Chapter 22

Industrial Chemistry

Major Concepts

22.1 Introduction: Introduction to Chemical Process Industry and Raw Materials used.
22.2 Safety Considerations in Process Industries
22.3 Dyes
22.4 Pesticides
22.5 Petrochemicals
22.6 Synthetic Polymers (PVC and Nylon)
22.7 Cosmetics: Lipstick, Nail Varnish and Remover, Hair Dyes

Learning Outcomes:

Students will be able to:

- Discuss the importance of the chemical industries in the economy of Pakistan. **(Analyzing)**
- Describe the raw materials available in Pakistan for various chemical industries. **(Applying)**
- Describe the chemical processes of addition and condensation polymerization. **(Understanding)**
- Interpret difference between petrochemical and chemicals derived from them. **(Understanding)**
- Describe the fractional distillation and refining of Petroleum. **(Understanding)**
- List the various raw materials for Petrochemical industry. **(Analyzing)**
- Identify the important fractions. **(Analyzing)**
- Describe the basic building block processes in Petrochemical technology. **(Understanding)**
- Describe the Petrochemical process technology. **(Understanding)**
- List some major petrochemicals. **(Applying)**
- Discuss types and applications of hair dyes. **(Applying)**
- Describe the formation and uses of PVC and Nylon. **(Applying)**
- Describe preparation and applications of various cosmetics like nail varnish, nail polish remover and lipsticks. **(Understanding)**
- Describe types and applications of synthetic adhesives. **(Understanding)**

Introduction

Industrial chemistry is the branch of chemistry which is concerned with using physical and chemical processes towards the transformation of raw materials into useful and profitable products. These products are used both as consumer goods and as intermediates for the manufacture of other, more complex products, such as household appliances, automobiles etc. It plays an important role in our society. It has increased the standard of living of people. Life at present without the benefits of industrial chemistry would be problematic and of low quality. Industrial chemistry is also helpful in bringing prosperity of the nation by increasing the exports, which helps in bringing wealth and earning valuable foreign exchange for the country.

22.1 Introduction to the Chemical Industry and Raw Materials Used

22.1.1 Introduction to Chemical industry

The branch of economic activity that is concerned with the processing of raw materials and manufacture of goods in factories is known as industry. The industries that produce chemicals are called chemical industries. They convert raw materials such as oil, natural gas, air, water, metals, and minerals into thousands (more than 70,000) different products that we use in our day-to-day life.

The chemical industry has touched all our aspects of life like agriculture, environment, food, hygiene, décor, transportation etc. The chemical industry provides:

i) The chemicals such as preservatives, taste enhancers and flavours play an important role in our food. These chemicals help the food to be edible and increase the shelf life (the period of time that a product can be stored and remain fresh, useful or suitable for consumption).

ii) Fertilizers and pesticides to the farmers, which are essential for the crop production.

iii) Polymers and plastics, which are used in clothing, home décor, PVC piping, water tanks and many other things.

iv) Medicines and drugs for saving life of peoples and animals.

v) Toiletries such as soaps, detergents, shampoos, body wash, face wash, toothpaste, toothbrush, deodorant and many more products that we use every day.

The chemical industry is a very important contributor to the wealth of a country. The chemical industry has many challenges which must be overcome in order to help society to maintain and improve its standard and sustainable way of living.

In the Pakistan the average growth in chemical industry sector is recorded to about 10.01% during 2014-15 and 2015-16 eras. The major chemical industries of the

country include sulphuric acid (the king of chemicals), soda ash, caustic soda, paints, varnish, petrochemicals, polymer and plastic products, fertilizers, cement, limestone, gypsum, soaps and many more.

The table 22.1 shows some important chemical sector products (Source: Economic Survey of Pakistan, 2015-16) so the reader can imagine the quantity of their production.

Table 22.1: Production of Selected Items

Year	Soda Ash (Tonnes)	Sulphuric Acid (Tonnes)	Caustic Soda (Tonnes)	Chlorine Gas (Tonnes)	Plants & Varnishes (Tonnes)	Polishes, Creams & Footwear (mln. Grams)
2014-15	325.6	50.5	127.7	13.4	33142	675.1
2015-16	345.6	63.5	161.9	12.2	40162	681.9

Mostly these products are used up inside the country and saves up the valuable foreign exchange, but some amount is also exported and thus foreign exchange is earned bringing up the prosperity of the country.

