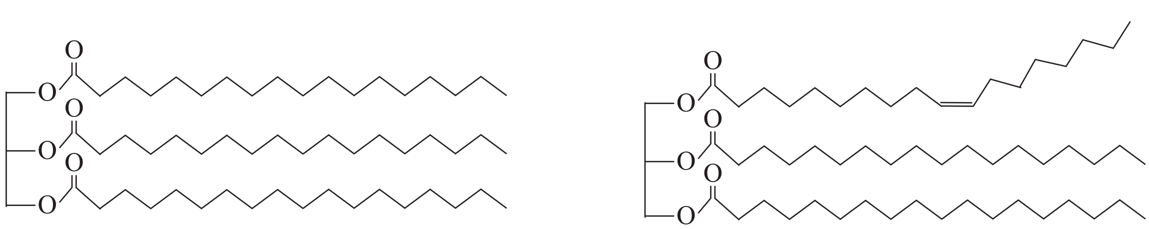
You have noted earlier that fats are triglycerides of fatty acids. Animal fats mostly contain saturated fatty acids, while vegetable oils contain unsaturated fatty acids as well. Long chains of tetrahedral carbon atoms in a saturated fatty acid get packed closely together. Moreover, van der Waal's forces between the long saturated chains are sufficiently strong to convert saturated fats into solid form at room temperature.

The long carbon chains of unsaturated fatty acids contain one or more C=C double bonds. This produces one or more '**kinks**' in the chain, (see the Fig. 16.1) which prevent the molecules from packing closely together. The van der Waals forces between the unsaturated chains are weak. The melting points of unsaturated fats therefore, are lower.

Natural fats are mixtures of triglycerides. They do not have sharp melting points, and usually melt over a range of temperatures. The more unsaturated the fat lower is its melting point and less crystalline it is. Some examples of fats are given in Table 16.1.

A C=C can have geometrical isomers **cis and trans**. In the **cis** form of an unsaturated fatty acid the two hydrogens on the two double bonded carbons are on the same side of the double bond, whereas they are on the opposite sides in the **trans** isomer. The **cis** isomer is the most common form of unsaturated fats. The **trans** form occurs only in animal fats and processed unsaturated fats. **Trans fats** are **difficult to metabolize** and may build up to dangerous levels in fatty tissue.

Fats in the form of **lipoprotein** are used in the body for transport of cholesterol. Excessive low density lipoprotein **(LDL)** results in deposition of **cholesterol in blood vessels**, which in turn, results in the increased risk of cardio vascular disease. There is some evidence that eating large amounts of saturated or trans unsaturated fats, increase the tendency of cholesterol getting deposited in blood vessels. Cis fats do not cause formation of such deposits and decrease chance of developing coronary heart disease.



a. A saturated fat molecule

b. An unsaturated fat molecule.

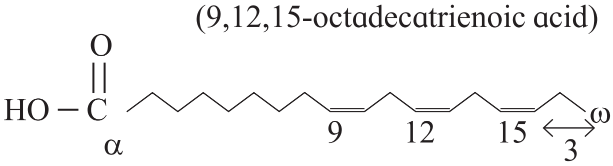
Fig. 16.1 Molecular shapes of fats (A schematic representation)

Table 16.1 : Natural fats and their physical states

Mainly Saturated fats	Mainly mono-unsaturated fats	Mainly poly-unsaturated fats
Coconut fat/oil, butter fat, lard, margarine, vanaspati ghee	Olive oil, peanut oil, canola oil	Safflower oil, sunflower oil, soyabean oil, corn oil, fish oil
solid	liquid	liquid

iv. Omega-3 : Two categories of the natural unsaturated fats of concern include those containing either Omega-3 or Omega-6 fatty acids. These names are given for the position of the double bond in a long carbon chain of the fatty acid. Omega denotes the last carbon of the carbon chain. Omega-3 fatty acids have C=C bond between the third and fourth carbon from the end of a carbon chain.

