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UNIT

1

VITAMINS AND DRUGS

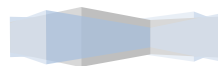
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1.0 AIMS AND OBJECTIVES

After studying this unit, you should be able to:

- Define vitamins and classify them
- Explain the sources and physiological functions of vitamins
- Describe the deficiency symptoms of vitamins
- Define and differentiate some important drugs



1.1 DEFINITION AND TYPES OF VITAMINS

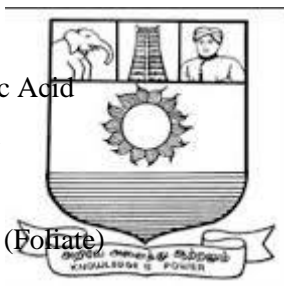
A vitamin is an organic compound and a vital nutrient that an organism requires in limited amounts. Thirteen vitamins are universally recognized at present. Vitamins are classified by their biological and chemical activity. Our body cannot produce vitamins itself, so must be supplied through food.

Types of vitamins:

There are two types of vitamins: fat-soluble and water-soluble. Fat-soluble vitamins are stored in our fat cells. Water-soluble vitamins are not stored in our body; therefore, they need to be replenished daily.

Water soluble vitamins:

- Vitamin B1 or Thiamin
- Vitamin B2 or Riboflavin
- Vitamin B3 or Niacin
- Vitamin B5 or Pantothenic Acid
- Vitamin B6 or Pyridoxine
- Vitamin B7 or Biotin
- Vitamin B9 or Folic Acid (Folate)
- Vitamin B12
- Vitamin C or Ascorbic acid



Fat soluble vitamins:

- Vitamin A or Retinol
- Vitamin D or Cholecalciferol
- Vitamin E or Tocopherol
- Vitamin K or phytonadione

1.2 SOURCES, FUNCTIONS AND DEFICIENCY SYMPTOMS OF WATER-SOLUBLE VITAMINS:

1.2.1 Sources of water-soluble vitamins

Vitamin B complex:

Bananas, kidney beans, nuts, citrus fruits, leafy vegetables, whole grains and cereals are some of the food sources of vitamin B complex.

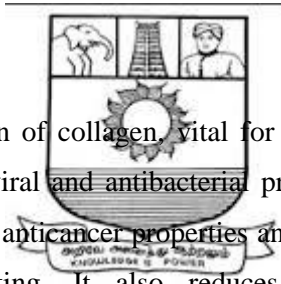
Vitamin C:

Berries such as cranberries, strawberries, raspberries, blueberries and fruits such as pineapple, papaya, mango, kiwi, squash, melon, tomatoes, citrus fruits and leafy vegetables, red/green peppers, potatoes, broccoli and cauliflower are some of the foods loaded with vitamin C.

1.2.2 Functions of water-soluble vitamins

Vitamin B complex:

Vitamin B complex is imperative for promoting healthy nervous system. Pyridoxine (vitamin B6) and Niacin (vitamin B3) are the main components strengthening the nervous system. Vitamins B12, B6 and B1 are compulsory for effective functioning of the brain. Vitamin B5 is fundamental for the production of particular hormones enabling proper functioning of the adrenal glands. Vitamin B3 controls the production of stress hormones, providing a “feel good” factor preventing symptoms of anxiety and stress. Vitamin B6, B3, B2 and B1 aid proper digestion. Vitamin B1 improves appetite, Vitamin B3 keeps the tongue in shape helping in the process of digestion. Vitamin B9 helps to maintain healthy gastrointestinal tract.



Vitamin C:

Vitamin C helps in the formation of collagen, vital for the development of strong bones, teeth and joints. It contains antiviral and antibacterial properties preventing infections and boosts the immune system. It has anticancer properties and hence reduces risk of cancer and prevents abnormal blood clotting. It also reduces potential risk of scurvy and cataracts. Vitamin C improves cardiac health by maintaining healthy triglyceride, cholesterol, blood sugar and blood pressure levels. It enables easy absorption of iron and help convert food to energy. It is also responsible for the production of anti stress hormones and facilitate appropriate adrenal function.

1.2.3 Deficiency symptoms of water-soluble vitamins

Vitamin B complex:

Skin disorders, hair fall, muscle spasm, pain in the abdomen, depression, anaemia and fatigue are some of the symptoms associated with vitamin B deficiency.

Vitamin C:

Low levels of vitamin in the body may lead to digestive disorders, periodontal disease, joint ache, bruises, fractures, slow healing of wounds, general weakness and loss of appetite.



1.3 SOURCES, FUNCTIONS AND DEFICIENCY SYMPTOMS OF FAT-SOLUBLE VITAMINS

1.3.1 Sources of fat-soluble vitamins

Vitamin A:

Dietary sources of vitamin A include milk, dairy products such as cheese, butter, yogurt, fish liver oils, eggs, chicken, liver, beef, fruits like mangoes, peaches, apricots, leafy vegetables, pumpkin, carrots and sweet potatoes.

Vitamin D:

Dairy products and milk are loaded with vitamin D in abundance. So also are cereals, liver, eggs, cod liver oils and oily fish such as sardines, salmon and herring.

Vitamin E:

Richly endowed with vitamin E are walnuts, almonds, sunflower seeds, Green leafy vegetables, liver, fortified cereals, mangoes, broccoli, spinach, Sweet potatoes, asparagus, butter, and oils like olive, safflower, peanut, sunflower and sesame.

Vitamin K:

Leafy green vegetables, soybeans, dairy products, meats, legumes and vegetables are some of the sources of Vitamin K.



1.3.2 Functions of fat-soluble vitamins

Vitamin A:

Vitamin A improves immune health, maintain healthy mucous membranes and battle against diseases. It helps develop strong teeth, healthy bones, protect against cataracts, arthritis, cardiac problems and age related macular degeneration. Vitamin A contains anti ageing properties that prevent formation of fine lines and wrinkles on the skin assisting in cell rejuvenation.

Vitamin D:

Since Vitamin D is concerned with calcium metabolism, they control the absorption of phosphorous and calcium from the small intestine. Therefore it is vital for the development of strong teeth and healthy bones.

Vitamin E:

Vitamin E supports cardiac health by maintaining healthy cholesterol levels. It protects the body from free radicals and prevents infections thereby enhancing the body's immune system. Apart from this, it also reduces the risk of cancers of the prostate and the breast. Vitamin E when applied locally on the skin removes stretch marks, scars and relieves burns. Combined with Vitamin A and C, it delays the process of ageing preventing formation of fine lines and wrinkles, keeping the skin soft, supple and smooth.

Vitamin K:

Vitamin K keeps coronary artery diseases at bay, prevents formation of kidney stones and regulates calcium level in the body that is responsible for building strong healthy bones and teeth. It helps in elevation of bone mass thus preventing osteoporosis.

1.3.3 Deficiency symptoms of fat-soluble vitamins

Vitamin A:

Vision problems including night blindness, growth retardation, low resistance often leading to infectious diseases, fatigue, depression, anxiety, kidney stones, bladder problems, skin disorders, anaemia, sleeplessness, nerve damage and gum disease are some of the symptoms correlated with Vitamin A deficiency.

Vitamin D:

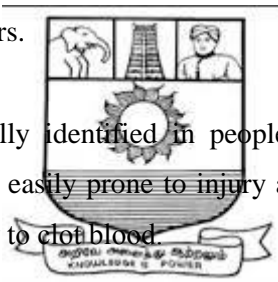
Vitamin D deficiency may lead to osteomalacia, rickets, sleeplessness, weak bones, muscles and osteoporosis.

Vitamin E:

Vitamin E deficiency causes anemia, problems of reproductive system, renal deterioration, cardiac problems and skin disorders.

Vitamin K:

Vitamin K deficiency is generally identified in people with improper digestive health. People deficient in vitamin K are easily prone to injury and bruises, which becomes rather critical, due to the body's inability to clot blood.



1.4 DEFINITION OF DRUGS

Microorganisms like bacteria, fungi, viruses and protozoa cause many infectious diseases.

Example: Pneumonia, tuberculosis and diphtheria are caused by bacteria. Malaria, syphilis and dysentery are caused by protozoa. Influenza, small pox polio, measles cholera are caused by viruses. The chemical substances employed in the treatment of infectious diseases are referred to as drugs. In the past almost all medicines were extracted from plants. Now adays synthetic drugs are widely used.

1.5 SOME IMPORTANT DRUGS

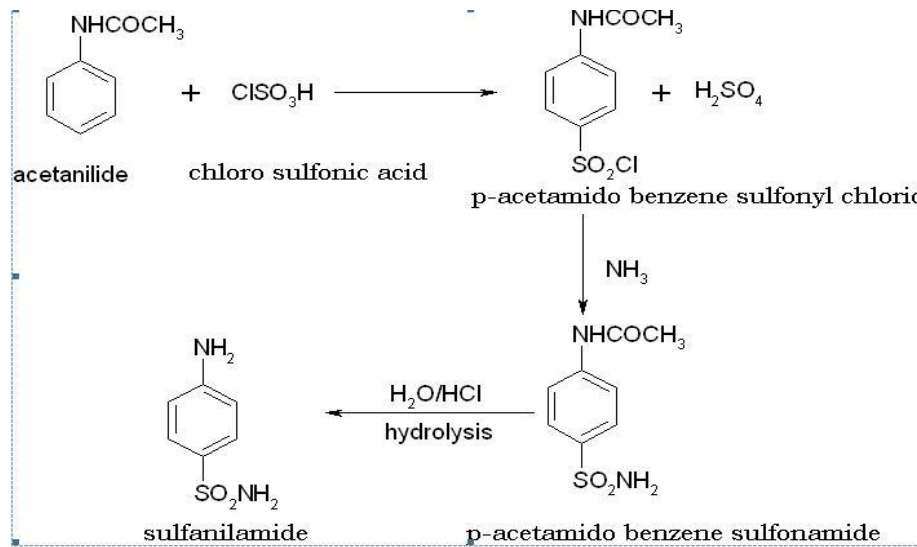
1.5.1 Antibacterials

These are synthetic drugs widely used for the cure of bacterial infections in man. These are derivatives of sulphanilamide. Thus antibacterials are also known as sulpha drugs.