22.1.2 Raw Materials used in Chemical Industries

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 a useful source for raw materials. The six important industrial gases that are nitrogen, oxygen, argon, neon, krypton and xenon are separated from liquid air by fractional distillation. Nitrogen is the most abundant gas and oxygen is the second most abundant gas found in the atmosphere. The other gases are found in much smaller proportions.

Raw Materials from the Hydrosphere

Seawater is also a useful source of raw materials. Several useful substances such as sodium chloride, magnesium, bromine and sodium hydroxide are obtained from seawater. Sodium chloride is an important raw material and is obtained by evaporating it out from sea water. The electrolysis of aqueous solution of sodium chloride (brine) produces three useful products that are hydrogen, chlorine and sodium hydroxide. The electrolysis of molten sodium chloride produces two useful products that are sodium and chlorine.

Raw Materials from the Lithosphere

Lithosphere provides minerals. Minerals are natural compounds formed through geological processes. Minerals are very important to us because many of the elements such as gold, silver, copper, aluminium and iron are obtained from the earth's crust in the form of mineral ores. They are used to make automobiles, airplanes, computer chips, windows and many more valuable things of our interest. In addition to minerals and ores, the products obtained from lithosphere are coal, natural gas and crude petroleum. They are important in meeting our energy needs.

Lithosphere is a source of many valuable gemstones such as diamond, amethyst, etc. Gemstones are used in jewellery and other adornments.

Raw materials from the biosphere

Before industrialization, we got a majority of our materials from the biosphere. Now it is estimated that we get 70% of all the materials from the lithosphere. The oils, fats, waxes, resins, sugar, leather, cotton, wool, silk and other natural fibres are examples of products obtained from biosphere.

22.2 Safety considerations in Process Industries

Chemical industries during the manufacture of materials involve the processing of reactive chemicals, flammable liquids, vapours, gases and powders. The safety record of the chemical industry is good but uncontrolled fires, explosions and chemical reactions can result in hazardous situations. A strategy is required that ensures that the chemical manufacturing activities are carried out safely. The objective of the strategy is to establish and maintain safe manufacturing practices in a manner that is compatible with the plant design, the operating conditions, production demands, commercial requirements and economic factors.

The following safety considerations will help you to ensure the health and safety of workers and eliminating chances of damage to machinery and equipment in the process industries.

i) The proper safety training should be given to all workers prior to permitting them to go to work.

ii) Government has to make number of legislations in order to ensure industrial safety.

iii) The safety committee should be made that can help in creating safety consciousness.

iv) Increase the communication in the workplace. This will encourage employees to communicate about potential problems effectively with one another. This can make the work place safer by reducing potential hazards.

v) Take regular breaks while working in industry. Taking regular breaks help you stay fresh and able to stay more alert when working.

vi) Use tools and machines properly and avoid shortcuts. Shortcuts may lead to workplace injury. Furthermore, regularly clean and inspect tool and equipment to ensure that it is safe.

vii) Keep clear access to equipment shutoffs in case you need to quickly stop them from functioning. In addition, place equipment in proper storage areas after use. It will help keep the work area and emergency exits clear.

viii) Wear the correct safety equipment such as safety googles, hard hats, gloves or full-face mask for a task. Additionally, check that your safety equipment is safe. It significantly reduces your chance of getting injured.

ix) Extra care should be made for the receipts, storage, handling and disposal of chemicals and other hazardous materials.

x) Fire extinguishers and fire buckets should be provided at all fire hazardous locations. The extinguishers should be inspected, serviced and maintained.

xi) Inspection and maintenance of your equipment should be scheduled regularly so that your equipment is not only safe to use, but its lifetime is also extended.

xii) Clear passageways and clean spills to prevent employees from tripping or slipping. Likewise, check your workplaces to make sure there are no holes, loose boards, or nails projecting from the floor.

xiii) Combustible materials should be stored away from sources of ignition. Furthermore, store combustible waste in metal containers and discard it daily.

