CHAPTER 22

INDUSTRIAL CHEMISTRY

Introduction

Before we define industrial chemistry, it may be helpful to know that the development of industrial chemistry started when a need to know how various chemicals are produced in much more than the laboratory scale, arose. Chemistry knowledge was applied to furnish the rapidly expanding chemical industries with "recipes" which we now call chemical processes. Industrial chemistry keeps up with the progress in science and technology. It incorporates other emerging disciplines such as biotechnology, microelectronics, pharmacology and material science. The discipline is also concerned with economics and the need to protect the environment.

Industrial Chemistry

"The branch of chemistry which applies physical and chemical procedures towards the transformation of natural raw materials and their derivatives to products that are of benefit to humanity is called industrial chemistry."

Classical chemistry (organic, inorganic and physical chemistry) is very essential for advancing the science of chemistry by discovering and reporting new products, routes and techniques. On the other hand industrial chemistry helps us to close the gap between classical chemistry as it is taught in colleges and universities, and chemistry as it is practiced commercially.

Scope of Industrial Chemistry:

- The exploitation of materials and energy in appropriate scale.
- Application of science and technology to enable humanity experiences the benefits of chemistry in areas such as food production, health and hygiene, shelter, protection, decoration, recreation and entertainment.

(A) Introduction to the Chemical Industry

Classification of industrial chemistry

The chemical industry can also be classified according to the type of main raw materials used and/or type of principal products made. We therefore have:

(i) Industrial inorganic chemical industries

Industrial inorganic chemical Industries extract inorganic chemical substances, make composites of the same and also synthesize inorganic chemicals.

(ii) Industrial organic chemical industries

- Heavy industrial organic chemical industries produce petroleum fuels, polymers, petrochemicals and other synthetic materials, mostly from petroleum.
- Light organic industries produce specialty chemicals which include pharmaceuticals, dyes, pigments and paints, pesticides, soaps and detergents, cosmetic products and miscellaneous products.

The Structure of the Global Chemical Industry

We normally put a value to something according to how much it has cost us. Some things are of high value while others are of low value. For low valued products, you need to produce them in large volumes to make significant profit. This means that the raw materials are cheap and easily accessible. There is also an existing, relatively simple, and easily accessible processing technology. To sell a large volume of product, there must be a large market. This brings stiff competition which also makes the price to remain low.

Commodity Chemicals

The global chemical industry is founded on basic inorganic chemicals (BIC) and basic organic chemicals (BOC) and their intermediates. Because they are produced directly from natural resources or immediate derivatives of natural resources, they are produced in large quantities.

In the top ten BIC, almost all the time, sulphuric acid, nitrogen, oxygen, ammonia, lime, sodium hydroxide, phosphoric acid and chlorine dominate.

Q. Why sulphuric acid (H_2SO_4) is called king of chemicals?

Ans. Because it is used in the manufacture of fertilizers, polymers, drugs, paints, detergents and paper. It is also used in petroleum refining, metallurgy and in many other processes.

The top ranking of oxygen is to do with its use in the steel industry. Ethylene and propylene are usually among the top ten BOC. They are used in the production of many organic chemicals including polymers.

Q. What are commodity chemicals?

Ans. Basic inorganic chemicals (BIC) and basic organic chemicals (BOC) are referred to as commodity or industrial chemicals. Commodity chemicals are therefore defined as low-valued products produced in large quantities mostly in continuous processes. They are of technical or general purpose grade.

Q. What are Specialty Chemicals?

Ans. "High-value adding involves the production of small quantities of chemical products for specific end uses. Such products are called specialty chemicals."

These are high value-added products produced in low volumes and sold on the basis of a specific function.

Examples: Medicinal chemicals, agrochemicals, pigments, flavour and fragrances, personal-care products, surfactants and adhesives.

Q. What are performance chemicals?

Ans. Performance chemicals are high value products produced in low volumes and used in extremely low quantities. They are judged by performance and efficiency.

Examples: Enzymes and dyes are performance chemicals.

Q. Define fine chemicals.

Ans. Fine chemicals:

Specialty chemicals are mainly used in the form of formulations. Purity is of vital importance in their formulation. This calls for organic synthesis of highly valued pure chemicals known as fine chemicals.

At times we will find that the raw materials for our product need to be very pure for the product to function as desired. Research chemicals are in this category as also are pharmaceutical ingredients. Such purified or refined chemicals are called fine chemicals. By **definition** they are high value-added pure organic chemical substances produced in relatively low volumes and sold on the basis of exact specifications of purity rather than functional characteristics.

The global market share for each type is roughly as follows:

Commodities	80%
Specialties	18%
Fine	2%

Exercise: Q.3 (i) What is chemical industry? Discuss different raw materials used in this industry.

(B) Raw material for the Chemical Industry

All chemicals are derived from raw materials available in nature. The price of chemicals depends on the availability of their raw materials. Major chemical industries have therefore developed around the most plentiful raw materials.

The natural environment is the source of raw materials for the chemical industry.

Raw materials from the atmosphere

The atmosphere is the field above ground level. It is the source of air from which six industrial gases namely N_2, O_2, Ne, Ar, Kr and Xe are manufactured. The mass of the earth's atmosphere is approximately 5×10^{15} tons and therefore the supply of the gases is virtually unlimited.

Raw materials from the hydrosphere

Ocean water which amounts to about 1.5×10^{21} litres contains about 3.5 percent by mass dissolved material. Seawater is a good source of sodium chloride, magnesium and bromine.

Raw materials from the lithosphere

The vast majority of elements are obtained from the earth's crust in the form of mineral ores, carbon and hydrocarbons. Coal, natural gas and crude petroleum besides being energy sources are also converted to thousands of chemicals.

Raw materials from the biosphere

Vegetation and animals contribute raw materials to the so-called agro-based industries. Oils, fats, waxes, resins, sugar, natural fibres and leather are examples of thousands of natural products.

QUICK QUIZ

1. Name those disciplines which play important role in industrial chemistry.

Ans. The industrial chemistry has a strong link with the classical chemistry which includes organic, inorganic and physical chemistry. The classical chemistry discovers and report new products, routes and techniques which are then used in industrial chemistry.

2. Define industrial chemistry.

Ans. It is the branch of chemistry which applies physical and chemical procedures towards the transformation of natural raw material and their derivatives to product.

3. What is difference between organic and inorganic chemical industries?

Ans. Inorganic chemical industries

Industrial inorganic chemical Industries extract inorganic chemical substances, make composites of the same and also synthesize inorganic chemicals.

Organic chemical industries

- Heavy industrial organic chemical industries produce petroleum fuels, polymers, petrochemicals and other synthetic materials, mostly from petroleum.
- Light organic industries produce specialty chemicals which include pharmaceuticals, dyes, pigments and paints, pesticides, soaps and detergents, cosmetic products and miscellaneous products.

4. What type of products are obtained from heavy and light organic industries?

Ans. Heavy organic industries produce petroleum, fuels, and polymers, petrochemical whereas light organic industries produce dyes, paint, pigment, soap and detergents.

5. What raw material is obtained from atmosphere?

Ans. Raw materials include gases N_2, O_2, Ar, Kr, Ne, Xe.

6. In which ratio dissolved materials are present?

Ans. 3.5 percent by mass dissolved materials are present.

7. Give few natural products.

Ans. Oil, fats, waxes, resin, sugar, natural fibre and leathers.

8. Give examples of Basic organic chemicals.

Ans. Ethylene and propylene are usually among the top ten BOC. They are used in the production of many organic chemicals including polymers.

9. What do you mean by commodity chemicals?

Ans. Commodity chemicals are defined as low valued products produced in large quantity mostly in continuous processes. These includes:

- Basic inorganic chemicals (BIC) such as:
  - Sulphuric acid
  - Oxygen
  - Ammonia etc.
- Basic organic chemicals (BOC) such as:
  - Ethylene
  - Propylene etc.

10. What is meant by performance chemicals?

Ans. Performance chemicals which are high value products produce in low volume and used in low quantity.

11. Give share of different types of chemicals in global market.

Ans. Commodities = 80%
Specialities = 18%
Fine = 2%

Safety Considerations in Process Industries (Important role of process safety technology)

Introduction

Process safety technology has played an important role in the chemical processing industries so that handling of flammable and combustible liquids and gases could proceed without undesirable consequences. During the 1980s, the oil and gas industries, for example, recognized that process safety technology alone, without process safety management, would not prevent catastrophic incidents. With this in mind, a number of industry associations, such as, in the United States, the Centre for Chemical Process Safety (CCPS), the American Petroleum Institute (API) and the Chemical Manufacturers' Association (CMA), initiated programmes to develop and provide process safety management guidelines for use by their members.

Process Safety Management Requirements

Process safety management is an integral part of the overall chemical processing facility safety programme. An effective process safety management programme requires the leadership, support and involvement of top management, facility management, supervisors, employees, contractors and contractor employees.

Elements of the Process Safety Management Programme

There are a number of basic requirements which should be included in every chemical process safety management programme:

(1) Process safety information

Process safety information is used by the process industry to define critical processes, materials and equipment. Process safety information includes all available written information concerning process technology, process equipment, raw materials and products and chemical hazards before conducting a process hazard analysis. Other critical process safety information is documentation relating to capital project reviews and design basis criteria.

(2) Employee involvement

Process safety management programmes should include employee participation in the development and conduct of process safety analysis and other elements of the programme. Access to process safety information, incident investigation reports and process hazard analysis is usually provided to all employees and contractor employees working in the area. Most industrialized nations require that workers be systematically instructed in the identification, nature and safe-handling of all chemicals to which they may be exposed.

(3) Process hazard analysis

After the process safety information is compiled, a thorough and systematic multi-disciplinary process hazard analysis, appropriate to the complexity of the process, is conducted in order to identify, evaluate and control the hazards of the process. Persons performing the process hazard analysis should be knowledgeable and experienced in relevant chemistry, engineering and process operations. Each analysis team normally includes at least one person who is thoroughly familiar with the process being analysed and one person who is competent in the hazard analysis methodology being used.

(4) Management of change

Chemical process facilities should develop and implement programmes which provide for the revision of process safety information, procedures and practices as changes occur. Such programmes include a system of management authorization and written documentation for changes to materials, chemicals, technology, equipment, procedures, personnel and facilities that affect each process.

(5) Operating procedures

Chemical processing facilities must develop and provide operating instructions and detailed procedures to workers. Operating instructions should be regularly reviewed for completeness and accuracy (and updated or amended as changes occur) and cover the process unit's operating limits.

(6) Safe work practices

Chemical process facilities should implement hot-work and safe work permit and work order programmes to control work conducted in or near process areas. Supervisors, employees and contractor personnel must be familiar with the requirements of the various permit programmes, including permit issuance and expiration and appropriate safety, materials handling and fire protection and prevention measures

(7) Employee information and training

Chemical process facilities should use formal process safety training programmes to train and educate incumbent, reassigned and new supervisors and workers. The training provided for chemical process operating and maintenance supervisors and workers should be comprehensive.