Example: Sulphadiazine, sulphapyridine, ciprofloxacin

Sulphonamide

Sulpha drugs are readily prepared from p-acetyl sulphanilyl chloride which in turn is obtained by chlorosulphonation of acetanilide. p-acetylsulphanilyl chloride with ammonia followed by hydrolysis produce sulphonamide.



Use:

In the control of infections such as pneumococci, streptococci, meningococci etc.

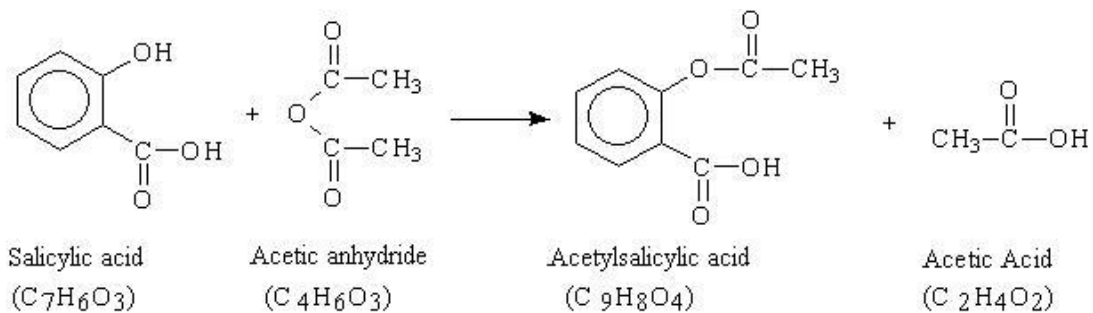
1.5.2 Antipyretics

The drugs which are capable of reducing body temperature are used to treat fever. These drugs are called antipyretics.

Example: Aspirin, paracetamol, analgin

Aspirin

It is the acetyl derivative of salicylic acid. It is prepared by refluxing salicylic acid and acetic anhydride in the presence of pyridine.



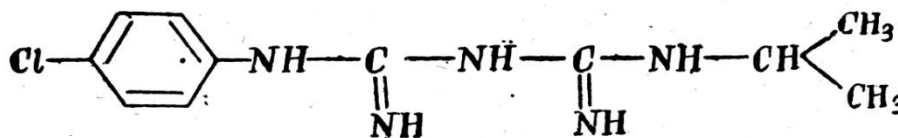
1.5.3 Antimalarials

Drugs used against malarial parasites are called antimalarials.

Example: Paludrine, quinine, primaquine

Paludrine

It is the trade name of proguanil. It is less toxic and is a suppressive drug of choice for falciparum as well as vivax malaria. The structure of paludrine is given below



Paludrine is usually taken in combination with another antimalarial drug, such as [atovaquone](#)

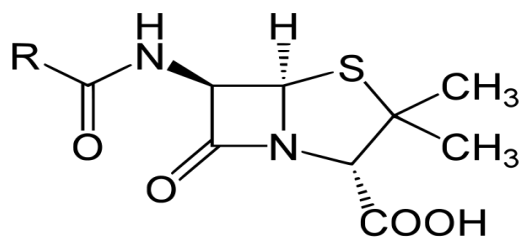
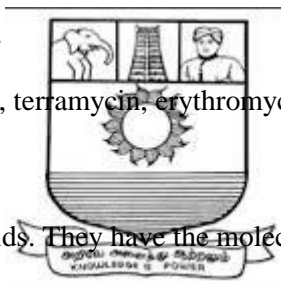
1.5.4 Antibiotics

Antibiotics are the naturally occurring chemotherapeutic agents. These are chemical substances produced by or derived from microorganisms like fungi and mould. Penicillin was the first antibiotic discovered.

Example: Penicillin, streptomycin, terramycin, erythromycin

Penicillins

These are derivatives of amino acids. They have the molecular formula $C_9H_{11}N_2O_4SR$.



Penicillin is a group of antibiotics which include penicillin G, penicillin V, procaine penicillin and benzathine penicillin. They are derived from *Penicillium* fungi. Penicillin antibiotics were among the first medications to be effective against many bacterial infections caused by staphylococci and streptococci. All penicillins are β -lactam antibiotics.

Check your progress

1. Vitamin A is ----- soluble.
2. Dairy products and milk are loaded with vitamin -----
3. Weak bones and muscles are due to the deficiency of -----
4. The synthetic drug widely used for the cure of bacterial infections is -----

LET US SUM UP

A vitamin is an organic compound and a vital nutrient that an organism requires in limited amounts.

Fat-soluble vitamins are stored in our fat cells. Water-soluble vitamins are not stored in our body; therefore, they need to be replenished daily to live a healthy life.

Antibacterials, antimalarials, antipyretics and antibiotics are some important drugs.

KEY WORDS

Vitamin: Vitamin is an organic compound and a vital nutrient that an organism requires in limited amounts.

Drugs: The chemical substances employed in the treatment of infectious diseases are referred to as drugs.



QUESTIONS FOR DISCUSSION

1. What are vitamins and how are they classified?
2. Give the sources of water soluble vitamins.
3. Discuss the deficiency symptoms of fat-soluble vitamins.
4. What are antibiotics? Explain with an example.
5. Explain with examples antimalarials and antipyretics.

Check your progress

Answer

1. Fat
2. D
3. Vitamin D
4. Antibacterials
5. Salicylic acid.

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UNIT

2

FERTILIZERS

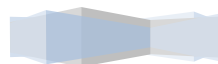
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- 2.1 Definition and types of fertilizers
- 2.2 Nitrogenous fertilizers
 - 2.2.1 Ammonium sulphate
 - 2.2.2 Urea
- 2.3 Potassium fertilizers
- 2.4 Phosphate fertilizers
- 2.5 NPK fertilizers (Mixed fertilizers)
- 2.6 Micronutrients and their role
- 2.7 Biofertilizers
- 2.8 Plant growth hormones

2.0 AIMS AND OBJECTIVES

After studying this unit, you should be able to:

- Define fertilizers and classify them
- Describe the manufacture and action of fertilizers
- Explain micronutrients and their role
- Describe biofertilizers and plant growth hormones.



2.1 DEFINITION AND TYPES OF FERTILIZERS

Fertilizers are the substances which are added to the soil in order to make up the deficiency of essential elements required for the growth of plants.

Various chemical compounds which can be synthesised by chemical methods used as fertilizers are called artificial chemical fertilizers. These are mainly classified into three groups based on the nature of element present.

- (i) Nitrogenous fertilizers (ii) Phosphatic fertilizers (iii) Potash fertilizers

2.2 NITROGENOUS FERTILIZERS

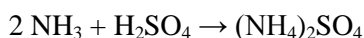
These are nitrogenous compounds which supply nitrogen in the form of NH_3 to the soil.

Example: Ammonium sulphate $(\text{NH}_4)_2\text{SO}_4$, Calcium ammonium nitrate $[\text{Ca}(\text{NO}_3)_2\text{NH}_4\text{NO}_3]$, Urea $\text{CO}(\text{NH}_2)_2$, Calcium cyanamide (CaCN_2) .

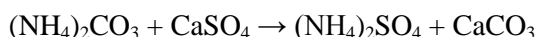
2.2.1 Ammonium sulphate

Manufacture:

Ammonium sulphate is made by treating ammonia and sulphuric acid



Ammonium sulphate is also manufactured from gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). Finely divided gypsum is added to ammonium carbonate solution. Calcium carbonate precipitates as a solid, leaving ammonium sulphate in the solution.

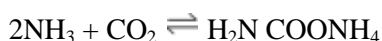


Action:

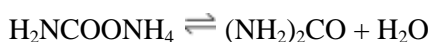
It contains 21% nitrogen and 24% sulphur. The primary use of ammonium sulphate is as a fertilizer for alkaline soils. In the soil the ammonium ion is released and forms a small amount of acid, lowering the pH balance of the soil, while contributing essential nitrogen for plant growth.

2.2.2 Urea Manufacture:

Liquid ammonia reacts with gaseous carbon dioxide (CO_2) at high temperature and pressure to form ammonium carbamate ($\text{H}_2\text{NCOONH}_4$)

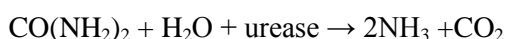


Ammonium carbamate decomposes into urea and water:



Action:

Urea is highly soluble in water and is, therefore, also very suitable for use in fertilizer solutions. Urea breakdown begins as soon as it is applied to the soil. If the soil is totally dry, no reaction happens. But with the enzyme urease, and any small amount of soil moisture, urea normally hydrolyses and converts to ammonia and carbon dioxide. This can occur in 2 to 4 days and happens quicker on high pH soils. Unless it rains, urea must be incorporated during this time to avoid ammonia loss. Losses might be quite low in the spring if the soil temperature is cold. The chemical reaction is as follows:



(urea)

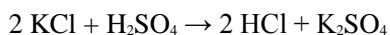
2.3 POTASSIUM FERTILIZERS

These are substances which supply the macronutrient potassium.