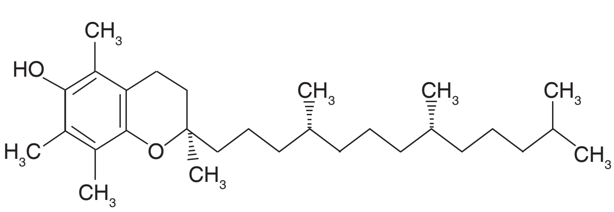
For example : Linolenic Acid (9,12,15-octadecatrienoic acid)



Omega-3 fats are found to raise the High density lipoprotein HDL (good cholesterol) level of blood. On the contrary, Omega-6 fats are considered to have risk of high blood pressure. Foods such as walnuts, flaxseeds, chia seeds, soyabeans, cod liver oil are rich source of Omega- 3 fatty acids.

v. Antioxidants as food additives : An antioxidant is a substance that delays the onset of oxidation or slows down the rate of oxidation of food stuff. It is used to extend the shelf life of food. Antioxidants react with oxygen-containg free radicals and thereby prevent oxidative rancidity.

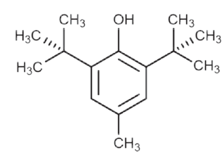
For example, vitamin E (tocopherol) is



Vitamin E (Tocopherol)

a very effective natural antioxidant which is added to pack edible oils. The phenolic OH group in its structure is responsible for its antioxidant activity, while the long chain of saturated carbons makes it fat soluble. It is found in foods such as wheat germ, nuts, seeds, green leafy vegetables and oils like safflower oil.

For economic reason **synthetic antioxidants** are used as additives to increase the shelf-life of packed foods. Common structural units found in synthetic antioxidants are phenolic OH group and tertiary butyl group. For example BHT, which is 3, 5-di-tert-butyl-4-hydroxytoluene.



BHT

16.2 Compounds with medicinal properties

Can you tell?

1. What type of medicine is applied to a bruise ?
2. When is an antipyretic drug used ?
3. What is meant by a broad spectrum antibiotic ?
4. What is the active principle of cinnamon bark ?

A chemical which interacts with biomolecules such as carbohydrates, lipids, proteins and nucleic acid and produces a biological response is called **drug**. A drug having therapeutic and useful biological response is used as **medicine**. A medicine contains a drug as its **active ingredient**. Besides it contains some additional chemicals which make the drug suitable for its use as medicine. Medicines are used in diagnosis, prevention and treatment of a disease.

Drugs being foreign substances in a body, often give rise to undersirable, adverse side effects.

Drug design is an important branch of medicinal chemistry which aims at synthesis of new molecules having better biological response. There is an increasing trend in the current research in medicinal chemistry to take cognizance of traditional medical knowledge such as Ayurvedic medicine or natural materials to discover new drugs.

In this section, we consider some simple compounds having medicinal properties and active ingredients of some natural materials those are traditionally known to possess medicinal properties.

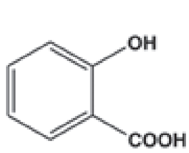
Do you know ?

The drug manufacturing companies usually have a patent for drugs which are sold with the brand name. After the expiry of patent the drug can be sold in the name of its active ingredient. These are called generic medicines.

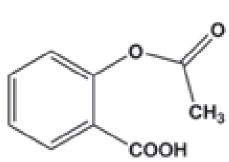
16.2.1 Analgesics and antipyretics

'Algesis' is a Greek word meaning 'feeling of pain.' Drugs which give relief from pain are called analgesics. About half of the analgesics are anti-inflammatory drugs, which kill pain by reducing inflammation or swelling. Antipyretics are used to reduce fever.