QUICK QUIZ

1. **What are requirement of process safety management?**

Ans. Process safety management requirements:
Leadership, support, involvement of top management, faculty management, supervisors, employees, contractor etc.

2. **How employees should be involved in safety management programme?**

Ans. Employees participates in the development and conduct of process safety analyses and other elements of the program, also access to process safety information, incident investigation report.

3. **What is analysis team?**

Ans. Analysis team normally includes at least one person who is thoroughly familiar with the process being analyzed and one person who is competent in the hazard analysis methodology being used.

4. **What is role of management of change in process industries?**

Ans. Role of management include to change material, chemicals, technology, equipment, procedures and that facilities which effects.

Exercise: Q.3(ii) What are dyes? How are they classified on the basis of structure?

Dyes

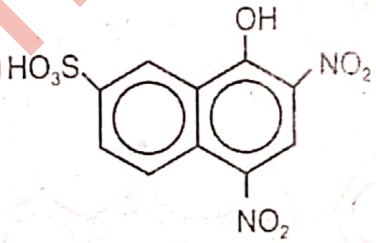
A dye is a coloured compound, normally used in solution, which is capable of being fixed to a fabric. The dye must be 'fast' or chemically stable so that the color will not wash with soap and water, or fade on exposure to sunlight (ultraviolet light).

A dye owes its color to the presence of a chromophore and its fixing property to the acidic or basic auxochromic groups such as OH, SO_3H, NH_2, NR_2, etc. The polar auxochrome makes the dye water-soluble and binds the dye to the fabric by interaction with the oppositely charged groups of the fabric structure.

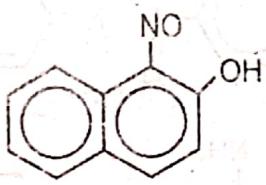
Classification of Dyes by structure

Dyes may be classified according to the type of chromophores present in their structures. This method of classification includes the following main types:

(1) Nitro and Nitroso Dyes: the NO_2 and NO groups are chrmophores in this class of dyes. Examples are,



Naphthol Yellow S

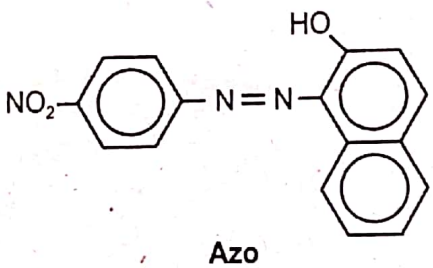


Mordant Green 4

(2) Azo Dyes: The azo dyes contain one or more azo groups, $-N=N-$ as the primary chromophore. The common auxochromres are NH_2, NR_2, OH, SO_3H, etc.

Azo dyes form the largest and most important group of synthetic group of synthetic dyes. They are highly colored and can be prepared by diazotising an aromatic amine and subsequent in both the diazonium salt and the coupling compound series azo dyes can be produced with almost any color. Examples are,

(a) Para Red

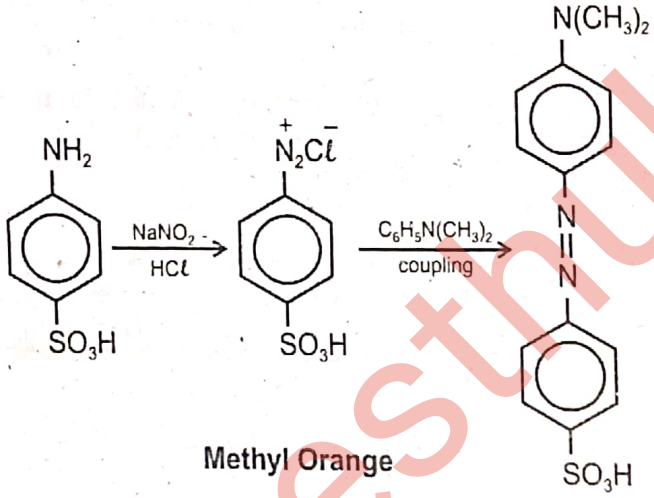


Azo

It was the first azo dye to be prepared. Para red is obtained by the reaction of diazotized p-nitroaniline with β-naphthol on fabric itself.

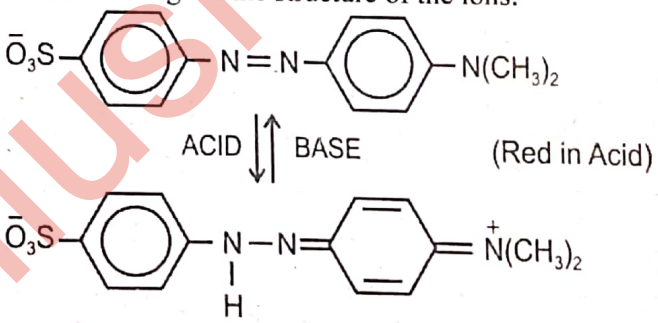
(b) Methyl Orange:

Methyl orange is obtained from sulphanilic acid by the following steps:

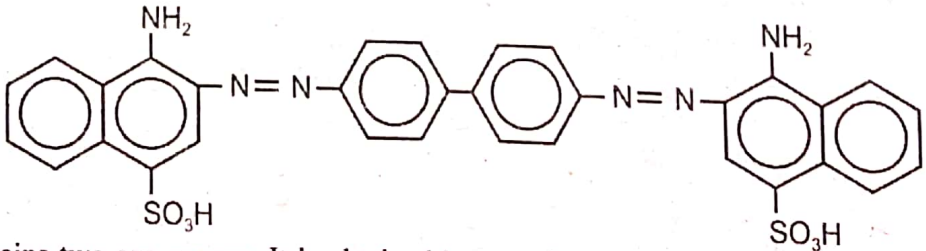


Methyl Orange

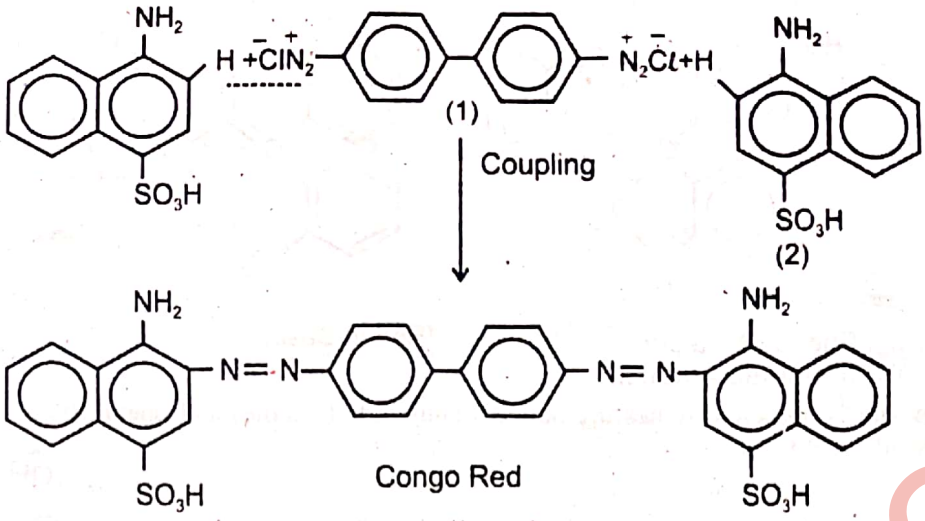
Methyl orange imparts orange color to wool and silk but the color is not fast to sunlight or washing. It is a valuable indicator for acid-base titrations because it gives yellow color in basic solution and red color in acid solution. The change in color is due to the change in the structure of the ions.



(c) Congo Red



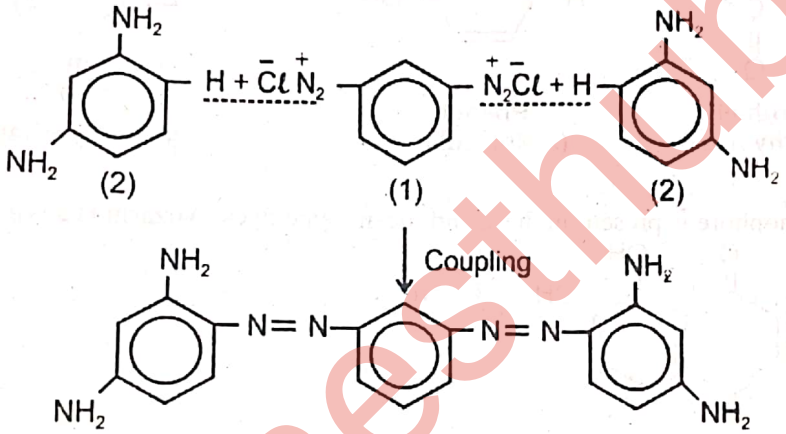
Congo red contains two azo groups. It is obtained by coupling tetrazotised benzidine (1) with two molecules of naphthionic acid (2).



It is a direct dye and its sodium salt is used for dying cotton red from aqueous solutions. Congo red is also used as an indicator, being red in alkali and blue in acid solutions.

(d) Bismarck Brown

It is obtained by coupling tetrazotised *m*-diaminobenzene (1) with two molecules of *m*-diaminobenzene (2).

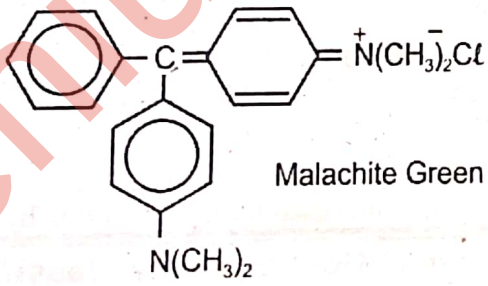


Bismarck Brown

Bismarck brown is a brown dye used in boot polishes and for dyeing wool and cotton.