Potassium sulphate

Manufacture:

Potassium sulphate may be produced by the reaction of potassium chloride with sulphuric acid.



2.4 PHOSPHATE FERTILIZERS

These are substances which supply the macronutrient phosphorous.

Superphosphate

Manufacture:

Superphosphate fertilizers are produced by treatment of phosphorite rock with calculated quantity of phosphoric acid.



The reaction mixture is allowed to stand for about three months so that the reaction goes to completion. The grey solid mass is called triple superphosphate. It is crushed to powder and used.

2.5 NPK FERTILIZERS (MIXED FERTILIZERS)

These are obtained by mixing nitrogenous, phosphatic and potash fertilizers in suitable proportions. The mixed fertilizers can supply all the three primary nutrients [Nitrogen (N), Phosphorus (P), and Potassium (K)] to the plants.

Example: (i) Vijay mixed fertilizer [N (17%), P (17%), and K(17%)]

(ii) Vijay mixed fertilizer [N (14%), P (28%), and K(14%)]

2.6 MICRONUTRIENTS AND THEIR ROLE

Plants differ in their requirements for certain micronutrients. The micronutrients are boron, chlorine, copper, iron, manganese, molybdenum and zinc. These plant food elements are used in very small amounts, but they are just as important to plant development and to profitable crop production as the major nutrients.

1. Boron:

- Essential for germination of pollen grains and growth of pollen tubes.
- Essential for seed and cell wall formation.
- Promotes maturity.
- Necessary for sugar translocation.
- Affects nitrogen and carbohydrate.

2. Chlorine:

- Essential in plants for their healthy growth.
- Essential in the transfer of electrons from water to photo-oxidised chlorophyll in photosynthesis.
- Enhances maturity of small grains on some soils.

3. Copper:

- Catalyzes several plant processes.
- Essential for the photosynthetic production of oxygen.
- Increases sugar content.
- Intensifies colour.
- Improves flavor of fruits and vegetables.
- Highly toxic to plants when present in large quantities.

4. Iron:

- Promotes formation of chlorophyll.
- Acts as an oxygen carrier.
- Involves in cell division and growth.

5. Manganese:

- Activates certain enzymes like oxidases, peroxidases and dehydrogenase.
- Helps in chlorophyll synthesis.
- Plays a key role in carbohydrate metabolism.

6. Molybdenum:

- Absorbed as molybdate ions.



- Acts as a catalyst in the reduction of nitrates.
- Component of the enzyme, nitrate reductase which reduces nitrates into ammonia.
- Helps in the formation of legume nodules.
- Needed to convert inorganic phosphates to organic forms in the plant.

7. Zinc:

- Essential for the synthesis of the amino acid tryptophan.
- Activates a group of oxidizing enzymes.
- Necessary for chlorophyll production.
- Necessary for carbohydrate formation.
- Necessary for starch formation.
- Helps in seed formation.

2.7 BIOFERTILIZERS

Biofertilizers are low cost, renewable sources of plant nutrients which supplement chemical fertilizers. These are nothing but selected strains of beneficial soil microorganisms cultured in the laboratory and packed in a suitable carrier. They can be used either for seed treatment or soil application. Environmental pollution resulting from both production and applications of chemical fertilizer is reduced.

Example: Rhizobium, Azotobacter, Azospirillum and blue green algae

Rhizobium plays a very important role in agriculture by inducing nitrogen fixing nodules on the root of legumes such as peas, beans and clove.

Azotobacter can be used with crops like wheat, maize, mustard, cotton, potato and other vegetable crops. Azotobacter fixes the atmospheric nitrogen in the soil and make it available to the plants. It protects the roots from other pathogens present in the soil

Azospirillum inoculations are recommended mainly for sorghum, millets, maize, sugarcane and wheat.

Blue green algae fix atmospheric nitrogen and are used as inoculations for paddy crop grown both under upland and low-land conditions.

2.8 PLANT GROWTH HORMONES (PGR)

Plant hormones, also known as phytohormones are not nutrients, but chemicals that in small amounts promote and influence the growth, development and differentiation of cells and tissues. Plants lack glands to produce and store hormones. Plants utilize simple chemicals as hormones, which move more easily through the plants tissues.

They are produced within the plant and occur in extremely low concentrations. Hormones determine the formation of flowers, stems, leaves, the shedding of leaves, and the development and ripening of fruit.

Example: Abscisic acid, Auxins, Cytokinins, Ethylene, Gibberellins

Abscisic acid (also called ABA) is one of the most important plant growth regulators. This class of PGR is composed of one chemical compound normally produced in the leaves of plants, originating from chloroplasts, especially when plants are under stress. It accumulates within seeds during fruit maturation, preventing seed germination within the fruit or seed germination before winter.

Auxins are compounds that influence cell enlargement, bud formation and root initiation.

Cytokinins or CKs are a group of chemicals that influence cell division and shoot formation.

Ethylene affects cell growth and cell shape. When a growing shoot hits an obstacle while underground, ethylene production greatly increases, preventing cell elongation and causing the stem to swell. Ethylene affects fruit-ripening.

Gibberellins initiate mobilization of storage materials in seeds during germination, cause elongation of stems, stimulate bolting in biennials and stimulate pollen tube growth.

Check your progress

1. Ammonium sulphate supply the element -----
2. The macronutrient phosphorous is supplied by the fertilizer -----
3. Selected strains of beneficial soil microorganisms which supplement chemical fertilizers are -----
4. Abscisic acid is an example for -----
5. The micronutrient ----- acts as an oxygen carrier.

LET US SUM UP

Fertilizers are the substances which are added to the soil in order to make up the deficiency of essential elements required for the growth of plants. The elements nitrogen, phosphorous and potassium are macronutrients.



Micronutrients such as boron, chlorine, copper, iron, manganese, molybdenum and zinc are used in very small amounts and are important to plant development and to profitable crop production.

Biofertilizers are low cost, renewable sources of plant nutrients which supplement chemical fertilizers. Plant hormones are chemicals that in small amounts promote and influence the growth, development and differentiation of cells and tissues. Plants lack glands to produce and store hormones.

KEY WORDS

NPK fertilizers: These mixed fertilizers supply all the three primary nutrients [Nitrogen (N), Phosphorus (P) and Potassium (K)] to the plants.

Micronutrients: Micronutrients are used in very small amounts and are important to plant development and to profitable crop production.

QUESTIONS FOR DISCUSSION

1. Explain the preparation of urea and ammonium sulphate.
2. What are NPK fertilizers? Explain.
3. Discuss the role of micronutrients in plant growth.
4. Define biofertilizers. Give examples.
5. Give a brief account of plant hormones

Check your progress:

Answer

1. Nitrogen
2. Superphosphate
3. Biofertilizer
4. Plant hormone
5. Iron

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UNIT

3

POLYMER CHEMISTRY

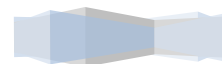
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 - 3.6.3 Neoprene

3.0 AIMS AND OBJECTIVES

After studying this unit, you should be able to:

- Define Monomers, Oligomers and Polymers
- Classify polymers.



- Describe thermoplastics with examples
- Explain thermosetting plastics
- Differentiate natural rubber and synthetic rubber

3.1 DEFINITION OF MONOMERS, OLIGOMERS, POLYMERS

Monomer:

Monomer is a molecule of low molecular weight capable of reacting with identical or different molecules of low molecular weight to form a polymer.

Example: Ethylene is the monomer of polyethylene.

Oligomer:

Oligomer is a molecular complex that consists of a few monomer units, in contrast to a polymer, where the number of monomers is not limited. Dimers, trimers and tetramers are oligomers composed of two, three and four monomers, respectively.

Example: Oils such as liquid paraffin are oligomeric.

Polymer:

A polymer is defined as a large molecule of high molecular weight formed by combination of a number of one or more types of molecules of low molecular weight.

Example: Polythene, PVC, Rubber, Starch

3.2 CLASSIFICATION OF POLYMERS

3.2.1 On the basis of source or origin, the polymers are classified into natural and synthetic polymers.

a) Natural polymers

Polymers found in nature, mostly in plants and animal sources are called natural polymers.

Example: Starch, cellulose, proteins, RNA, DNA, natural rubber etc.

b) Synthetic polymers

Polymers which are prepared in the laboratory are referred to as synthetic polymers or man-made polymers.

Examples: Polyethylene, polystyrene, synthetic rubber, nylon, PVC, bakelite etc.

3.2.2 On the basis of arrangement of polymer chain, the polymers are classified into linear, branched and cross-linked polymers

a) Linear polymers



In these polymers monomers are linked with each other and form a long straight chain. Their molecules are closely packed and have high density, tensile strength and melting point.

Example: Polyethene, PVC, Nylon, polyester etc.

b) Branched polymers

They have a straight long chain with different side chains. Their molecules are irregularly packed hence they have low density, tensile strength and melting point.

Example: Polypropylene, amylopectin and glycogen.

c) Cross-linked (network) polymers

Adjacent linear chains are joined to one another at various positions by covalent bonding of atoms. They are hard, rigid and brittle due to their network structure.

Example: Bakelite, melamine, formaldehyde resins, vulcanised rubber etc.

3.2.3 On the basis of physical properties and application, the polymers are classified into plastics, elastomers and fibres

a) Plastics

Plastics are high molecular weight polymers and can be moulded into any stable shape by heat and pressure.

Example: Bakelite, PVC, cellulose acetate.

b) Elastomers

Elastomers are rubber like polymers which undergo very large reversible elongation. Polymer chains are held together by weak intermolecular forces.