Industries that have increased risk of workplace accidents must be extra attentive about potential workplace hazards. They have to implement key safety measures to keep their workers happy, healthy and productive.

22.3 Dyes

Dyes are organic compounds that are widely used for imparting colour to various substrates such as paper, leather, fur, hair, drugs, food, cosmetics, waxes, greases, plastics and textile materials.

Dyes are normally water-soluble or water dispersible organic compounds that are capable of being absorbed into the substrate destroying the crystal structure of the substance. The dye molecules are usually chemically bonded to the surface and become a part of the material on which it is applied. The dyes must have high colour intensity. The colour intensity of the dye molecule depends on how strongly it absorbs radiation in the visible region, which extends from 400 to 800 nm. The dye should be resistant to the action of water, dilute acids and alkalies (all the detergents and soaps are alkaline in nature).

22.3.1 Chemical Composition of Dye

A 'ye is made up of two kinds of parts: Chromophores and Auxochromes.

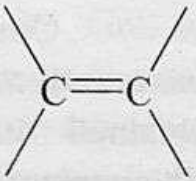
Chromophores

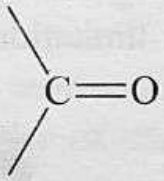
They are unsaturated groups. An organic compound looks coloured due to presence of these groups. The important chromophores are:

i) Nitroso group, —NO

ii) Nitro group, $-NO_2$

iii) Azo group $-N=N-$

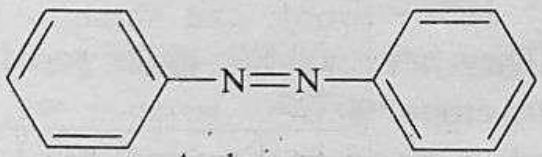
iv) Ethylene group 

v) Carbonyl group 

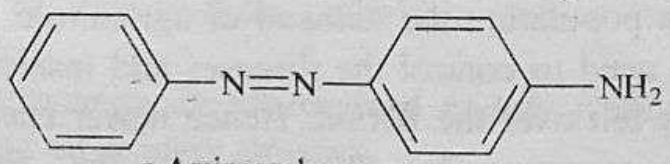
The intensity of colour increases with the number of chromophores or the degree of conjugation. The compounds that have chromophore groups are called chromogen.

Auxochromes

The groups that deepen or intensify the colour in the presence of chromophore are called auxochromes (colour intensifying groups). Example of auxochromes are hydroxyl group (—OH), carboxyl group (—COOH), sulphonic acid group ($-SO_3H$), amino group ($-NH_2$), secondary amine group (—NHR) and tertiary amine group ($-NR_2$). These groups impart no colour in the absence of chromophore. A chromogen without an auxochrome can never act as a dye. For example, azobenzene although red coloured yet is not a dye; on the other hand, *p*-amino azobenzene is a yellow dye.



Azobenzene



p-Aminoazobenzene

22.3.2 Classification of Dyes

There are several ways for classification of dyes. They are classified based on their source, application, structure and nature of their respective chromophores.

Classification Based on Source of Dyes

There are two types of dyes on the basis of source: natural dyes and synthetic dyes.

Natural Dyes

The dyes derived from biological sources such as plants (roots, berries, bark, leaves, seeds, stem, and flowers), insects (cochineal, lac and tyrian purple), or minerals (iron oxide and buff) are called natural dyes. Other organic sources include fungi and lichens. The prominent examples of natural dyes are alizarin (red dye) and indigo (blue dye). Logwood is a natural dye obtained from plants. Tyrian purple is obtained from animals and Prussian blue is an inorganic dye obtained from naturally occurring minerals. The natural dyes have the limitations that they have limited shades and are not durable.

Synthetic Dyes

The man-made dyes that are manufactured in the laboratory or industry are called synthetic dyes. These dyes are made from petroleum, sometimes in combination with mineral-derived components. The first man-made organic aniline dye, mauveine, was discovered by William Henry Perkin in 1856. Synthetic dyes are used everywhere in everything from clothes to paper and from food to wood. This is because they are cheaper to produce, brighter, more colour-fast, and easy to apply to fabric. Examples are acid dyes, azo dyes, basic dyes, mordant dyes, etc.