(3) Triarylmethane Dyes: in triarylmethane dyes, a central carbon is bonded to three aromatic rings one of which is in the quinoid form (the chromophore). The auxochromes are $-NH_2$, $-NR_2$ and $-OH$. Examples are:

(a) Malachite Green

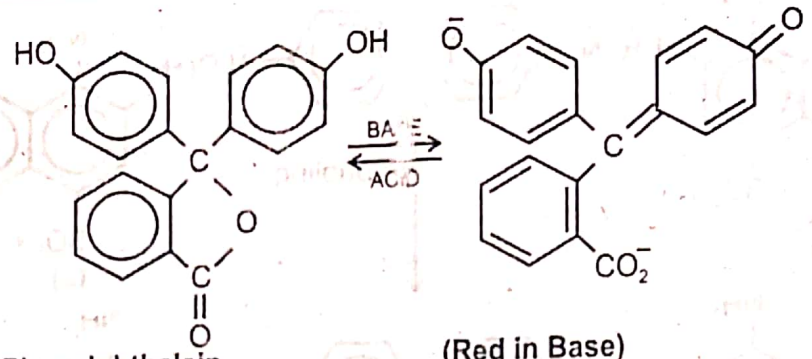


Malachite Green

Malachite green has a deep green-blue color. Although the color fades in light, malachite green is used as a direct dye for wool and silk,

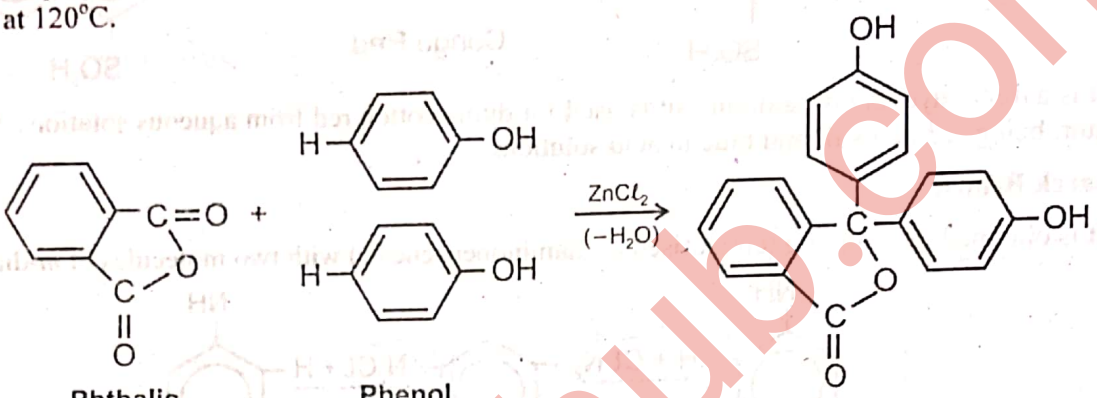
(b) Phenolphthalein:

It is also a triarylmethane dye but it is better known as an acid-base indicator.



Phenolphthalein (Colourless in Acid) (Red in Base)

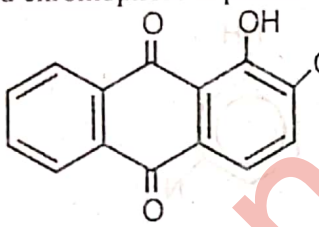
Phenolphthalein is prepared by heating phthalic anhydride (1 mole) and phenol (two moles) in the presence of anhydrous zinc chloride at 120°C.



Phthalic Anhydride — Phenol (2 Molecules) — Phenolphthalein

(4) Anthraquinone Dyes:

The para quinoid chromophore is present in these anthracene-type dyes. Alizarin is a typical anthraquinone dye.

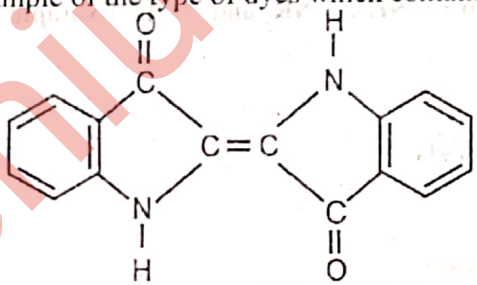


Alizarin

Alizarin forms ruby red crystals which dissolve in alkali to give purple solutions. It is used to dye wool and cotton.

(5) Indigo Dyes:

Indigo is an example of the type of dyes which contain carbonyl chromophore.



Indigo

It is a dark-blue crystalline compound, insoluble in water. It is used for dyeing cotton by the *Vat Process*.

Exercise Q.3(iii) What do you know about dyes? How are they classified on the basis of application?

Classification of dyes by methods of application

The chemical classification of dyes is of interest to the chemist but the dyer is concerned mainly with the application of dyes to fabrics. The method used for application in a particular case depends on the nature of both the dye and the fiber to be dyed. The dyes are often classified on the basis of technique employed for their application.

(1) Direct Dyes

These can be applied to a fabric by direct immersion in a water solution of the dye. A direct dye contains acidic or basic auxochrome which combines with the opposite polar group present in the chemical structure of the fiber. Wool and silk are readily dyed by this method. Martius Yellow; a typical direct dye, has the acidic auxochrome –OH which interacts with the basic-NH_2 group of wool or silk.

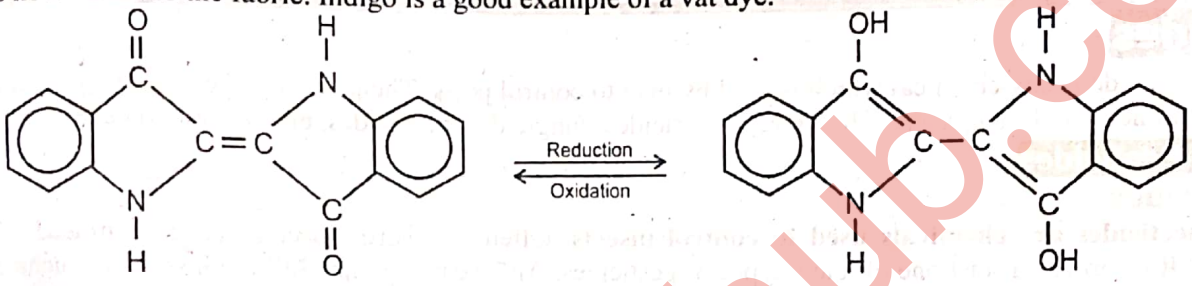
$$\text{Fiber} - NH_2 + HO-\text{Dye} \longrightarrow \text{Fiber} - \overset{+}{N}H_3 \cdots O-\text{Dye}$$

(wool or silk)

Exercise: Q.3(iv) Write a note on: (i) Vat Dyes (ii) Mordant Dyes

(2) Vat Dyes

These dyes are insoluble in water but on reduction with sodium hydrosulphide in a vat form a colorless soluble compound which has a great affinity for cotton and other cellulose fibers. The cloth is soaked in the solution of a reduced dye and then hung in air, or treated with oxidants. As a result, the colorless compound is oxidized back to the insoluble dye which is now bound to the fabric. Indigo is a good example of a vat dye.

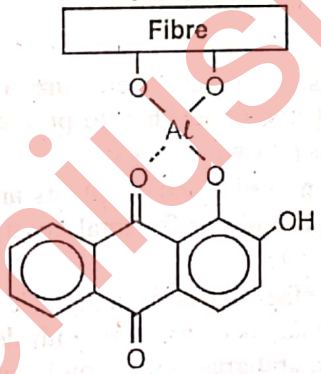


Indigo (Blue) Indigo White (Colourless)

Indigo white has auxochrome –OH which bind the dye fast to the cellulose fiber that contains ethereal oxygen and OH groups by hydrogen bonding.

(3) Mordant Dyes

This class of dyes has no natural affinity for the fabric and are applied to it with the help of salts e.g., oxides of aluminum or chromium. These salts are called mordants. A fiber such as cotton is first treated with a mordant and then with the dye solution. The mordant forms an insoluble coordination complex between the fiber and the dye and binds the two. The insoluble complex compound appears in the form of lakes that are fast to light and washing. The mordant dyeing is the most suitable for wool and nylon. Alizarin is an example of a mordant dye.



(4) Azoic Dyes (Ingrain Dyes)

In this method of dyeing, the water insoluble azo dye is produced in the fabric itself. The cloth is first soaked in the solution of a coupling reagent usually a phenol or naphthol. Then it is immersed in the solution of an auxochromes. The azoic dyeing is particularly suitable for cotton and other cellulosic fiber but may also be used for nylon.

(5) Disperse Dyes

These dyes are insoluble in water but can be dispersed in a colloidal form in water. The fabric is immersed in the colloidal dispersion of the dye. The fine dye particles are absorbed into the crystal structure of the fabric. Disperse dyes are used with modern synthetic fabrics such as nylon, orlon, polyester and cellulose acetate.

QUICK QUIZ

1. **Which one is first azo dye?**

Ans. Para red was the first azo dyes to be prepared.

2. **What is the color of Methyl orange: (i) in acidic medium (ii) in basic medium.**

Ans. (i) Red colour (ii) Yellow colour

3. **Which dye is used in boot polish and in dyeing wool and cotton?**

Ans. Bismark Brown is used in boot polish and to dye wool and cotton.

4. **What is the color of phenolphthalein in (i) acidic medium (ii) basic medium.**

Ans. (i) Colorless in acidic medium (ii) Red in basic medium.

Exercise: Q.3(v) What is meant by pesticides? Describe its types in detail.

Pesticides

A pesticide is any chemical which is used by man to control pests. The pests may be insects, plant diseases, fungi, weeds, nematodes, snails, slugs, etc. Therefore, insecticides, fungicides, herbicides, etc., are all types of pesticides.

Types of Pesticides

1-Insecticides

Insecticides are chemicals used to control insects. Often the word "insecticide" is confused with the word "pesticide." It is, however, just one of many types of pesticides. An insecticide may kill the insect by touching it or it may have to be swallowed to be effective. Some insecticides kill both by touch and by swallowing. Insecticides called **Systemics** may be absorbed, injected, or fed into the plant or animal to be protected. When the insect feeds on this plant or animal, it ingests the systemic chemical and is killed.

2-Miticides (Acaricides)

Miticides (or Acaricides) are chemicals used to control mites (tiny Insects spider-like animals) **and ticks.** The chemicals usually must contact the mites or ticks to be effective. These animals are so numerous and small, that great care must be used to completely cover the area on which the mites live. Miticides are very similar in action to insecticides and often the same pesticide kills both insects and mites.

3- Fungicides

Fungicides are chemicals used to control the fungi which cause molds, rots, and plant diseases. All fungicides work by coming in contact with the fungus, because fungi do not "swallow" in the normal sense.

4-Herbicides

Herbicides are chemicals used to control unwanted plants. These chemicals are a bit different from other pesticides because they are used to kill or slow the growth of some plants, rather than to protect them. Some herbicides kill every plant they contact, while others kill only certain plants. It is of following types:

Nonselective herbicides are toxic to all plants. These are often used when no plants are wanted in an area. For example, nonselective herbicides could be used for clearing under guardrails or for total control of weeds in industrial areas.

Selective herbicides kill some plants with little or no injury to other plants. Usually selective types will kill either broadleaved plants or grassy plants. These are useful for lawns, golf courses or in areas with desirable trees. Some very selective herbicides may kill only certain plants in a group; for example, crabgrass killers on lawns.

5-Rodenticides

Rodenticides are chemicals used to control rats, mice, bats and other rodents. Chemicals which control other mammals, birds, and fish are also grouped in this category by regulatory agencies. Most rodenticides are stomach poisons and are often applied as baits.

6-Nematicides

Nematicides are chemicals used to control nematodes. Nematodes are tiny hair-like worms, many of which live in the soil and feed on plant roots. Very few of these worms live above ground. Usually, soil fumigants are used to control nematodes in the soil.

7-Molluscicides

Molluscicides are chemicals used to control snails and slugs. Usually the chemicals must be eaten by the pest to work. Baits are often used to attract and kill snails or slugs in an area.