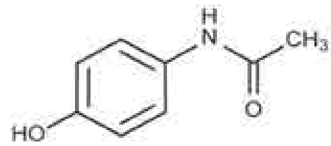
Pain-killing and fever reducing properties of an extract of bark of willow plant (commonly found in Europe) have been known for centuries. In nineteenth century its active ingredient, **salicylic acid** (2-hydroxybenzoic acid) was isolated and purified. The compound **aspirin** which is acetyl derivative of salicylic acid was found to have a fewer side effects than salicylic acid. It is one of the most widely used analgesic to date. It however, retains stomach irritating side effects of salicylic acid. A less problematic pain-killer is **paracetamol**, which is a phenol.



Salicylic acid



Aspirin (prodrug)

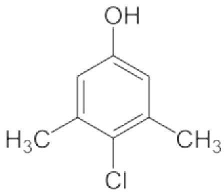


Molecular structure of paracetamol

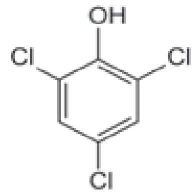
16.2.2 Antimicrobials :

The name **antimicrobial** is an umbrella term for any drug that inhibits or kills microbial cells that include bacteria, fungi and viruses. **Disinfectants** are non-selective antimicrobials, which kill a wide range of microorganisms including bacteria. Disinfectants are used on non-living surfaces for example, floors, instruments, sanitary ware and many others. **Antiseptics** are used to sterilise surfaces of living tissue when the risk of infection is very high, such as during surgery, on wounds and so on. **Antibiotics** are a type of antimicrobial designed to target bacterial infections within or on the body.

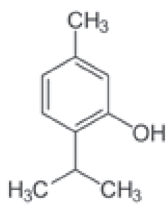
a. Antiseptics and disinfectants : Commonly used antiseptics include **inorganics** like iodine and boric acid or **organics** like iodoform and some phenolic compounds. Tincture of iodine (a 2 - 3 percent solution of iodine in alcohol- water mixture) and iodoform serve as powerful antiseptics and find use to apply on wounds. A dilute aqueous solution of boric acid is a weak antiseptic used for eyes. Various phenols are used as antiseptics and disinfectants. A dilute aqueous solution of phenol (known as **carbolic acid**) was one of the first antiseptic used in medicine in the late nineteenth century. It was however, found to be corrosive. Many chloro derivatives of phenols have been realized as more potent antiseptics than the phenol itself. They can be used with much lower concentrations, which reduce their corrosive effects. Two of the most common phenol derivatives in use are trichlorophenol (TCP) and chloroxylenol. The latter is the active ingredient (4.8 % W/V) of the popular antiseptic dettol. The other ingredients of dettol are isopropyl alcohol, pine oil, castor oil soap, caramel and water. Thymol obtained from oil of thyme (a spice plant) is an excellent non-toxic antiseptic. The p-chlorobenzyl phenol is used as disinfectant in all purpose cleaners.