Example: Silicone rubber, neoprene rubber, natural rubber.

c) Fibres

Fibres can be drawn to long filament- length 100 times the diameter. They have high rigidity and stiffness.

Example: Nylon, terylene, orlon

Differences between plastics, elastomers and fibres

Plastics	Elastomers	Fibres
Linear, Branched or cross linked	Linear, Branched or cross linked	Linear
Extensibility 100-200%	Extensibility 1000%	Extensibility 10-20%

Exhibit plasticity	Exhibit elasticity	Exhibit elasticity
Undergo reversible deformation	Undergo reversible deformation	Undergo irreversible deformation

3.2.4 On the basis of the composition of basic polymer unit, the polymers are classified into homopolymers and co-polymers

a) Homopolymers : Polymers containing identical monomeric units are called homopolymers.

Example: Polyethylene, PVC etc.

b) Copolymers: Polymers having different types of monomeric units are called copolymers. Copolymers are further divided into four types:

i) Alternating copolymer: If two monomer units are arranged alternatively, the polymer is called alternating copolymer.

Example: Vinyl chloride -Vinylidene chloride copolymer

ii) Random copolymer: A random copolymer has the different monomer units arranged in a chain at random.

Example: Styrene -Butadiene copolymer

iii) Block copolymer: In block copolymer, the different monomers are arranged in blocks.

Example: Styrene -Isoprene copolymer

iv) Graftcopolymer: In graft copolymer, the main chain is made of one monomer unit while the branch chains are made of another monomer unit.

Example: Styrene -Acrylonitrile copolymer.

3.3 THERMOPLASTICS

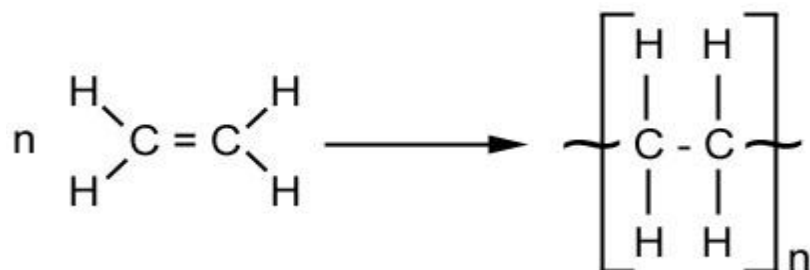
They are easily moulded in desired shapes by heating and subsequent cooling at room temperature. They are soft in hot and hard on cooling.

Example: Polythene, polystyrene, PVC.

3.3.1 Polyethylene:

Polyethylene is vinyl polymer, made from the monomer ethylene.

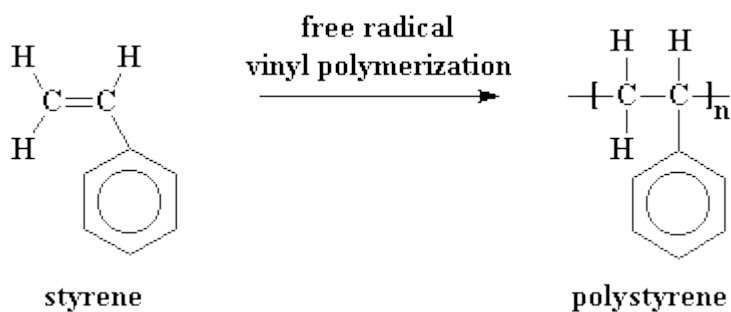




This is the polymer that makes grocery bags, shampoo bottles, children's toys and even bullet proof vests.

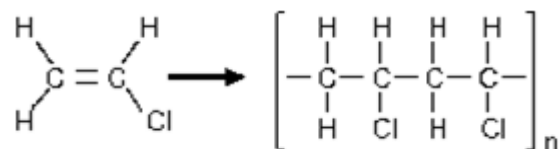
3.3.2 Polystyrene:

Polystyrene is a vinyl polymer. Structurally, it is a long hydrocarbon chain, with a phenyl group attached to every other carbon atom. Polystyrene is produced by free radical vinyl polymerization from the monomer styrene.

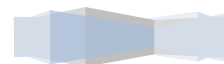


3.3.3 Poly Vinyl Chloride:

Polyvinyl chloride is produced by polymerization of vinyl chloride monomer.

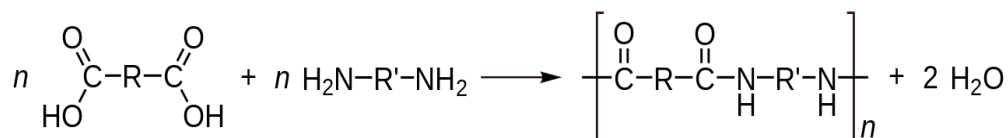


PVC's are relatively low cost, biological and chemical resistance and workability. It is used for sewerage pipes and other pipe applications where cost or vulnerability to corrosion limit the use of metal. By adding plasticizers, it can become flexible enough to be used in cabling applications as a wire insulator.



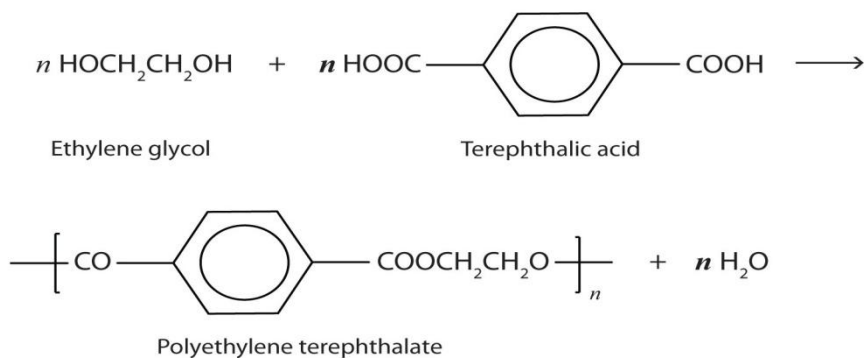
3.3.4 Nylon:

Nylons are condensation copolymers formed by reacting difunctional monomers containing equal parts of amine and carboxylic acid. Most nylons are made from the reaction of a dicarboxylic acid with a diamine or a lactam or amino acid with itself.



3.3.5 Polyester:

Polyester is a synthetic polymer made of purified terephthalic acid or its dimethyl ester, dimethyl terephthalate and monoethylene glycol.



Uses:

Clothing, carpets, curtains, wall coverings, hoses, power belting, ropes and nets, thread etc.

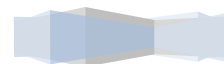
3.4 THERMOSETTING PLASTICS

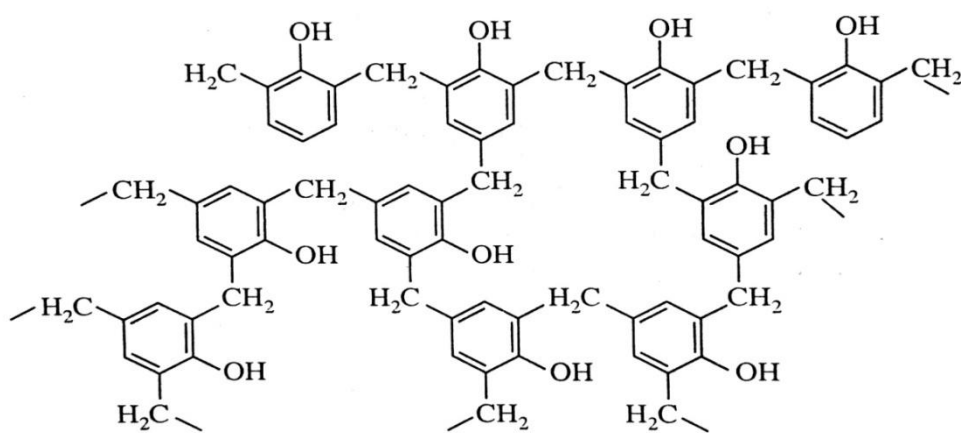
Thermosetting Plastics are hard and infusible on heating. These are not soft on heating under pressure and they are not remoulded. These are cross linked polymers and are not reused.

Example: Bakelite, Urea – formaldehyde resin

Phenol formaldehyde:

Phenol formaldehyde resins (PF) are synthetic polymers obtained by the reaction of phenol or substituted phenol with formaldehyde. It is also known as Bakelite.

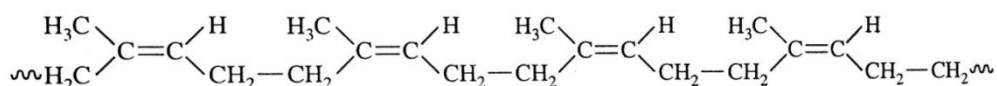




Bakelite (A thermosetting polymer)

3.5 NATURAL RUBBER

Rubber is an elastomer, which is obtained from (rubber plant scientific name: *Hevea brasiliensis*) in the form of a white fluid called latex. Natural rubber is an unsaturated polymer of 2-methylbuta-1, 3-diene (isoprene). The double bonds present in the natural rubber have cis-configuration (Z-configuration). The structure of natural rubber is as follows:



Natural rubber is a soft and sticky solid and is often associated with a peculiar smell. It has low elasticity and low tensile strength. It softens in hot weather and gets hardened in cold weather. It is soluble in organic solvents such as carbon disulphide, petrol, ether and so on. The above properties of natural rubber make it unsuitable for use as automobile tyres and tubes. To improve the properties, rubber is cured by vulcanization. It is carried out by heating rubber with sulphur at 52° C. Vulcanisation improves the tensile strength by way of cross linking. A polymer of isoprene (from natural sources) that has trans-configuration at the double bonds is known as Gutta-Percha.