8-Repellent

A repellent is a pesticide that makes a site or food unattractive to a target pest. They are registered in the same way other pesticides are and must be used according to the label. Insect repellents are available as aerosols and lotions and can be applied to skin, clothing, or plants to repel biting and nuisance insects. Vertebrate repellents are available as concentrates to be mixed with water, powders, and granules. They can be sprayed or painted on nursery crops, ornamental plantings, orchards, vineyards, vegetables, and seeds. Repelling deer, dogs, birds, raccoons, and others can protect sites from damage.

QUICK QUIZ

1. Differentiate between (i) Pesticides and Insecticides (ii) Fungicides and herbicides.

Ans. (i) Pesticides and Insecticides:

A pesticides is any chemical which is used by man to control pests. The pests may be insect, plant diseases, fungi, weeds while insecticides are chemicals used to control insects.

(ii) Fungicides and herbicides:

Fungicides are chemicals used to control the fungi which cause molds, rots and plant diseases. Where as herbicides are chemicals used to control unwanted plants.

2. What do you understand by systemics?

Ans. Systemics are chemicals which are made to enter into a body system of living organisms by different ways. These may be absorbed, injected or fed into the plant or animal to be protected.

3. How do herbicides different from other pesticides?

Ans. Herbicides are chemicals used to control unwanted plants.

4. Give different types of repellents.

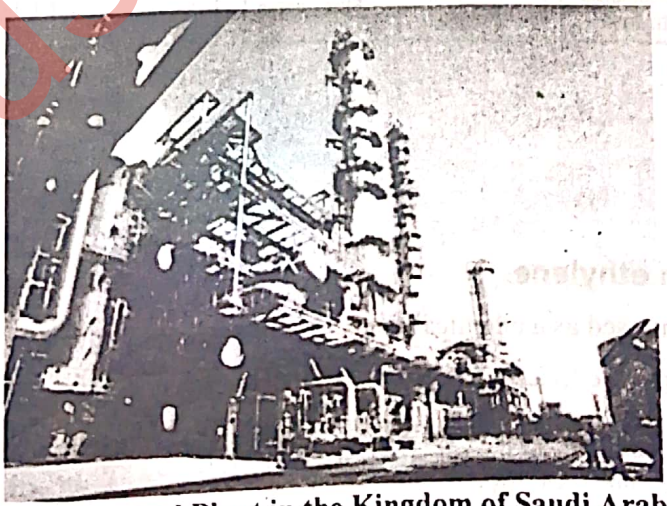
Ans. Ornamental plantings, orchards, vineyards, vegetables and seeds are different type of repellent.

5. What are molluscicides?

Ans: Molluscides are chemical used to control snails and slugs.

Petrochemical

The prefix "petro-" is an arbitrary abbreviation of the word "petroleum"; since "petro-" is Ancient Greek word for "rock" and "oleum" means "oil". Therefore, the etymologically correct term would be "oleochemicals". However, the term oleochemical is used to describe chemicals derived from plant and animal fats.



Petrochemical Plant in the Kingdom of Saudi Arabia

Meanings

Petrochemicals are chemical products derived from petroleum. Some chemical compounds made from petroleum are also obtained from other fossil fuels such as coal or natural gas, or renewable sources such as corn or sugar cane.

Exercise: Q.3(vi) Describe the basic building block in petrochemicals technology.

Types/Classes of Petrochemical raw materials (Building Blocks)

Petrochemical classes are:-

(a) Olefins including ethylene and propylene

(b) Aromatics

(c) Synthesis Gas

Olefins and aromatics are the building blocks for a wide range of materials such as solvents, detergents, and adhesives.

Primary petrochemicals are divided into three groups depending on their chemical structure:

(a) Olefins includes ethylene, propylene, and butadiene. Ethylene and propylene are important sources of industrial chemicals and plastics products. Butadiene is used in making synthetic rubber. Olefins are the basis for polymers and oligomers used in plastics, resins, fibers, elastomers, lubricants, and gels. At oil refineries olefins are produces mainly from hydrocarbons by chemical cracking such as steam cracking and by catalytic reforming.

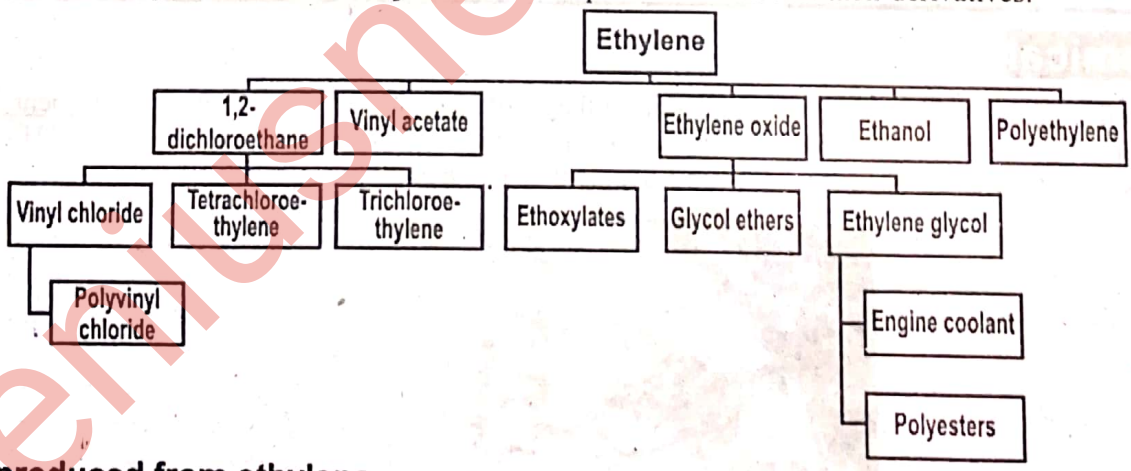
(b) Aromatics includes benzene, toluene, and xylenes. Benzene is a raw material for dyes and synthetic detergents, and benzene and toluene for isocyanates Manufacturers use xylenes to produce plastics and synthetic fibers. At oil refineries, aromatic hydrocarbons are mainly produced by catalytic reforming or similar processes.

(c) Synthesis gas is a mixture of carbon monoxide and hydrogen used to make ammonia and methanol. Ammonia is used to make the fertilizer urea and methanol is used as a solvent and chemical intermediate.

World production of ethylene is around 110 million tons per annum of propylene 65 million tons and of aromatic raw materials 70 million tons. The largest petrochemicals industries are to be found in the USA and Western Europe, though the major growth in new production capacity is in the Middle East and Asia. There is a substantial inter-regional trade in petrochemicals of all kinds.

List of significant petrochemicals and their derivatives

The following is a partial list of the major commercial petrochemicals and their derivatives:



Chemicals produced from ethylene

Ethylene - the simplest olefin; used as a chemical feedstock and ripening hormone

(i) polyethylene - polymerized ethylene

(ii) ethanol - via ethylene hydration (chemical reaction adding water) of ethylene

(iii) ethylene oxide - via ethylene oxidation

(a) ethylene glycol - via ethylene oxide hydration

(b) engine coolant - ethylene glycol, water and inhibitor mixture

(c) polyesters - any of several polymers with ester linkages in the backbone chain

(d) glycol ethers - via glycol condensation

(e) ethoxylates

iv) vinyl acetate

v) 1,2-dichloroethane

(a) trichloroethylene

(b) tetrachloroethylene - also called perchloroethylene; used as a dry cleaning solvent and degreaser

(c) vinyl chloride - monomer for polyvinyl chloride

polyvinyl chloride (PVC) - type of plastic used for piping, tubing, other things

emicals produced from propylene

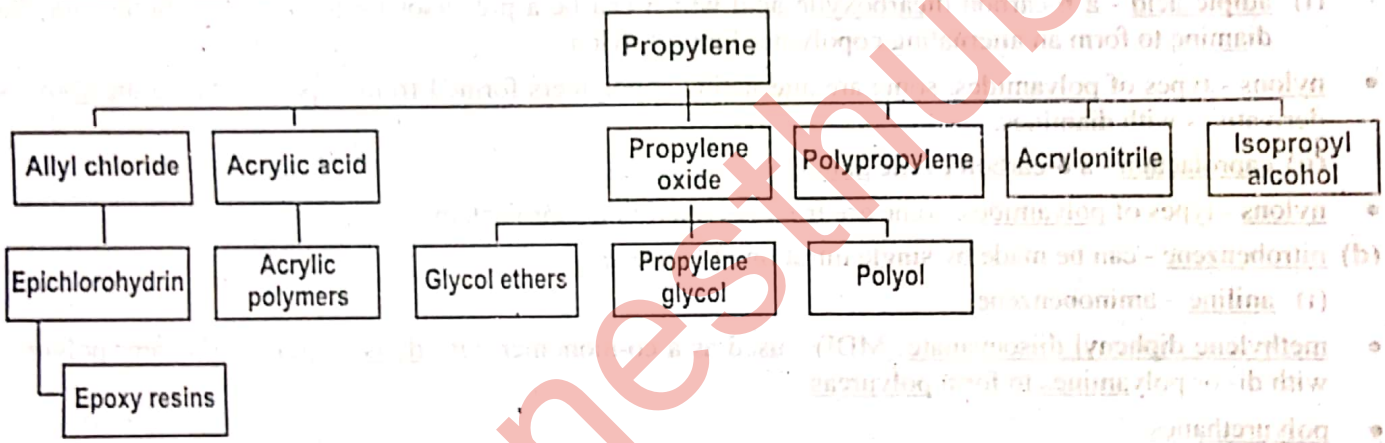
propylene - used as a monomer and a chemical feedstock

(a) isopropyl alcohol - 2-propanol; often used as a solvent or rubbing alcohol

(b) acrylonitrile - useful as a monomer in forming Orlon, ABS

(c) polypropylene - polymerized propylene

(d) propylene oxide



(i) polyol - used in the production of polyurethanes

(ii) propylene glycol - used in engine coolant and aircraft deicer fluid

(iii) glycol ethers - from condensation of glycols

(e) acrylic acid

(i) acrylic polymers

(f) allyl chloride -

(i) epichlorohydrin - chloro-oxirane; used in epoxy resin formation

epoxy resins - a type of polymerizing glue from bisphenol A, epichlorohydrin, and some amine

emicals produced from benzene

(a) Benzene - the simplest aromatic hydrocarbon

(i) ethylbenzene - made from benzene and ethylene

(ii) styrene made by dehydrogenation of ethylbenzene; used as a monomer

- polystyrenes - polymers with styrene as a monomer

(b) cumene - isopropylbenzene; a feedstock in the cumene process

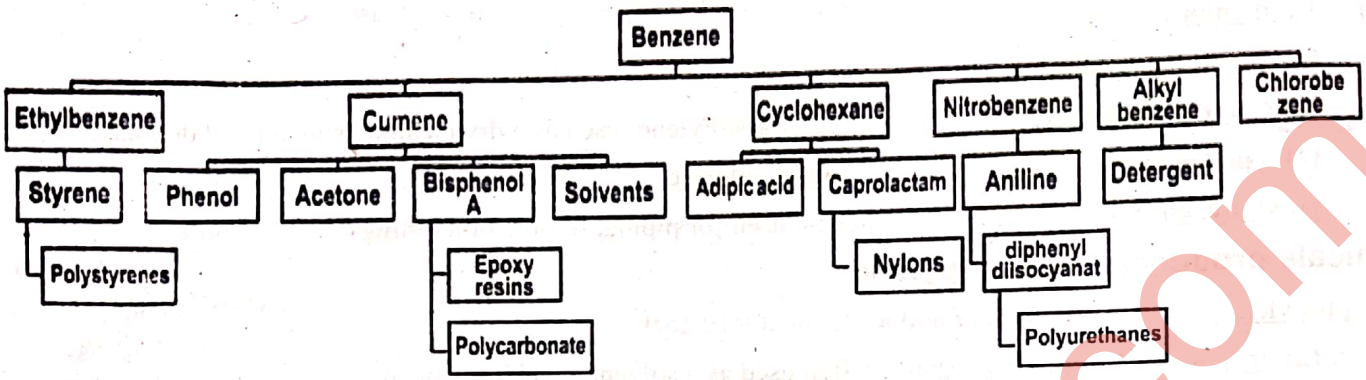
(i) phenol - hydroxybenzene; often made by the cumene process