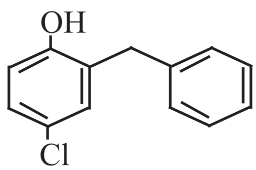
Chloroxylenol



2, 4, 6 Trichlorophenol

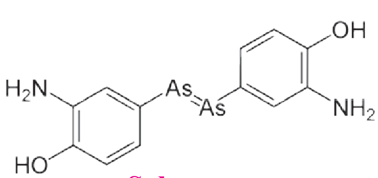


Thymol

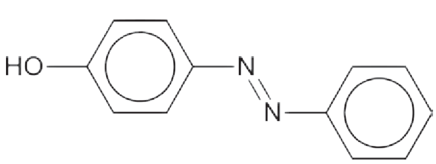


p - Chloro - o - benzylphenol

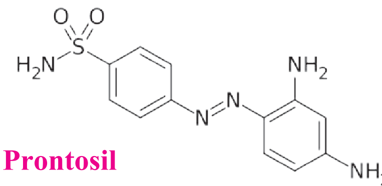
b. Antibiotics : Antibiotics are purely synthetic or obtained from microorganisms (bacteria, fungi or molds). Arsenic compounds were known to be highly poisonous to humans since long. **Paul Ehrlich,** German bacteriologist investigated arsenic based organic compounds in order to produce less toxic substances for the treatment of syphillis. He discovered the first effective treatment of syphilis, the synthetic antibiotic named **salvarsan**. He was awarded the Nobel prize for medicine (1908) for this discovery. Ehrlich noticed similarily in the structures of salvarsan and azodyes. With further investigations he succeded in synthesis of an effective diazo antibacterial, pronitosil, in 1932. Subsequently it was discovered that prontosil gets converted into a simpler compound sulphanilamide in our body. This gave further direction to research in drug design which led to discovery of a wide range of sulpha drugs, analogues to sulphanilamide. One of the most effective being **sulphapyridine**.



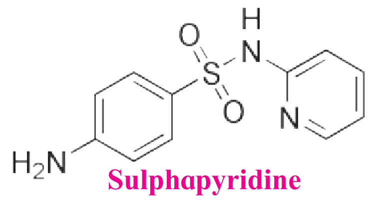
Salvarsan



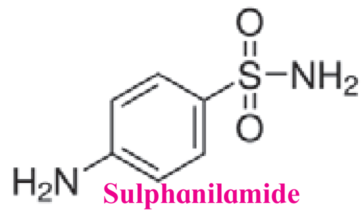
Azodye



Prontosil

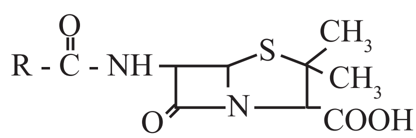


Sulphapyridine

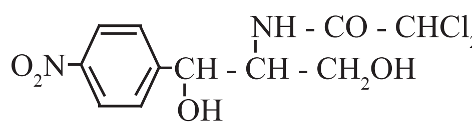


Sulphanilamide

In 1929, **Alexander Fleming** discovered the antibacterial properties of a penicillium fungus. The clinical utility of the purified active ingredient penicillin as antibiotic drug was established in the next thirteen years. This is the first antibiotic of microbial origin. Chloramphenicol, isolated in 1947 is another antibiotic of microbial origin.



General structure of penicillin



Chloramphenicol

Antibiotics can be of three types : broad spectrum (effective against wide range of bacteria), narrow spectrum (effective against one group of bacteria) or limited spectrum (effective against single organism).

A disadvantage of broad spectrum antibiotics is that they also kill the useful bacteria in the alimentary canal. Today many broad spectrum, narrow spectrum and limited spectrum antibiotics are known. They are synthetic, semisynthetic or of microbial origin.

6.2.3 Traditional knowledge in medicine

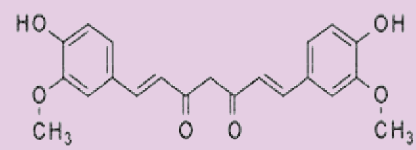
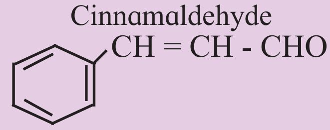
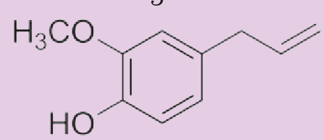
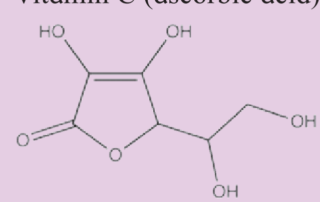
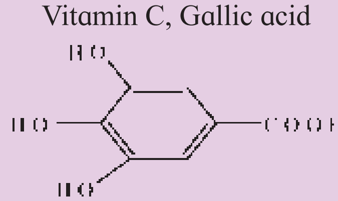
Do you know ?

The turmeric patent battle :

India won the legal against US patent and Trademark office (PTO) in 1997 and protected its intelectual property of traditional Indian knowledge about turmeric against patenting. Dr. Raghunath Mashelkar, the then Director General of the concil of Scientific and Industrial Research, New Delhi, India led this case and upheld the national pride. In this year long battle the CSIR argued that turmeric, a native Indian plant, had been used for centuries by its people for wound healing.