3.6 SYNTHETIC RUBBER

3.6.1 Buna - N

It is a copolymer of acrylonitrile with butadiene. It is prepared by emulsion polymerisation of acrylonitrile and butadiene using azo initiators.

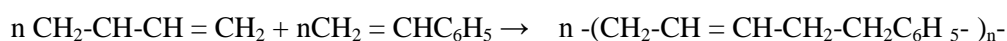


Uses:

- i) It has better oil resistance than natural rubber and hence used for making hoses for oil transport.
- ii) It is also used as oil seals (oil resistant cable insulation)

3.6.2 Buna-S

It is a copolymer of styrene with butadiene. It is made by emulsion polymerisation of styrene and butadiene using cumenehydroperoxide as initiator.

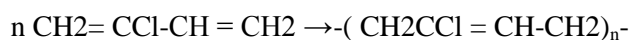


Uses:

- i) It is a good substitute for natural rubber in making automobile tyres.
- ii) It is superior to natural rubber for the manufacture of conveyor belts, shoe soles, gloves, tank lining, floor tiles, gaskets and electrical insulation.

3.6.3 Neoprene

Polychloroprene is called neoprene. It is made by the emulsion polymerisation of chloroprene.



Uses:

Neoprene rubber has better oil resistance than natural rubber and hence used for making industrial hoses to carry oil and for oil resistant cable insulation.

Check your progress

1. Low molecular weight molecules capable of forming a polymer is -----
2. Polymers having different types of monomeric units are called -----
3. Synthetic polymer made of terephthalic acid and ethylene glycol is -----
4. Polymers which are hard, infusible on heating and not remoulded are -----
5. Polychloroprene is called -----

LET US SUM UP

A polymer is a large molecule of high molecular weight formed by combination of a number of one or more types of molecules of low molecular weight.

On the basis of source, structure and application polymers are classified into several types. Several synthetic polymers can be prepared for various applications

Natural rubber is an unsaturated polymer of 2-methylbuta-1, 3-diene obtained from rubber plant.

KEY WORDS

Polymers: Synthetic and natural macromolecules of high molecular weight.

Rubber: Rubber is an elastomer which is obtained from rubber plant. Buna- N, Buna- S and neoprene are synthetic analogues of improved quality.

QUESTIONS FOR DISCUSSION

1. How are polymers classified on the basis of source ?
2. Explain thermoplastics and thermosetting plastics.
3. What are homopolymer and copolymers? Explain with suitable examples.
4. Give a brief note on nylon, polyester and PVC.
5. Discuss the preparations of any three synthetic rubbers.

Check your progress:

Answer

1. Monomer
2. Copolymers
3. Polyester
4. Thermosetting Plastics
5. Neoprene

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3. Text Book of Organic chemistry, P.L. Soni, Sultans Chand, 1991, New Delhi.
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UNIT

4

DYES

CONTENTS

- 4.0 Aims and Objectives
- 4.1 Colour and constitution of Dyes
- 4.2 Classification of dyes according to the mode of application
- 4.3 Classification of dyes according to the chemical constitution
- 4.4 Preparation of some important dyes**
 - 4.4.1 Methyl orange
 - 4.4.2 Fluorescein
 - 4.4.3 Malachite green
 - 4.4.4 Alizarin
 - 4.4.5 Bismark brown
 - 4.4.6 Para rosaniline
- 4.5 Laser dyes
- 4.6 Dyes used in electro - photography.

4.0 AIMS AND OBJECTIVES

After studying this unit, you should be able to:

- Explain the theories of colour and constitution of dyes
- Describe the classification of dyes
- Explain the preparation of some important dyes and the dyes used in electrophotography.

4.1 COLOUR AND CONSTITUTION OF DYES

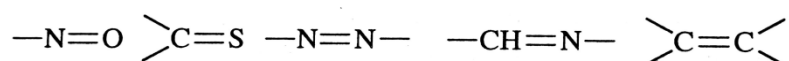
Dyes are coloured organic compounds used to impart colour to cloth, paper, plastic, leather and cosmetics. An organic compound appears coloured only if it absorbs the radiations in the visible part of the electromagnetic spectrum.

4.1.1 Witt Theory:

Witt (1876) suggested the Chromophore-Auxochrome theory for coloured organic compounds. The various terms defined accordingly are as follows:

Chromophores: The groups with unsaturation and electron withdrawing nature have an appreciable effect on the absorption of light and when present in conjugation, are responsible for the colour of compound. Such groups are known as chromophores. The compounds containing chromophore group are known as chromogens.

Example:



Auxochromes:

These groups are not responsible for colour but when present along with chromophore groups are responsible for deepening of the colour. These are electron-donating groups.

Example: $-\text{NH}_2$, $-\text{NHR}$, $-\text{OH}$, $-\text{OR}$

Limitations of Witt's theory: There is no explanation why some groups act as chromophores and others as auxochromes. Further, there is no explanation for deep colours of indigo and triphenyl methane dyes, which have only weak chromophores.

4.1.2 Quinonoid Theory:

According to this theory, ortho or paraquinonoid structures in a compound are responsible for its colour. The drawback of this theory is that it has no explanation for deep colour of azo dyes, which have no quinonoid structure.

4.1.3 Modern Theory:

If E_1 is the energy in ground state and E_2 is the energy in excited state, energy required (ΔE) for excitation,

$$\Delta E = E_2 - E_1 = h\gamma = hc/\lambda$$

This shows that the frequency of light (γ) absorbed by a compound is related directly to ΔE .

This means that,

- If ΔE has a high value, a high frequency is absorbed, that is, absorption occurs at a shorter wavelength.
- If ΔE has a low value, low frequency is absorbed, that is, absorption occurs in a high wavelength region called the visible region.

In organic molecules with conjugated multiple bonded systems, the delocalization of π electrons occur. This delocalization, known as mesomeric or resonance effect, causes stabilization in excited state and thus decreases ΔE value. As a result, longer wavelength absorption occurs (visible region) and the compound appears coloured. The

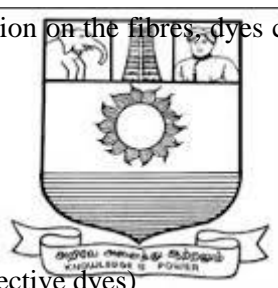
chromophores(weak or strong) and auxochrome groups present in a compound cause deepening of colour by increasing the number of charged contributing structures during resonance effect. The increased conjugation (or delocalization) in a system shifts the absorption towards the longer wavelength region (lower energy) and is known as bathochromic shift. Similarly, shifting of absorption towards shorter wavelength region (higher energy) is known as hypsochromic shift.

Example: Nitrobenzene is yellow in colour whereas p-nitroaniline is orange in colour. The NO_2 group is a chromophore which imparts a yellow colour due to resonance effect. On the other hand, the -NH_2 group is an auxochrome which causes deepening of colour by increasing the number of contributing structures during resonance effect. Similarly, picric acid has a dark yellow colour due to increased number of contributing structures because of the presence of three -NO_2 groups.

4.2 CLASSIFICATION OF DYES ACCORDING TO THE MODE OF APPLICATION

According to the mode of application on the fibres, dyes can be classified into the following seven types:

- (i) Acid dyes
- (ii) Basic dyes
- (iii) Direct or substantive dyes
- (iv) Mordant dyes (Indirect or Adjective dyes)
- (v) Vat dyes
- (vi) Azo dyes (Ingrain or Developed dyes)
- (vii) Sulphur dyes.



(i) Acid dyes: These are the sodium salts of sulphonic acids or nitrophenols. These can be used for dyeing animal fibres and synthetic fibres.

Example: Martius yellow, Naphthol yellow-S and Picric acid

(ii) Basic dyes: These are the cationic dyes containing basic groups such as -NH_2 , -NHR , -NR_2 and their salts (mostly in the form of hydrochloride salts). These are used for dyeing animal fibres and can also be used for dyeing fibres of plant origin after mordanting with tannins.

Example: Malachite green, Magenta, and para-rosaniline

(iii) **Direct or substantive dyes:** This class of dyes mainly includes various acid or basic dyes and can be directly used for the fibres of plant origin. The dyeing of the fibres is carried out in the presence of common salt, so these dyes are also called salt dyes.

Example: Congo red.

(iv) **Mordant dyes (indirect or adjective dyes):** These dyes are insoluble in water and a third substance is used as a binding material of the fibre with dye. This third substance is called mordant. In the dyeing process, fibre is dipped in mordant, dried and then again dipped into the dye solution. Mordant forms a complex with the dye and is deposited on the fibre giving it a permanent shade. For acid dyes, a basic mordant [like metal salts $\text{Fe}(\text{OH})_3$, $\text{Al}(\text{OH})_3$] is used and for basic dyes, an acid mordant such as tannic acid is used.

Example: Alizarin

(V) **Vat dyes:** These dyes are applied directly on the fibre and are generally insoluble in water. These can be used only on cotton and not on silk and wool. The dyeing, in this case, is a continuous process and is carried out in a large vessel called vat. For this reason, these dyes are termed as vat dyes. These dyes are first of all converted into water soluble form by reduction in alkaline medium. The fabric to be dyed is dipped in the solution of the reduced dye. The fabric is then dried in air where oxidation takes place and coloured fabric is obtained.

Example: Indigo

(vi) **Azo dyes (ingrain or developed dyes):** These are applied directly on the fibre. The process includes the diazotization and the coupling reaction at low temperature on the fibre itself.