(ii) acetone - dimethyl ketone; also often made by the cumene process

(iii) bisphenol A - a type of "double" phenol used in polymerization in epoxy resins and making a common type of polycarbonate

epoxy resins - a type of polymerizing glue from

- bisphenol A, epichlorohydrin, and some amine
- polycarbonate - a plastic polymer made from bisphenol A and phosgene (carbonyl dichloride)



(iv) solvents - liquids used for dissolving materials; examples often made from petrochemicals include ethanol, isopropyl alcohol, acetone, benzene, toluene, xylenes.

(c) cyclohexane - a 6-carbon aliphatic cyclic hydrocarbon sometimes used as a non-polar solvent.

(i) adipic acid - a 6-carbon dicarboxylic acid which can be a precursor used as a co-monomer together with a diamine to form an alternating copolymer form of nylon.

- nylons - types of polyamides, some are alternating copolymers formed from copolymerizing dicarboxylic acid or derivatives with diamines.

(ii) caprolactam - a 6-carbon cyclic amide.

- nylons - types of polyamides, some are from polymerizing caprolactam.

(d) nitrobenzene - can be made by single nitration of benzene.

(i) aniline – aminobenzene.

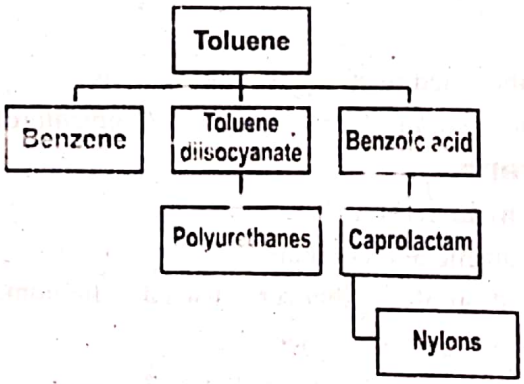
- methylene diphenyl diisocyanate (MDI) - used as a co-monomer with diols or polyols to form polyurethanes or with di- or polyamines to form polyureas.
- polyurethanes.

(e) alkylbenzene - a general type of aromatic hydrocarbon which can be used as a presursor for a sulfonate surfactant (detergent).

(i) detergents - often include surfactants types such as alkylbenzenesulfonates and nonylphenol ethoxylates

(f) chlorobenzene.

Chemicals produced from toluene



(A) toluene - methylbenzene; can be a solvent or precursor for other chemicals.

(a) benzene.

(b) toluene diisocyanate (TDI) - used as co-monomers with diols or polyols to form polyurethanes or with di- or polyamines to form polyureas.

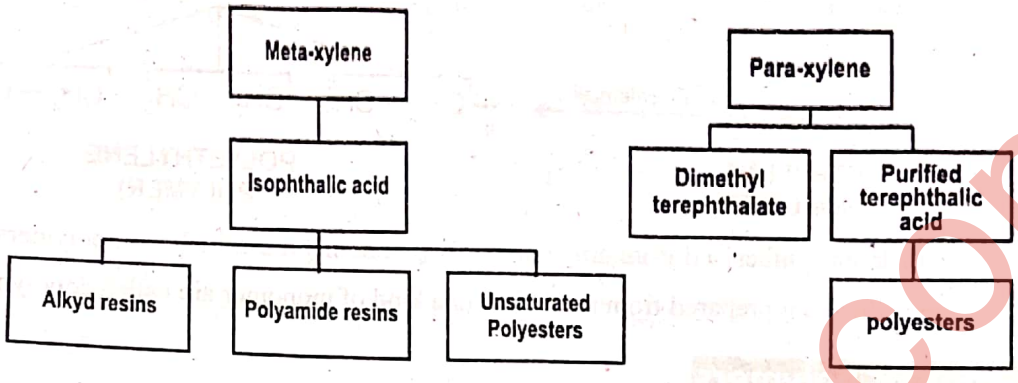
(i) polyurethanes - a polymer formed from diisocyanates and diols or polyols.

(c) benzoic acid – carboxybenzene.

(i) caprolactam.

- nylon

Chemicals produced from xylenes



(A) mixed xylenes - any of three dimethylbenzene isomers, could be a solvent but more often precursor chemicals.

(a) *ortho*-xylene - both methyl groups can be oxidized to form (*ortho*-)phthalic acid.

(i) phthalic anhydride.

(b) *para*-xylene - both methyl groups can be oxidized to form terephthalic acid.

(i) dimethyl terephthalate - can be copolymerized to form certain polyesters.

- polyesters - although there can be many types, polyethylene terephthalate is made from petrochemical products and is very widely used.

(ii) purified terephthalic acid - often copolymerized to form polyethylene terephthalate.

- polyesters.

(c) *meta*-xylene

(i) isophthalic acid

- alkyd resins.
- Polyamide Resins.
- Unsaturated Polyesters.

QUICK QUIZ

1. What do you mean by petrochemicals?

Ans. Petrochemicals are chemical products derive from petroleum.

2. What are classes of petrochemical raw materials?

Ans. (a) Olefins including ethylene and propylene.
(b) Aromatic
(c) Synthesis gas.

3. What are important fractions of petroleum?

Ans. Important fractions of petroleum are petroleum gas, gasoline, naphtha, keroscene oil, diesel oil, lubrication oil, fuel oil.

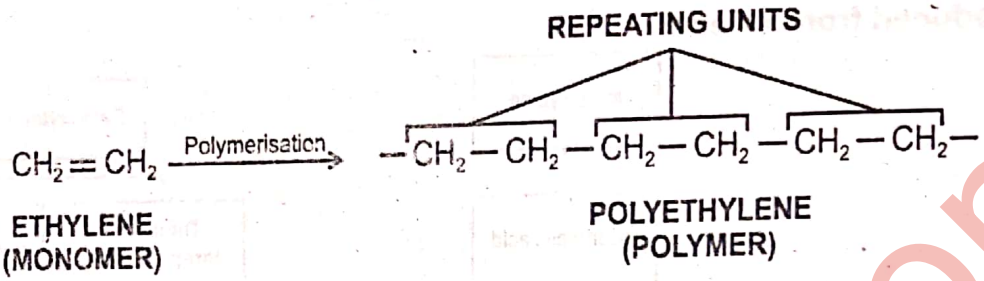
4. How does refining of petroleum carried out in Pakistan?

Ans. The oil obtained from the oil fields of Dhulain, Khaur, Balkasar and Joyameer is refined by Pakistan oil field limited near Rawalpindi. The imported crude oil is refined at Karachi.

Synthetic Polymers

Polymers are high molecular weight compounds whose structures are made up of a large number of simple repeating units. The repeating units are usually obtained from low molecular weight simple compounds referred to as monomers. The reaction by which monomers are converted into polymers is known as polymerization.

The formation of polyethylene from ethylene is an example of polymerisation reaction.



- Polymers which are synthesized from only one kind of monomer are called homopolymers.
- e.g. polymers which are prepared from more than one kind of monomer are called copolymers.

Classification of polymers

There are two main types of polymers:

Addition polymers and condensation polymers.

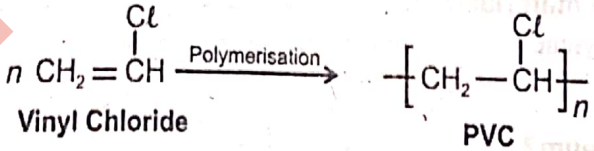
(I) Addition Polymers (*Chain-Growth Polymers*)

Addition polymers are formed by combination of alkenes monomers to produce a single huge molecule only. These reactions are catalyzed by peroxides or acids. The reactions require pressures of 1000 atmospheres at 2000°C. Much lower temperatures and pressures can be used with so called **Ziegler Catalysts** ($TiCl_3$ and $Al(C_2H_5)_2\,Cl$) which consist of a trialkyl aluminum and titanium tetrachloride in an inert soivent.

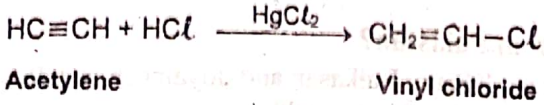
(1) Polyethylene (Polythene): It is obtained by polymerizing ethylene. Polyethylene has been produced commercially since 1943. It is used in the manufacture of houseware such as buckets and dustbins, carpet backing, packing materials, and cable insulation.

Notice that the monomer (ethylene) contains a double bond and the polymer does not. The electrons of the monomer pi bond have moved and are used to link one monomer unit to another by sigma bonds as indicated by extended lines in abbreviated polymer formula. The backbone of the polymer consists of the carbon atoms that originally formed the double bonds. Nothing is lost. The monomers simply add to each other.

(2) Polyvinyl Chloride (PVC): It is obtained by polymerizing vinyl chloride. PVC is used in the manufacture of imitation leather, floor covering, corrugated roofing material and gramophone records.



Vinyl chloride is obtained from acetylene by treatment with HCl in the presence of $HgCl_2$.