Since ancient times, in India, many *grandma remedies* are practised for curing ailments. The ancient medicinal system of India has documented medicinal uses of innumerable Indian plants. There is an increasing trend in the modern medicinal chemistry to make use of the traditional knowledge from various parts of world, to isolate active ingredients from medicinal plants and further develop new drugs. Table 16.2 enlists a few medicinal plants, their medicinal property and active ingredients therein.

Table 16.2 Active ingredients of some medicinal plants

Plant	Medicinal property	Name and structure of the active ingredient
Turmeric	antiseptic	Curcumin 
Wintergreen	analgesic	Methyl salicylate 
Cinnamon	antimicrobial for colds	Cinnamaldehyde 
Clove	antimicrobial, analgesic	Eugenol 
Citrus fruits	antioxidant	Vitamin C (ascorbic acid) 
Indian gooseberry (amla)	antidiabetic, antimicrobial antioxidant	Vitamin C, Gallic acid 

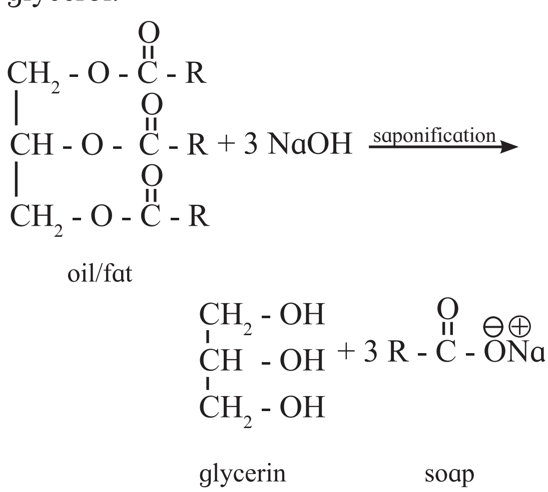
16.3 Cleansing Agents : Cleansing agents are substances which are used to remove stain, dirt or clutter on surfaces. They may be natural or synthetically developed.

Can you tell?

- Can we use the same soap for bathing as well as cleaning utensils or washing clothes ? Why ?
- How will you differentiate between soaps and synthetic detergent using borewell water?

16.3.1 Types of cleansing agents : Commercially cleansing agents are mainly of two types depending upon chemical composition : **soaps** and **synthetic detergents**.

a. Soaps : Soaps are sodium or potassium salts of long chain fatty acids. They are obtained by alkaline hydrolysis of natural oils and fats with NaOH or KOH. This is called **saponification** reaction. Chemically oils are triesters of long chain fatty acids and propan-1, 2,3-triol commonly known as **glycerol** or **glycerin**. Saponification of oil produces soap and glycerol.



The quality of soap depends upon the nature of oil and alkali used. Potassium soaps are soft to skin. Therefore toilet soaps are prepared by using better grades of oil and KOH. Care is taken to remove excess of alkali. Laundary soaps are made using NaOH. These also contain fillers like sodium rosinate (a lathering agents), sodium silicate, borax, sodium and trisodium phosphate.

Hard water and soap : Soaps are water soluble. They form scum in hard water and become inactive. This is because hard water contains dissolved salts of calcium and magnesium, which react with soap, precipitating calcium or magnesium salt of fatty acid (scum) which sticks to fabric.

$$2\ R\text{-}COONa\ (aq) + CaCl_2(aq) \longrightarrow (R\text{-}COO)_2Ca(s) + 2NaCl(aq)$$

Washing soda (Na_2CO_3) precipitates the dissolved calcium salts as carbonate and helps the soap action by softening of water.

b. Synthetic detergents : Synthetic detergents are man made cleansing agents designed to use even in hard water. There are three types of synthetic detergents, anionic detergents, cationic detergents and nonionic detergents. i. Anionic detergents are sodium salts of long chain alkyl sulphunic acids or long chain alkyl substituted benzene sulphonic acids. ii. Cationic detergents are quaternary ammonium salts having one long chain alkyl group. iii. Nonionic detergents are ethers of polyethylene glycol with alkyl phenol or esters of polyethylene glycol with long chain fatty acid. Table 16.3 displays some syntheic detergents.