(vii) **Sulphur dyes:** These are complex water insoluble dyes containing sulphur. But these dyes are soluble in sodium sulphide (Na_2S) solution and thus the dyeing process is carried out in Na_2S solution. These dyes are generally used for dyeing cotton fibre.

4.3 CLASSIFICATION OF DYES ACCORDING TO THE CHEMICAL CONSTITUTION

Due to the variation in the structures of dyes, no distinct classification can be given but roughly their classification can be given depending on their chemical constitution. Some selected chemical classes of dyes are as follows:

- (i) Nitro dyes
- (ii) Nitroso dyes
- (iii) Azo dyes
- (iv) Phthalein dyes
- (v) Triphenylmethane dyes

(Vi) Anthraquinone dyes

(i) **Nitro dyes:** These are the polynitro derivatives of phenols or naphthols.

Example: Picric acid, Martius yellow

(ii) **Nitroso dyes:** These are nitroso derivatives of phenols or naphthols.

Example: Naphtholgreen Y

(iii) **Azo dyes:** These are the largest group of industrial dyes characterised by the presence of azo(-N=N-) groups. They are labeled as monoazo, diazo, triazo and polyazo dyes according to the number of azo groups present. The azo dyes are produced almost exclusively by the diazotisation of a primary aromatic amine to a diazonium salt. This on coupling with phenol or an aromatic amine gives dye.

Example: Methyl orange, Bismark brown, Congo red

(iv) **Phthalein dyes:** These are dihydroxytriphenyl methane derivatives.

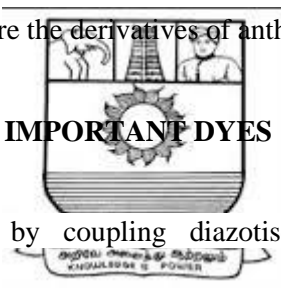
Example: Phenolphthalein, fluorescein

(v) **Triphenylmethane dyes:** These dyes have the basic triphenylmethane nucleus.

Example: Malachite green, Rosaniline

(vi) **Anthraquinone dyes:** These are the derivatives of anthraquinone.

Example :Alizarin



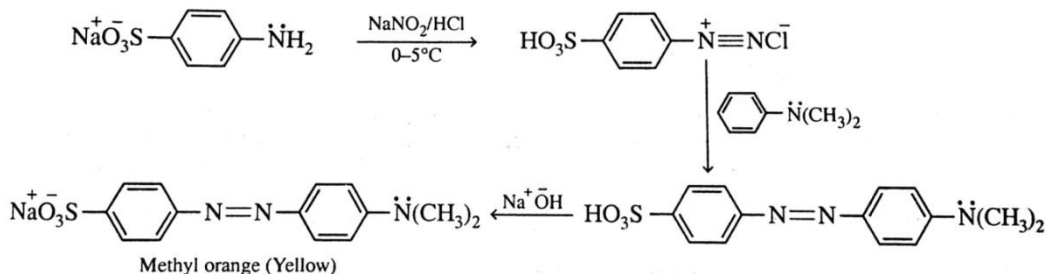
4.4 PREPARATION OF SOME IMPORTANT DYES

4.4.1 Methyl orange:

Methyl orange is synthesized by coupling diazotisedsulphanilic acid with N, N-dimethylaniline at

low temperature (0-5 ° C). Diazotisedsulphanilic acid is prepared by treating sulphanilic acid with

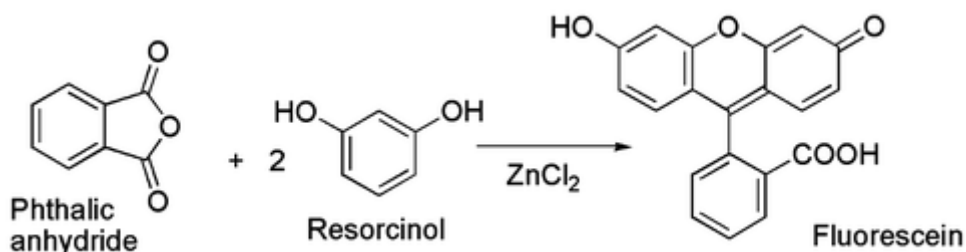
nitrous acid (prepared in-situ from NaNO₂/HCl) at 0-5 ° C.



It is a yellow coloured fugitive dye, which is used extensively as an indicator in acid-base titrations (pH range 3.0-4. 4). In alkaline solution, it gives a yellow colour while in acidic solution it gives a red colour due to a quinonoid structure.

4.4.2 Fluorescein:

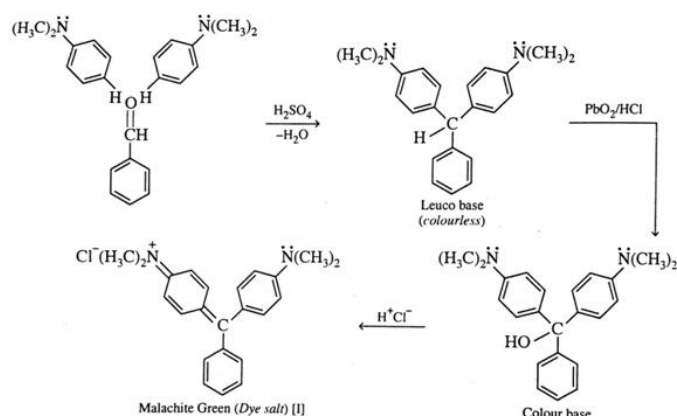
Fluorescein can be prepared from phthalic anhydride and resorcinol in the presence of zinc chloride.



It is an orange solid, which in alkaline solution gives a reddish brown colour. This on dilution imparts yellow-green fluorescence.

4.4.3 Malachite green:

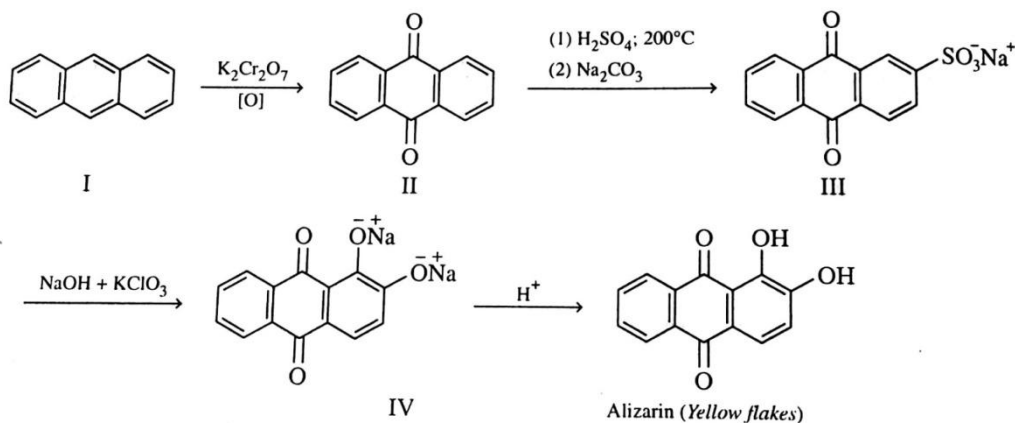
Malachite green is prepared by the condensation of benzaldehyde and dimethylaniline to give a leuco base. The leuco base on oxidation with lead oxide (PbO₂) in presence of HCl gives a colourless carbinol base also known as colour base of malachite green. This colour base on treatment with excess of HCl gives malachite green as a dye salt.



4.4.4 Alizarin:

Alizarin (1, 2-Dihydroxyanthraquinone) occurs in nature as glucoside in the roots of the madder plant. The synthesis of alizarin involves the oxidation of anthracene (I) with

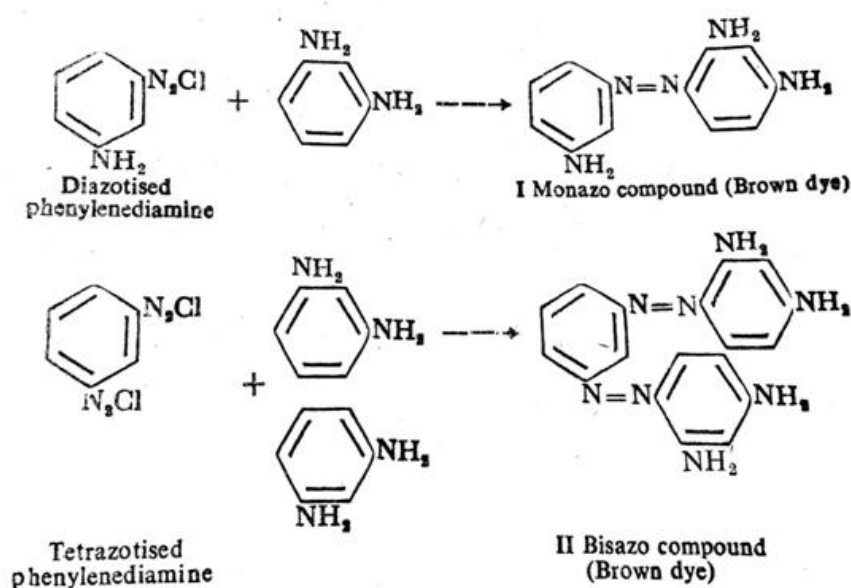
potassium dichromate to anthraquinone (II). Sulphonation of (II) with fuming sulphuric acid at high temperature (200° C) followed by treatment with sodium carbonate gives sodium salt of anthraquinone-2-sulphonic acid (III). The fusion of (III) with a mixture of sodium hydroxide and potassium chlorate gives disodium salt of alizarin (IV) that on acidification yields alizarin.



Alizarin exists as yellow flakes and in aqueous alkali gives violet colour. It is a mordant dye and in presence of different metallic mordants, it produces different colours.