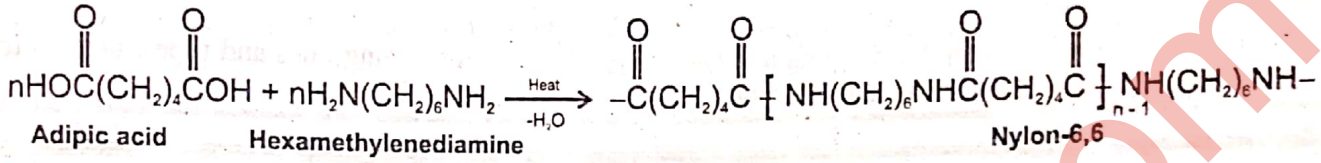
(ii) Condensation Polymers (step-growth polymers)

Condensation polymers are formed by combination of monomers with the elimination of simple molecules such as H_2O or CH_3OH. There are two main types of condensation polymers:

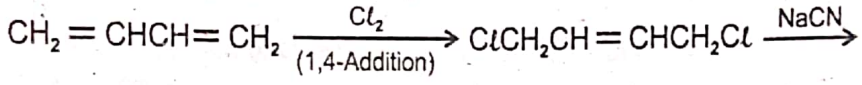
Polyesters or polyamides. The most common example is:

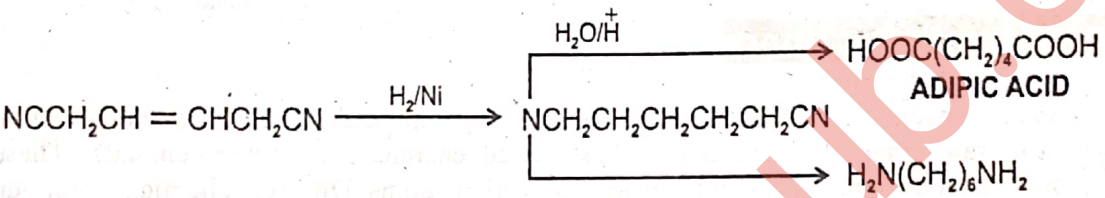
Q. What is Nylon-6,6 and how it is prepared.

Ans. **Nylon-6,6** is the most important polyamide. It is obtained by heating adipic acid with hexamethylene diamine under nitrogen at 2000°C. Nylon-6,6 derives its name from its starting materials, adipic acid and hexamethylene diamine, both of which have six carbons.



Both starting materials can be prepared from 1,3-butadiens as shown below:





Nylon-6,6 was developed as a synthetic fiber for the production of stocking and other wearing apparel. It was introduced to the public at the New York World's Fair in 1939. It is used to make fibers for clothing and carpeting, filaments for fishing lines and ropes, bristles for brushes, and molded objects such as gears and bearings.

Thermoplastic and thermosetting polymers

A thermoplastic polymer is one which softens on heating and becomes hard on cooling.

A thermosetting polymer is one which becomes hard on heating it cannot be softened by heating.

QUICK QUIZ

1. **What are uses of (i) PVC (ii) Nylon-6,6?**

Ans. **(i) PVC:**

PVC is used in the manufactures of floor covering, gramophone records and imitation leather.

(ii) Nylon-6,6

It is used to make fibres for clothing and carpeting, filament for fishing lines and ropes, brittle for brushes.

2. **What is the difference between addition and condensation Polymers?**

Ans. Addition polymers are formed by combination of alkene monomer to produce single huge molecule. Whereas condensation polymers are formed by combination of monomers with the elimination of simple molecules such as H_2O.

3. **Give difference between thermoplastic and thermosetting plastic.**

Ans. A thermoplastic polymer is one which softens on heating and become hard on cooling. Whereas, A thermosetting polymer is one which becomes hard on heating it cannot be soften by heating.

4. **How vinyl chloride is prepared from acetylene.**

Ans. Vinyl chloride is prepared from acetylene by treatment with HCl in the presence of $HgCl_2$.

$$H-C\equiv C-H + HCl \xrightarrow{HgCl_2} CH_2=CH-Cl$$

Vinyl chloride

5. Write formulae of (i) adipic acid (ii) hexamethylene diamine.

Ans. (I) $HOOC(CH_2)_4COOH$

Adipic acid

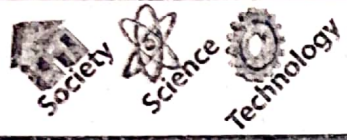
(ii) $H_2N(CH_2)_6NH_2$

Hexamethylene diamine

6. Give use of Nylon-6,6.

Ans. Use of Nylon-6,6:

It is used to make fibres for clothing and carpeting, filaments for fishing lines and ropes, bristles for brushes, and molded objects such as gears and bearings.



Development of synthetic fibers

Nylon is the first synthetic fiber.

Synthetic fibers are made from synthesized polymers or small molecules. The compounds that are used to make these fibers come from raw materials such as **petroleum** based chemicals or petrochemicals. These materials are polymerized into a long, linear chemical that bond two adjacent carbon atoms. Different chemical compounds will be used to produce different types of fibers.

There are several methods of manufacturing synthetic fibers but the most common is the **Melt-Spinning Process.** It involves heating the fiber until it begins to melt, then drawing out the molten fiber with tweezers as quickly as possible. The next step is to draw the molecules by aligning them in a parallel arrangement. This brings the fibers closer together and allows them to crystallize and orient. Lastly, is Heat-Setting. This utilizes heat to permeate the shape and dimensions of the fabrics made from heat-sensitive fibers.

In general, **synthetic** fibers are created by forcing, usually through **extrusion** (the act or process of pushing or thrusting out to create objects of a fixed, cross-sectional profile) fiber, forming materials through holes (called spinnerets) into the air, forming a thread. Before synthetic fibers were developed, artificially manufactured fibers were made from **cellulose.**

Uses of synthetic fibres.

Synthetic fibres are used for making:

- Clothes
- Ropes
- Nylon is used in making stockings, parachutes and other military equipment.
- Fish nets
- Carpets
- Tents
- Derclon is used in making rugs.

Glass fiber is used for:

- industrial, automotive, and home insulation (**glass wool**)
- reinforcement of **composite materials (glass-reinforced plastic, glass fiber reinforced concrete)**
- specialty papers in **battery** separators and filtration

Metallic fiber is used for:

- adding metallic properties to **clothing** for the purpose of **fashion** (usually made with composite plastic and **metal foils**)
- elimination and prevention of static charge build-up
- conducting **electricity** to transmit information

- conduction of heat

In the horticulture industry synthetics are often used in soils to help the plants grow better. Examples are:

- expanded polystyrene flakes
- urea-formaldehyde foam resin
- polyurethane foam
- phenolic resin foam

Cosmetic Chemistry

Introduction

The global market for skincare and color cosmetics exceeded 53 billion dollars in 2002. The number of new products brought to market continues to expand exponentially. Cosmetic chemists are always looking for interesting and exotic ingredients that improve skin's appearance and health. A vast array of compounds is required to supply these products. The latest edition of the Cosmetics Toiletries and Fragrance Association (CTFA) Dictionary lists more than 10,000 raw materials. Every year hundreds of new ingredients are added to the list of those that have been used for centuries.

This particular topic is very vast but we will restrict ourselves in the following topics and discuss them one by one with a sufficient detail in each case:

1. Nail Polish
2. Nail Polish Remover
3. Lipstick
4. Hair dyes

Nail Polish

Background

Unlike many other cosmetics that have a history of hundreds or even thousands of years, nail polish (or lacquer, or enamel) is almost completely an invention of twentieth century technology. Nail coverings were not unknown in ancient times - the upper classes of ancient Egypt probably used henna to dye both hair and fingernails - but essentially, its composition, manufacture and handling reflect developments in modern chemical technology.

Modern nail polish is sold in liquid form in small bottles and is applied with a tiny brush. Within a few minutes after application, the substance hardens and forms a shiny coating on the fingernail that is both water- and chip-resistant. Generally, a coating of nail polish may last several days before it begins to chip and fall off. Nail polish can also be removed manually by applying nail polish "remover," a substance designed to break down and dissolve the polish.

Exercise: Q.3(vii) Describe raw materials and manufacturing process of Nail Polish.

Raw Materials

There is no single formula for nail polish. There are, however, a number of ingredient types that are used. These basic components include:

1. **Film forming agents** e.g. Nitrocellulose
2. **Resins and plasticizers** e.g. castor oil, amyl and butyl stearate, and mixes of glycerol, fatty acids, and acetic acids
3. **Solvents** e.g. Butyl stearate and acetate compounds.
4. **Coloring agents** e.g. "pearl" or "fish scale"

The manufacturing process includes following steps

1. When properly and fully milled, the mixture is removed from the mill in sheet form and then broken up into small chips for mixing with the solvent. The mixing is performed in **stainless steel** kettles.

Caution:

This step is performed in a special room or area designed to control the hazards of fire and explosion. Most modern factories perform this step in an area with walls that will close in if an alarm sounds and, in the event of explosion, with ceilings that will safely blow off without endangering the rest of the structure.

2. At the end of the process, the mix is cooled slightly before the addition of such other materials as perfumes and moisturizers.

3. The mixture is then pumped into smaller, 55 gallon drums, and then trucked to a production line. The finished nail polish is pumped into explosion proof pumps, and then into smaller bottles suitable for the retail market.

Nail Polish Remover

Nail polish remover base commonly contains a mixture of two organic solvents **acetone** and **ethyl acetate.**

Acetone belongs to a group of organic molecules called ketones or alkanones. The proper name acetone is propanone. It is also sometimes called 2-propanone.

Interesting Information

Acetone is an organic liquid that is colorless, flammable and is often used as a solvent as it is completely miscible with water and nearly all other organic liquids.

Ethyl acetate belongs to a group of organic molecules called esters or alkyl alkanoates. The proper name for ethyl acetate is ethyl ethanoate.

1. Give composition of nail polish.

Ans. Basic component of nail polish:

(i) Film forming agents
(ii) Resins and plasticizers
(iii) Solvents
(iv) Coloring agents

2. What is use of plasticizers in nail polish?

Ans. The function of all plasticizers is to produce elasticity in the product.

3. In which material mixing of raw material of nail polish is preferred?

Ans. The mixing is performed in stainless steel kettles.

4. What is nail polish remover?

Ans. A substance design to break down and dissolve the polish.

5. Give composition of nail polish remover.

Ans. Nail polish remover commonly contains a mixture of two organic solvent

- acetone
- ethylacetate

Lipstick and Chemical Composition

Lipsticks are simple in chemical composition, however complicated their application or effects. They are made up of three ingredients - a waxy or fatty base, a dye and a perfume.

There is no danger in the use of lipstick. In fact, for sensitive mucous membranes they are protective. Anyone can eat a lipstick with no more harm than eating a pat of butter.

Raw Materials: The primary ingredients found in lipstick are wax (The wax used usually involves some combination of three types - beeswax, candelilla wax, or the more expensive camauba) oil (such as mineral, caster, lanolin, or vegetable oil) alcohol, fragrance and pigment, preservatives and antioxidants.

In general, wax and oil make up about 60 percent of the lipstick (by weight), with alcohol and pigment accounting for another 25 percent (by weight). Fragrance added to lipstick, accounts for one percent or less of the mixture.

The Manufacturing Process: The manufacturing process is easiest to understand if it is viewed as three separate steps: melting and mixing the lipstick; pouring the mixture into the tube; and packaging the product for sale.

Melting and mixing: First, the raw ingredients for the lipstick are melted and mixed-separately because of the different types of ingredients used. One mixture contains the solvents, a second contains the oils, and a third contains the fats and waxy materials.The solvent solution and liquid oils are then mixed with the color pigments. After the pigment mass is ground and mixed, it is added to the hot wax mass until a uniform color and consistency is obtained.