Mechanism of cleansing action : Soaps and detergents bring about cleansing of dirty, greasy surfaces by the same mechanism. Dirt is held at the surface by means of oily matter and, therefore, cannot get washed with water. The molecules of soaps and detergent have two parts. One part is polar (called head) and the other part is long nonpolar chain of carbons (called tail).

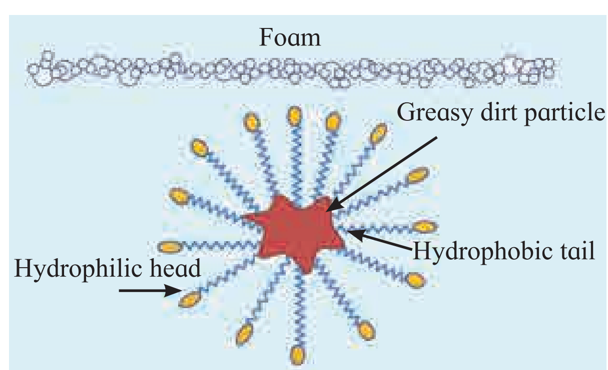
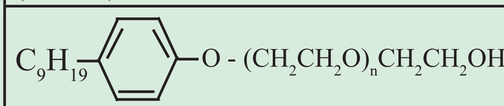


Fig. 16.2 : Soap micelle at work

The polar head (**hydrophilic**) can dissolve in water which is polar solvent. The nonpolar tail (**hydrophobic**) dissolve in oil/fat/grease. The molecules of soap/detergent are arranged around the oily droplet such that the nonpolar tail points towards the central oily drop while the polar head is directed towards the water. (see Fig. 16.2) Thus, micelles of soap/detergent are formed surrounding the oil drops, which are removed in the washing process.

Table 16.3 Synthetic detergents

Type	Example	Use
Anionic detergent	(sodium lauryl sulphate) $CH_3(CH_2)_{10}CH_2OSO_3^{\ominus}Na^{\oplus}$	Household detergent, additive in toothpaste
Cationic detergent	$CH_3(CH_2)_{15}$-$N^{\oplus}(CH_3)_3Br^{\ominus}$ (ethyltrimethyl ammonium bromide)	hair conditioner, germicide
Nonionic detergent	$CH_3(CH_2)_{16}$- COO (CH_2CH_2O)n CH_2 CH_2OH (an ester)	liquid dishwash
	 (an ether)	liquid detergent

Exercises

1. Choose correct option

A. Oxidative Rancidity is .... reaction
   a. addition b. subtitution
   c. Free radical d. combination

B. Saponification is carried out by ....
   a. oxidation b. alkaline hydrolysis
   c. polymarisation
   d. Free radical formation

C. Aspirin is chemically named as ....
   a. Salicylic acid
   b. acetyl salicylic acid
   c. chloroxylenol d. thymol

D. Find odd one out from the following
   a. dettol b. chloroxylenol
   c. paracetamol d. trichlorophenol

E. Arsenic based antibiotic is
   a. Azodye b. prontosil
   c. salvarsan d. sulphapyridine

F. The chemical used to slow down the browning action of cut fruit is
   a. SO_3 b. SO_2
   c. H_2SO_4 d. Na_2CO_3

G. The chemical is responsible for the rancid flavour of fats is
   a. Butyric acid b. Glycerol
   c. Protein d. Saturated fat

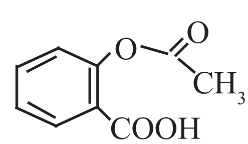
H. Health benefits are obtained by consumption of
   a. Saturated fats
   b. trans fats
   c. mono unsaturated fats
   d. all of these