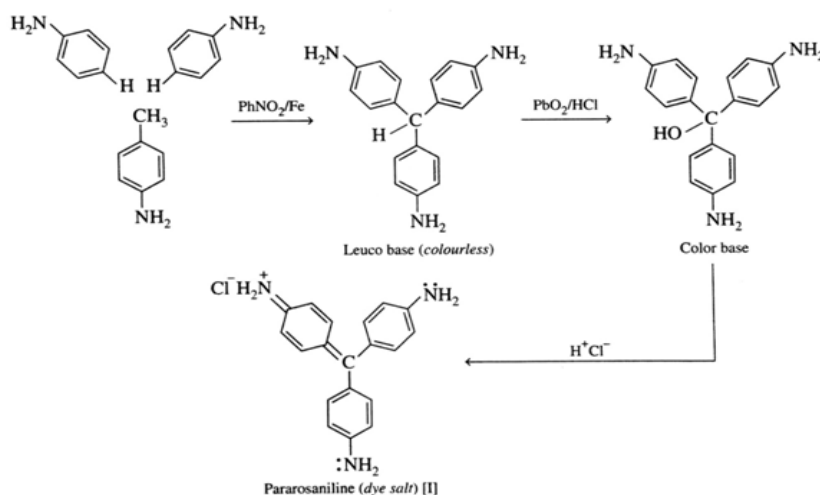
4.4.5 Bismark brown:

It is a brown dye obtained by the action of nitrous acid on excess of m-phenylenediamine dissolved in concentrated hydrochloric acid. In fact it is a mixture of two dyes obtained by the diazotisation of one or both amino groups followed by coupling with the unchanged diamine. Bismark Brown is used in boot polish and for staining wood before polishing. It is a direct dye for dyeing wool.



4.4.6 Para rosaniline:

Para rosaniline is synthesized by condensation of two moles of aniline and one mole of p-toluidine in the presence of oxidizing agent (nitrobenzene and iron). This results in the formation of a leuco base which on oxidation with PbO_2 in HCl followed by treatment with excess HCl gives pararosaniline as dye salt [I]. Para rosaniline is used as direct dye for wool and silk.



4.5 LASER DYES

Laser dyes are large organic molecules which when dissolved in a suitable liquid solvent (such as ethanol, methanol, or an ethanol-water mixture) can be used as laser medium in a dye laser. Laser dye solutions absorb at shorter wavelengths and emit at longer wavelengths. Successful laser dyes include the coumarins and the rhodamines. Coumarin dyes emit in the green region of the spectrum while rhodamine dyes are used for emission in the yellow-red. The colour emitted by the laser dyes depend upon the surrounding medium i.e. the medium in which they are dissolved. However, there are dozens of laser dyes that can be used to span continuously the emission spectrum from the near ultraviolet to the near infrared.

4.6 DYES USED IN ELECTROPHOTOGRAPHY

Electrophotography is a printing and photocopying technique that works on the basis of electrostatic charges. It is the dominant method of reproducing images and printing computer data and is used in copiers, laser printers and fax machines. The term electrophotography encompasses the familiar techniques of photocopying (xerography) and

laser printing. In both these systems, the ink is a toner, which is generally a powder consisting mainly of pigment, charge control agent and a low melting (60—70 °C) polymer. The most extensively used pigment is carbon black since most printing remains monochrome. However, the production of multi coloured prints by this method, using pigments of the three subtractive primary colours, yellow, magenta and cyan, is increasing in popularity. The yellows are commonly provided by diazo pigments, the magenta by quinacridones and the cyan by copper phthalocyanine.

Check your progress

1. A shift in the absorption towards the longer wavelength region is known as ----- shift.
2. The auxochrome present in p-nitroaniline is -----
3. Fluorescein is an example for ----- dye.
4. An example for vat dye is -----
5. The primary colours are -----, magenta and cyan.

LET US SUM UP

Dyes are coloured organic compounds used to impart colour to cloth, paper, plastic, leather and cosmetics.

In organic molecules with conjugated multiple bonded systems longer wavelength absorption occurs and the compound appears coloured. The chromophores and auxochrome groups present in a compound cause deepening of colour by increasing the number of charged contributing structures during resonance effect.

According to the mode of application on the fibres and their chemical constitution dyes are classified into several types which can be synthesized in the lab.

KEY WORDS

Dyes: Coloured organic compounds used to impart colour.

Colour and constitution : An organic compound appears coloured only if it absorbs the radiations in the visible part of the electromagnetic spectrum.

QUESTIONS FOR DISCUSSION

1. How are dyes classified according to the mode of application?
2. Explain the preparation of the following
 - i) Methyl orange
 - ii) Malachite green
3. Discuss the theory of colour and constitution of dyes.

Check your progress:

Answer

1. Bathochromic
2. -NH_2
3. Phthalein dyes
4. Indigo
5. Yellow

SUGGESTED READINGS

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UNIT

5

NANOTECHNOLOGY

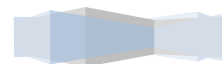
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- 5.0 Aims and Objectives
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 - 5.1.1 Magnetic properties
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- 5.3 Synthesis of nanomaterials
 - 5.3.1 Bottom-up and top-down approaches
 - 5.3.2 Thin film deposition
 - 5.3.3 Chemical vapour deposition
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- 5.5 Carbon nanotubes
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 - 5.5.2 Multi walled nano tubes
 - 5.5.3 Structures
- 5.6 Carbon nanofibre
- 5.7 Applications of nanoscience and nanotechnology

5.0 AIMS AND OBJECTIVES

After studying this unit, you should be able to:

- Explain the size dependent properties of nanomaterials



- Describe the synthesis of nanomaterials
- Understand the applications of nanoscience and nanotechnology

5.1 DEFINITION AND SIZE DEPENDENT PROPERTIES

Nanotechnology is the science of devices, derived from nanomaterials. The nanomaterials are any solid materials that have special dimensions in the range of 1 – 100 nm. The nanomaterials have extraordinary properties

- i. Physical and chemical properties of nanosized materials are influenced by the size of the particles.
- ii. The property like surface effect increases when the size of the nanoparticle decreases to lower level.
- iii. The property like melting point decreases as the size of the nanoparticle decreases.

5.1.1 Magnetic properties:

Nanoparticles exhibit magnetic properties that are different from that of bulk materials. Decreasing the size of a magnetic material to a nanoscale can increase the quality. Magnetisation increases significantly below the particle size of 20 nm.

5.1.2 Electrical properties:

Nanomaterials are having more energy than the corresponding bulk materials because of their large surface area and energy gap. The bulk material of CdSe behaves as an insulator, the 100 nm nanosized particle of the CdSe behaves as a semiconductor and the 20 nm nanosized material of the CdSe behaves as a conductor. Also the conduction is increased when the material size is still decreased to quantum dot.

5.1.3 Optical properties:

Gold nanoparticles exhibit different colours when coated on glass articles. When the size of the coated gold nanoparticles decreases, the glass articles will show red colour. If the size of the coated gold particles increases, the glass article will show yellow colour. This means that, as the size of the nanomaterials decrease, the surface area and the energy gap increase. Thus higher number of electrons is present on the small surface area. When a metallic particle becomes small enough, the atoms behave to develop a set of “molecular orbital” within which visible light absorption takes place. Thus the optical absorption band shifts to higher energy (blue shift) as the particle size is decreased and vice versa.

5.2 QUANTUM DOTS

A particle that exhibits a size of 1 - 10 nm in one dimensional network is called quantum dot. When dimensions length, width and height are reduced, the electrons have no freedom to move in any dimension. Hence a zero dimensional quantum dot structure is obtained.

The electronic effect like optical and fluorescence properties are greatly increased as the size of the nanoparticles are decreased to quantum dots (1 – 10 nm in diameter). This effect is called quantum size effect.

Example: Quantum dot sized CdSe nanomaterials are used to make switches, transistors and memory chips which are used for making flat panel displays in televisions, computers and laptops.

5.3 SYNTHESIS OF NANOMATERIALS

5.3.1 Bottom-up and top-down approaches:

Bottom up method involves wet chemical reduction of metal salts, electrochemical pathways or the controlled decomposition of metastable organo metallic compounds. A large variety of stabilizers eg. donor ligands, polymers and surfactants are used to control the growth of primarily formed nanocluster and to prevent them from agglomerating.

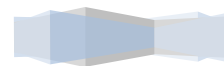
Top down method involves the mechanical grinding of bulk metals. The fine particles are stabilized by the addition of colloidal protective agents.

5.3.2 Thin film deposition:

There are two methods involved in thin film deposition. They are,

- (i) The physical methods include physical vapour deposition (PVD), laser ablation, molecular beam epitaxy and sputtering.
- (ii) The chemical methods comprise gas phase deposition methods and solution techniques.

The gas – phase methods are chemical vapour deposition and atomic layer epitaxy. Then solution techniques are spray pyrolysis, sol – gel, spin and dip coatings.



5.3.3 Chemical vapour deposition (CVD) method:

CVD is the most common method to synthesize nanosized metal oxides (ceramics), carbon nanotubes (CNTs) and nanocomposite crystallites. In this method, a solid is deposited on a heated surface of the substrate using the chemical reactions occur in the vapour phase.

The chemical reaction which occurs in the vapour phase needs activation energy. This energy is provided by any one of the following methods.

- (i) Thermal CVD method: In this method, the reaction is activated by a high temperature at above 900°C.
- (ii) Plasma CVD method: In this method, the reaction is activated by the plasma at the temperature range of 300 - 700°C.
- (iii) Laser CVD method: In this method, the chemical reaction is activated by the high energy laser beam.
- (iv) Photo laser CVD method: In this method, the chemical reaction is induced by both ultraviolet radiation and laser beam.