Molding: Once the lipstick mass is mixed and free of air, it is ready to be poured into the tube. A variety of machine setups are used, depending on the equipment that the manufacturer has. The melted mass is dispensed into a mold, "up-

side down" so that the bottom of the tube is at the top of the mold. The lipstick is cooled and separated from the mold, and the bottom of the tube is sealed. The lipstick then passes through a flaming cabinet (or is flamed by hand) to seal pinholes and improve the finish.

Labeling and packaging: After the lipstick is retracted and the tube is capped, the lipstick is ready for labeling and packaging. Labels identify the batch and are applied as part of the automated operation. The final step in the manufacturing process is the packaging of the lipstick tube. There are a variety of packaging options available.

QUICK QUIZ

1. Give composition of lipstick.

Ans. The ingredients of lipstick are a waxy or fatty base, a dye and a perfume.

2. What type of wax is used as raw material of lipstick?

Ans. Beeswax, candelilla wax, alcohol, fragrance and pigments.

3. How many steps are involved in manufacturing of lipstick?

Ans. (i) Melting and mixing
(ii) Molding
(iii) Labeling and packaging.

4. Give percentage of alcohol and pigments in lipstick.

Ans. Alcohol and pigments have 25% by weight.

Hair dye

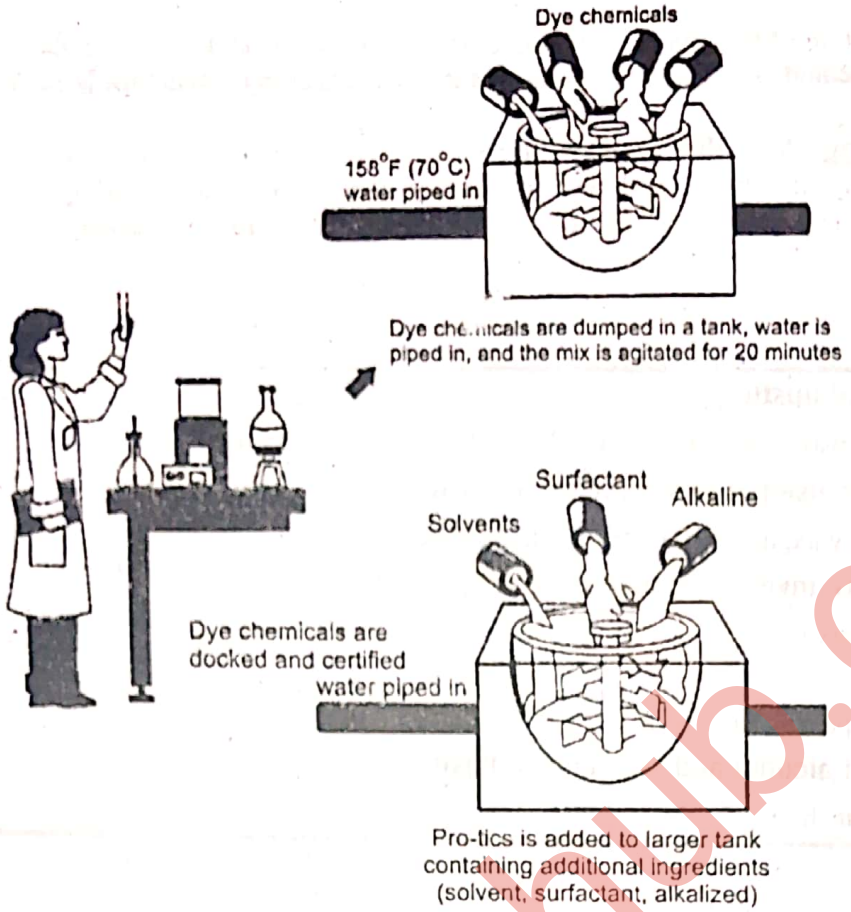
History:

1. Hair dye is one of the oldest known beauty preparations, and was used by ancient cultures in many parts of the world. Records of ancient Egyptians, Greeks, Hebrews, Persians, Chinese, and early Hindu peoples all mention the use of hair colorings.
2. Early hair dyes were made from plants, metallic compounds, or a mixture of the two.
3. Rock alum, quicklime, and wood ash were used for bleaching hair in Roman times. Henna was known in many parts of the world; it produces a reddish dye.
4. Many different plant extracts were used for hair dye in Europe and Asia before the advent of modern dyes.
5. Indigo, known primarily as a fabric dye (see section 22.3), could be combined with henna to make light brown to black shades of hair dye.
6. An extract of the flowers of the chamomile plant was long used to lighten hair, and this is still used in many modern hair preparations.
7. The bark, leaves, or nutshells of many trees were used for hair dyes.
8. Other dyes were produced from walnut leaves or nut husks.

Modern Age:

Preparations such as these were the only hair dyes available until the late nineteenth century. Hydrogen peroxide was discovered in 1818, but it was not until 1867 that it was exhibited at the Paris Exposition as an effective hair lightener. A London chemist and a Parisian hairdresser began marketing a 3% hydrogen peroxide formula at the Exposition as eau de fontaine de jouvence golden (golden fountain of youth water), and this was the first modern chemical hair colorant.

Advances in chemistry led to the production of more hair dyes in the late nineteenth century. The first synthetic organic hair dye developed was pyrogallol, a substance that occurs naturally in walnut shells.



Raw Materials

In general, hair dyes include:

1. **Dyes** e.g. 4-amino-2-hydroxytoluene
2. **Modifiers** e.g. resorcinol
3. **Antioxidents** e.g. sodium sulfite
4. **Alkalizers** e.g. ammonium hydroxide

Beyond these basic chemicals, many different chemicals are used to impart special qualities. They may be shampoos, fragrances, chemicals that make the formula creamy, foamy, or thick, or contribute to the overall action of the formula.

Hair dyes are usually packaged with a developer, which is in a separate bottle. The developer is most often based on hydrogen peroxide, with the addition of small amounts of other chemicals depending on the manufacturer.

The Manufacturing Process

The manufacturing process includes the following steps

1. First of all chemicals must be tested to make sure they are what they are labeled. Then weigh the chemicals accurately.
2. Further these chemicals are mixed in preheated water and other solvents. The premix is agitated for about 20 minutes.
3. The premix is then added to a large tank, containing the other ingredients of the hair dye.
4. After getting proper consistency this mixture is delivered to a tank where it is filled in bottles labeled caped, pack with developer and then distributed in the market.

Exercise: Q.3(viii) What are adhesives? Discuss its working and types?

Adhesives

Meanings:

Adhesives are meant to stick things together. An adhesive is a compound that adheres or bonds two items together. Adhesives may come from either natural or synthetic sources. Adhesives are nature product; it is also manufactured in Factories. Some modern adhesives are extremely strong, and are becoming increasingly important in modern construction and industry.

Types:

(a) **Natural adhesives:** are made from inorganic mineral sources, or biological sources such as vegetable matter, starch (dextrin), natural resins, animal skin. They are often referred to as bioadhesives.

(b) **Synthetic adhesives:** Elastomers, thermoplastic, and thermosetting adhesives are examples of synthetic adhesives.

(c) **Drying adhesives:** These adhesives are a combination of ingredients suspended in a solvent. White glue and rubber cements are members of the drying adhesive family. As the solvent evaporates, the adhesive hardens.

(d) **Contact adhesives:** Contact adhesives must be applied to both surfaces and allowed some time to dry before the two surfaces are pushed together. Some contact adhesives require as long as 24 hours to dry before the surfaces are to be held together

(e) **Hot Glue:** Also known as "hot melt" adhesives, these adhesives are thermoplastics; they are applied hot and simply allowed to harden as they cool. These adhesives have become popular for crafts because of their ease of use and the wide range of common materials to which they can adhere. The glue gun melts the solid adhesive and then allows the liquid to pass through the "barrel" of the gun onto the material where it solidifies.

(f) **UV and light curing adhesives:** UV and light curing adhesives consist essentially of low or medium molecular weight resins.

QUICK QUIZ

1. **Define adhesives.**

Ans. Adhesives are meant to stick things together. An adhesive is compound that adheres or bonds two items together.

2. **Give few examples of natural adhesives.**

Ans. Vegetable matters, starch, natural resins, animal skin.

3. **Why and when drying adhesives harden.**

Ans. When white glue and rubber cement add to harden cement. As the solvent evaporates, the adhesive hardens.

4. **How adhesives are used/applied.**

Ans. Adhesives are used to bond or stick substances.

5. **How hot glue is applied?**

Ans. Hot glue is thermoplastic. They are applied hot and simply allowed to harden as they cool.

6. **Low molecular resins are present in which category or adhesive.**

Ans. UV and light curing adhesives.

KEY POINTS

- Classical chemistry (organic, inorganic and physical chemistry) is very essential for advancing the science of chemistry by discovering and reporting new products, routes and techniques.
- Capital-intensive industries are classified as heavy while labour intensive industries are classified as light industries.
- Light industries are easier to relocate than heavy industries and require less capital investment to build.
- Specialty chemicals are mainly used in the form of formulations. Purity is of vital importance in their formulation. This calls for organic synthesis of highly valued pure chemicals known as fine chemicals.
- The polar auxochrome makes the dye water-soluble and binds the dye to the fabric by interaction with the oppositely charged groups of the fabric structure.
- Insecticides, fungicides, herbicides, etc., are all types of pesticides. Some pesticides must only contact (touch) the pest to be deadly. Others must be swallowed to be effective.

- Petrochemicals are **chemical products** derived from **petroleum**. Some **chemical compounds** made from petroleum are also obtained from other **fossil fuels** such as **coal** or **natural gas**, or renewable sources such as **corn** or **sugar cane**.
- Polymers which are synthesized from only one kind of monomer are called homopolymers. Polymers which are prepared from more than one kind of monomer are called copolymers.
- A thermoplastic polymer is one which softens on heating and becomes hard on cooling.
- A thermosetting polymer is one which becomes hard on heating it cannot be softened by heating.
- Modern nail polish is sold in liquid form in small bottles and is applied with a tiny brush.
- Nail polish remover base commonly contains a mixture of two organic solvents acetone and ethyl acetate.
- Lipsticks are simple in chemical composition, however complicated their application or effects. They are made up of three ingredients - a waxy or fatty base, a dye and a perfume.
- Many different plant extracts were used for hair dye in Europe and Asia before the advent of modern dyes.
- Elastomers, thermoplastic, and thermosetting adhesives are examples of synthetic adhesives.