2. Explain the following :

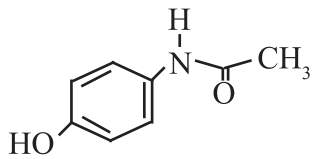
A. Cooking makes food easy to digest.
B. On cutting some fruits and vegetable turn brown.
C. Vitmin E is added to packed edible oil.
D. Browning of cut apple can be prolonged by applying lemon juice.
E. A diluted solution (4.8 % w/v) of 2,4,6-trichlorophenol is employed as antiseptic.
F. Turmeric powder can be used as antiseptic.

3. Identify the functional grops in the following molecule :

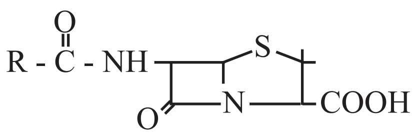
A. Aspirin



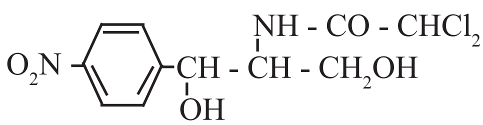
B. Paracetamol



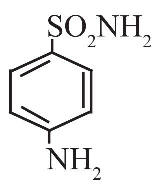
C. Penicillin



D. Chloramphenicol



E. Sulphanilamide



F. Glycerin

CH_2- OH
CH - OH
CH_2- OH

4. Give two differences between the following

A. Disinfectant and antiseptic
B. Soap and synthetic detergent
C. Saturated and unsaturated fats
D. Rice flour and cooked rice

5. Match the pairs.

A group	B group
A. Paracetamol	a. Antibiotic
B. Chloramphenicol	b. Synthetic detergent
C. BHT	c. Soap
D. Sodium stearate	d. Antioxidant
	e. Analgesic

6. Name two drugs which reduce body pain.

7. Explain with examples

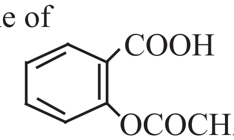
A. Antiseptics
B. Disinfectant
C. Cationic detergents
D. Anionic detergents
E. Non-ionic detergents

8. Explain : mechnism of cleansing Action of soap with flow chart.

9. What is meant by broad spectrum antibiotic and narrow spectrum antibiotics?

10. Answer in one senetence

A. Name the painkiller obtained from acetylation of salicyclic acid.
B. Name the class of drug often called as painkiller.
C. Who discovered penicillin?
D. Draw the structure of chloroxylenol and salvarsan.
E. Write molecular formula of Butylated hydroxy toulene.
F. What is the tincture of iodine ?
G. Draw the structure of BHT.
I. Write a chemical equation for saponification.
J. Write the molecular formula and name of



11. Answer the following

A. Write two examples of the following.
a. Analgesics
c. Antiseptics d. Antibiotics
e. Disinfectant
B. What do you understand by antioxidant ?

Activity :

Collect information about different chemical compounds as per their applications in day-to-day life.

Modern Periodic Table

Z
Symbol
Name
Atomic Mass

Groups →

Periods ↓	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H Hydrogen 1.008																	2 He Helium 4.003
2	3 Li Lithium 6.941	4 Be Berylium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Flourine 18.998	10 Ne Neon 20.180
3	11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
4	19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Cromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798
5	37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yattrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.293
6	55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71 La Lanthonids	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium 208.982	85 At Astanine 209.987	86 Rn Radon 222.018
7	87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 Ac Actinoids	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (280)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (289)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)

Series ↕

57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.243	61 Pm Promethium 231.036	62 Sm Samarium 231.036	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 231.036	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 162.500	99 Es Einstenium (254)	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium (262)

Alkali metal | Alkaline Earth | Transition Metal | Basic Metal | Metalloid | Nonmetal | Halogen | Nobal Gas | Lanthanoid | Actinoid