5.3.4 Sol - Gel method:

It is a wet chemical process. It involves a hydrolysis reaction followed by condensation – polymerization. Six steps are involved in Sol – Gel synthesis.

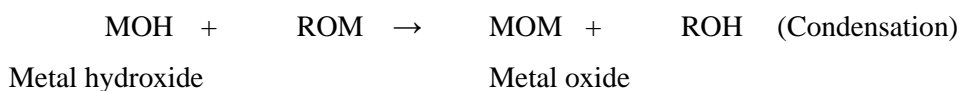
1. Hydrolysis:

This step involves the hydrolysis reaction of metal alkoxide using water as a solvent.



2. Condensation – Polymerisation:

The condensation reaction of metal hydroxide takes place to form metal oxide with the elimination of alcohol.



The metal oxide undergoes polymerization to form a colloidal solution or Sol.

3. Gelation:

The polymeric networks link up to convert the sol to a gel on ageing. The solvent water or alcohol remains inside the pores of the gel.

4. Drying:

Water or alcohol is removed at moderate temperatures, leaving a hydroxylated metal oxide and organic residues.

5. Dehydration:

The dried material is heated between 670 and 1070 K. The organic residues and chemically bound water are removed and gives a glassy metal oxide.

6. Densification:

When glassy metal oxide is heated to above 1270 K, a dense nanosized solid metal oxide is formed.

5.3.5 Chemical reduction method:

The most common method for synthesis of metal nanoparticles is the reduction of metal salts or complexes in dilute solution. A variety of reagents and methods have been developed. The various reactants, reducing agents and polymeric stabilizers (capping agents) generally used in the production of metal nanoparticles are given below.

Reactants	Reducing agents	Metal Nanoparticles
Palladium chloride	Hydrogen	Pd
Hydrogen hexachloroplatinate(IV)	Sodium citrate	Pt
Silver nitrate	Citric acid	Ag
Chloroauric acid	Sodium citrate, Hydroxylaminehydrochloride or Citric acid	Au

Polymeric stabilizers (capping agents)

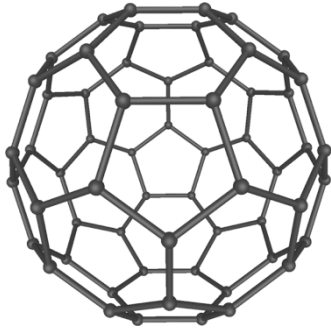
Polyvinyl pyrrolidone, Polyvinyl alcohol, Polyethyleneimine

Example: Synthesis of Gold nanoparticles

50 ml of 0.01% chloroauric acid is mixed with 1 ml of 0.5% sodium citrate and the mixture is kept at 100°C till colour changes. Then add 2 ml of polyvinyl pyrrolidone (a capping agent). The overall volume of the solution is maintained by adding water. The colloidal gold of uniform particle size of approximately 16 nm in diameter is obtained.

5.4 FULLERENES

Fullerenes are a form of nanomaterial, belonging to a family of carbon allotropes. They are molecules that are composed entirely of carbon. They may take the shape of a hollow sphere, ellipsoid, tube or plane. Spherical fullerenes are named as bucky balls and cylindrical ones are called as carbon nanotubes or bucky tubes.



5.5 CARBON NANOTUBES

A carbon nanotube (CNT) is an ultra thin carbon fibre with nanometer size diameter and micrometer size length. Nanotubes generally have a length to diameter ratio of about 1,000.

Carbon nanotubes are of two types

- (i) Single-walled nanotubes (SWNTs) and
- (ii) Multi-walled nanotubes (MWNTs)

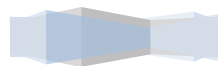


5.5.1 Single-walled nanotubes (SWNTs):

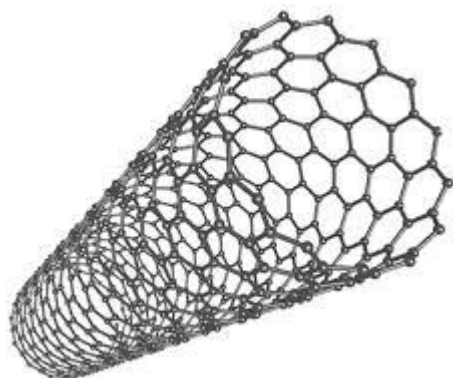
Most single-walled nanotubes (SWNT) can have the diameter of 1 – 2 nm and have the length of 100 μm . The structure of a SWNT can be explained by a one-dimensional ultra thin layer of graphite called graphene into a seamless cylinder.

5.5.2 Multi-walled nanotubes (MWNTs):

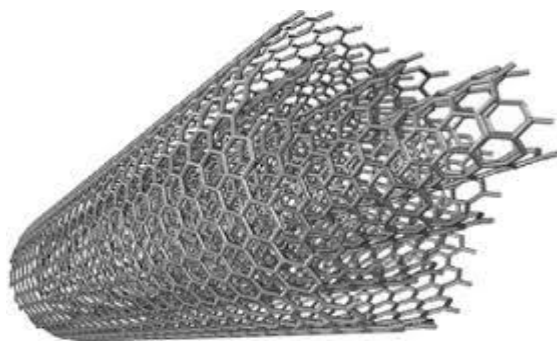
Multi-walled nanotube (MWNT) is composed of 2 to 30 concentric graphite layers having the diameter of 10 – 50 nm and have the length of more than 10 μm . There are two models which can be used to describe the structure of MWNT. In the Russian Doll model, sheets of graphite are arranged in concentric cylinders. In the Parchment model, a single sheet of graphite is rolled in around itself, resembling a rolled up newspaper.



5.5.3 Structures



Single-walled nanotube



Multi-walled nanotube

5.7 CARBON NANOFIBRE

Nanofibres are defined as fibres with diameters less than 100 nanometers. When compared to conventional fibers, nanofibres have numerous advantages because of their high surface area, small pore size and high pore volume. These characteristics lend themselves to many innovative applications. Nanofibres have applications in medicine, including artificial organ components, tissue engineering, implant material, drug delivery, wound dressing, and medical textile materials. Recently, researchers have found that nanofibre meshes could be used to fight against the HIV-1 virus, and be able to be used as a contraception. Nanofibres have also been used in pigments for cosmetics.

5.8 APPLICATIONS OF NANOSCIENCE AND NANOTECHNOLOGY

In nanochemistry, various nanosized materials like quantum dots, nanoparticles, nanoclusters, nanocrystallites, nanocomposites, carbon nanotubes are used in various fields. Some of them are given below.

Nanomaterial	Application
1.Nanocarbon tubes (CNTs)	Electronic devices, fuel cells, wear resistant rubber tyres, water proof cloth fibres, sports equipment, etc.
2.Nanophosphors	High resolution monitors
3.Nanoalumina and silica	Superfine polishing technology
4.Nanoiron oxide	Disk drives, audio tapes and cosmetics (lipstick)
5.Nano ZnO and TiO ₂	Sunscreens
6.Quantum dot of nana Pt	Powerful catalyst
7.Nano W, Ta, Ti carbides	Cutting tools which are harder, much more wear and erosion resistant.
8.Nano metals like Fe, Zn, Sn	High reactivities with chlorocarbons and useful in tackling environmental pollution.
9.Nanocrystalline Ni	High energy batteries with long life and less frequent charging.
10.Nano ZrO ₂ and SiC	Bio-compatible, suitable for artificial heart valves due to low mass, high strength, extreme hardness, wear resistance, inertness and corrosion resistance.
11.Semiconductor (ZnSe, ZnS, CdS, PbTe) nanoparticles	More efficient solar cells, nanoelectrical devices.
12.Nanocomposites	Medicine (Drug delivery system)

Check your progress

1. The nanomaterials have special dimensions in the range -----.
2. The size of the quantum dot is in the range -----
3. The colour of gold nanoparticles is -----
4. Fullerenes are allotrope of -----
5. Fibres with diameters less than 100 nanometers are called -----

LET US SUM UP

Nanotechnology is the science of devices, derived from nanomaterial with dimensions in the range of 1 – 100 nm.

Nanomaterials exhibit magnetic, optical and electrical properties different from that of bulk materials.

Nanosized materials like quantum dots, nanoparticles, nanoclusters, nanocrystallites, nanocomposites, carbon nanotubes are used in various fields such as electronic devices, high resolution monitors, fuel cells, cosmetics, medicines etc.

KEY WORDS

Nanomaterials: Nanomaterials are any solid materials that have special dimensions in the range of 1 – 100 nm.

Carbon nanotube: Carbon nanotube is a ultra thin carbon fibre with nanometer size diameter and micrometer size length.

QUESTIONS FOR DISCUSSION

1. Discuss the synthesis of nanoparticles by chemical reduction method.
2. Explain sol-gel method for the synthesis of nanoparticles.
3. Discuss the electrical and optical properties of nanoparticles
4. What are carbon nanotubes? Discuss their types, preparation and properties.
5. Give the applications of nanoscience and nanotechnology.

Check your progress:

Answer

1. 1-100 nm
2. 1-10 nm
3. Red
4. Carbon
5. Nanofibres

SUGGESTED READINGS

1. The Essentials Understanding Nano Science and Nanotechnology, T. Pradeep -. Tata McGraw-Hill Publishing Company Ltd., New Dehli.
2. Introduction to Nano technology, Charles P Poole Jr. & Frank J Owens, Wiley Interscience.