EXERCISE

Q1. Multiple Choice Questions. Encircle the correct answer:

- ✪ *Read the question carefully.*
- ✪ *Try to answer the question yourself before reading the answer choices.*
- ✪ *Guess only if you can eliminate one or more answer choices.*
- ✪ *Drawing a picture can help.*
- ✪ *Don't spend too much time on any one question.*
- ✪ *In-depth calculations are not necessary; approximate the answer by rounding.*

(1) **The branch of chemistry which applies physical and chemical procedures towards the transformation of natural raw material and their derivatives to products is called:**
(a) physical chemistry (b) classical chemistry **(c) industrial chemistry** (d) both b and c

(2) **Which dye is used in boot polish**
(a) azo dye (b) congo red (c) methyl orange **(d)** bismarck brown

(3) **Miticides are used to control**
(a) ticks and mites (b) fungi (c) unwanted plants (d) mice and bats

(4) **Aerosoles and lotions are used as**
(a) fungicides **(b)** repellent (c) herbicides (d) a and c

(5) **Petrochemicals are classified into how many classes?**
(a) one (b) two **(c)** three (d) four

(6) **How many classes of polymers?**
(a) one **(b)** two (c) three (d) four

(7) **Nylon is a polymer obtained by**
(a) addition polymerization **(b)** condensation polymerization
(c) homopolymer (d) none

(8) **Which of following is not a raw material for nail polish?**
(a) pearl (b) castor oil **(c)** resorcinol (d) nitrocellulose

(9) **A polymer which becomes hard on heating is:**
(a) thermosetting (b) thermoplastic (c) addition (d) none

(10) **Nail Polish remover base commonly contains a mixture of two organic solvents as**
(a) benzene and acetone (b) ethyl acetate and CS_2 (c) benzene and CS_2 **(d)**acetone and ethyl acetate

(11) **Which of following adhesives are also known as bioadhesives?**
(a) drying adhesives (b) synthetic adhesives **(c)** natural adhesives (d) hot glue

(12) **A chemical compounds which is meant to stick things together**
(a) nail polish (b) lipstick (c) hair dye **(d) adhesives**

(13) **In early ages hair dyes were made from**
(a) plants (b) animals (c) metallic compounds **(d) both a and c**

(14) **Polymers which are prepared from more than one kind of monomer are**
(a) homopolymer **(b) copolymer** (c) addition polymer (d) none

SOLVED EXERCISE MCQs

Q. No	Answer	Reason
(1)	(c) industrial chemistry	By definition it is industrial chemistry.
(2)	(d) bismarck brown	Bismarck Brown is used in boot polish.
(3)	(a) ticks and mites	The chemical which kills mites are called miticides.
(4)	(b) repellent	Aerosoles and Lotions are repellent.
(5)	(c) three	The three class of petrochemicals are olefins, aromatics and synthesis gas.
(6)	(b) two	There are two main type of polymers: • Addition polymers • Condensation polymers
(7)	(b) condensation polymerization	Nylon is polyamide. It is obtained by condensation of adipic acid and hexamethylene diamine with lose of water.
(8)	(c) resorcinol	Raw material for nail polish are pearl, castor oil and nitro cellulose.
(9)	(a) thermosetting	By definition it is thermosetting.
(10)	(d)acetone and ethyl acetate	Nail polish remover has based of two solvents, acetone and ethyl acetate.
(11)	(c) natural adhesives	Because they are obtained from living organism.
(12)	(d) adhesives	Adhesives bind or stick things together.
(13)	(d) both a and c	Early hair dyes were made from plant's, metallic compound or a mixture of two.
(14)	(b) copolymer	Polymer made up of two kind of polymer are called copolymers.

SHORT ANSWERS QUESTIONS

2. Give brief answers for the following questions.

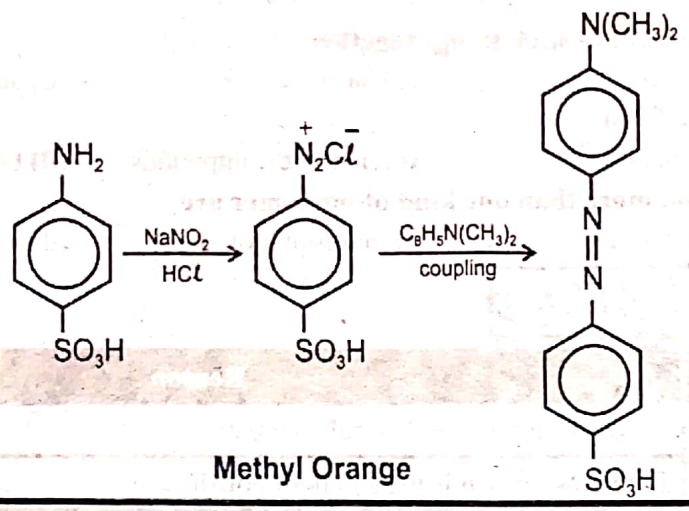
(i) What is the difference between classical and industrial chemistry?

Ans. The classical chemistry (organic, inorganic and physical chemistry) is very essential for advancing, the science of chemistry. It discovers and report new products, routes and techniques.

The industrial chemistry applies physical and chemical procedures, discovered by classical chemistry, towards the transformation of natural raw materials and their derivatives to products that are of benefit to humanity.

(ii) How is methyl orange prepared?

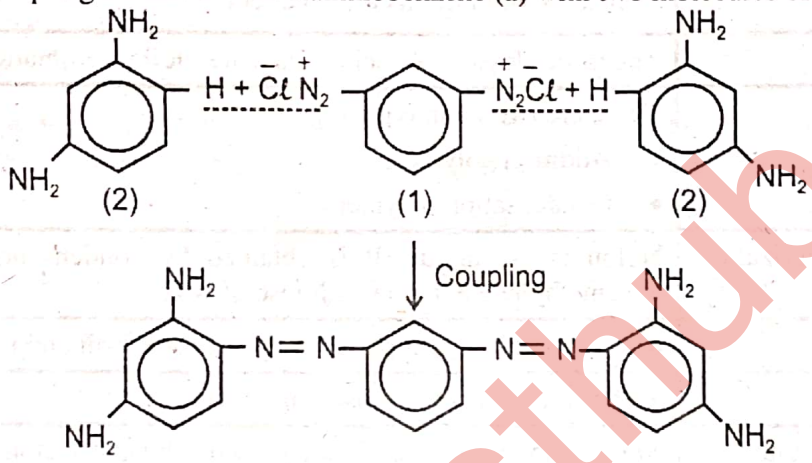
Ans. Methyl orange is obtained from sulphonic acid by the following steps;



Methyl Orange

(iii) How is Bismarck Brown prepared?

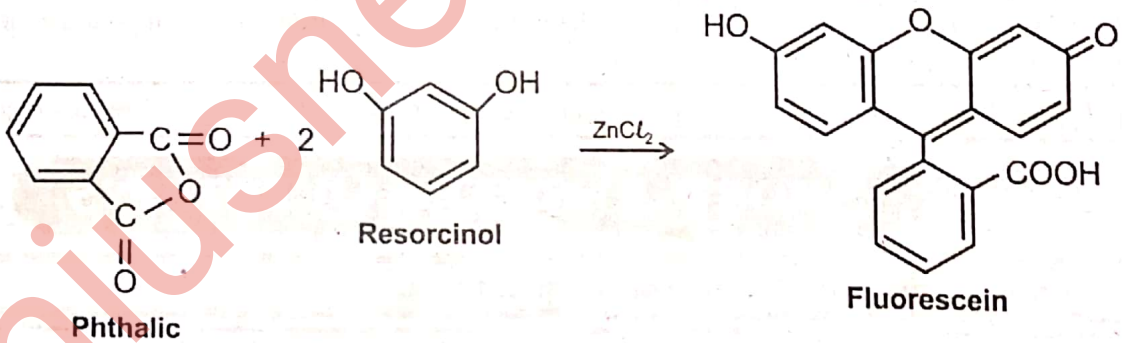
Ans. It is obtained by coupling tetrazotised m-diaminobenzene (a) with two molecules of m-diaminobenzene (b)



Bismarck Brown

(iv) How is Fluorescein prepared?

Ans. It can be prepared from phthalic anhydride and resorcinol in the presence of $ZnCl_2$ via the Friedel Crafts reactions.



Phthalic Anhydride **Resorcinol** **Fluorescein**

A second method to prepare fluorescein uses methanesulphonic acid as Bronsted acid catalyst. This route has a high yield under milder conditions.

(v) Enlist different chemicals produced from ethylene.

Ans. (1) Polyethylene
(2) Ethanol
(3) Ethylene oxide
(4) Vinyl acetate
(5) 1, 2-dichloroethane.

(vi) Write different chemicals produced from Toluene.

Ans. (1) Benzene
(2) Benzoic acid
(3) Toluene diisocyanate

(vii) Differentiate between homopolymer and Copolymer

Ans.

- Polymer which are synthesized from only one kind of monomer are called homopolymer e.g. poly vinyl acetate.

$$CH_2 = \underset{\underset{OCOCH_3}{|}}{CH} \longrightarrow -CH_2-\underset{\underset{OCOCH_3}{|}}{CH}-CH_2-\underset{\underset{OCOCH_3}{|}}{CH}-$$

(Vinyl Acetate) — Homopolymer (poly vinyl acetate)

- Polymer which are synthesized from more than one kind of monomer are called copolymers. e.g. vinylacetate and butylmaleate

$$CH_2 = \underset{\underset{OCOCH_3}{|}}{CH} + \underset{\underset{COOBU}{|}}{CH} = \underset{\underset{COOBU}{|}}{CH} \longrightarrow -CH_2-\underset{\underset{OCOCH_3}{|}}{CH}-CH_2-\underset{\underset{COOBU}{|}}{CH}-\underset{\underset{COOBU}{|}}{CH}-$$

Copolymer

(viii) What is the difference between thermoplastic and thermosetting polymer.

Ans.

- A thermoplastic polymer is one which softens on heating and become hard on cooling e.g. (PVC) poly vinyl chloride.
- A thermosetting polymer is one which becomes hard on heating it cannot be softened on heating e.g. Bakelite

(ix) How will you synthesize Nylon 6,6 from 1,3-Butadiene.

Ans.

$$CH_2 = CH - CH = CH_2 + Cl_2 \longrightarrow CH_2 - \underset{\underset{Cl}{|}}{CH} = CH - \underset{\underset{Cl}{|}}{CH_2}$$

$$Cl - CH_2 - CH = CH - CH_2 - Cl + 2NaCN \longrightarrow CN - CH_2 - CH = CH - CH_2 - CN$$

$$CN - CH_2 - CH = CH - CH_2 - CN \xrightarrow[Ni]{H_2} CN - CH_2 - CH_2 - CH_2 - CH_2 - CN$$

$$CN - CH_2 - CH_2 - CH_2 - CH_2 - CN \xrightarrow{H_3O^+} HOOC(CH_2)_4COOH \text{ (adipic acid)}$$

$$CN - CH_2 - CH_2 - CH_2 - CH_2 - CN \xrightarrow[LiAlH_4]{} H_2N(CH_2)_6NH_2 \text{ (Hexamethylenediamine)}$$

3. Give detailed answers for the following questions.

Note: Answers of all extensive questions are given with the related topics in the chapter.