Keep in Mind

Mordant dye, a colourant that combines with dye and fibre. They are available commonly in the form of salts from metals such as chromium, tin, copper, aluminium and iron. The metal ion acts as a bridge between the dye and fibre. These dyes are economical and are generally used to produce dark shades such as dark blues, dark greens and blacks. They are most readily used to dye the natural protein fibres, particularly wool; and sometimes the synthetic fibres particularly nylon.

22.4 Pesticides

The pesticides are the certain chemicals used to control pests, insects, weeds, fungus etc. They are generally used on fruit, vegetable and horticulture crops.

Although traditional pest control methods were in application since long in history, but with the increase in human population the demand of agriculture based food stuff increased many times and a need to control the diseases and insects that destroy a large part of vegetative crops felt over the period. Hence newer chemical methods were developed for the purpose. In this respect the famous

Dichlorodiphenyltrichloroethane (DDT) was synthesized in 1943, which was found to be effective against many insects like mosquitoes. Due to its hazardous nature DDT is no longer used now a days, and other chemicals of similar nature but with more safety nature were synthesized of which Aldrin, dieldrin, heptachlor, mirex, chlordane, biphenanthrine, tetramethionineetc. are important which have targeted action rather than global insecticidal nature, that is they control only desired species and do not affect the good helping insects and pests.

Classification of Pesticides

The Pesticides are classified on the basis of their action on specific species that spread disease or affect the crops. Thus some important types of pesticides are:

Insecticides: The insecticides are the substances that are used to control insects.

Fungicides: The fungicides are the substances that are used to control the fungus.

Herbicides: These are the chemicals that are used to control unwanted herbs in the crops.

Miticides: The miticides are used to kill mites and ticks of the crops.

Rodenticide: A large quantity of crop is damaged by the rodents like rats, mice, raccoons. Moreover birds and big mammals also affect the crops adversely. These are controlled by the use of chemicals called rodenticides.

Nematicides: These are the chemicals that control the action of harmful nematodes. The nematodes are tiny hair like worms that live in earth and feed on plant roots and the juices from plant roots.

Repellents: These are certain chemicals that repel the harmful pests, insects and other mammalians.

22.5 Petrochemicals

The chemicals derived from petroleum products and used for a variety of commercial purposes are called petrochemicals.

Petrochemicals can be converted into thousands of industrial and consumer products, including plastics, paints, rubber, pesticides, cosmetics, fertilizers, detergents, dyes, textiles and solvents.

22.5.1 Raw Materials for Petrochemicals

A raw material, also known as a feedstock or most correctly unprocessed material, is a basic material that is used to produce goods, finished products, energy, or intermediate materials which are feedstock for future finished products.

Petrochemicals are derived mainly from two feedstocks that are natural gas liquids and oil refinery streams.

Natural Gas Liquids (NGL)

Natural gas liquids are obtained from natural gas processing plants. They are mainly ethane, propane and butanes. They are cracked at high temperatures to yield the primary petrochemicals such as ethylene, propylene, butylenes and butadiene.

Oil Refinery Streams

Oil refinery streams are obtained from the fractional distillation of crude oil. They include naphtha, kerosene oil or gas oil. They are cracked to produce higher ratios of propylene, butylenes and butadiene plus the aromatic products benzene, toluene, xylenes along with other co-products. Primary petrochemicals are reacted to form secondary petrochemicals, other chemical products, or polymerized to form synthetic resins. These in turn are incorporated into a great variety of industrial and consumer products.

Interesting Information

Feedstocks are the raw hydrocarbons obtained from crude oil refining by distillation, thermal and catalytic processes. Natural gas and refinery products are the major source of feedstocks for petrochemicals.

Primary raw materials are naturally occurring substances that have not been subjected to chemical changes after being recovered. Examples of primary raw materials for petrochemicals include: olefins (ethylene, propylene and butadiene) aromatics (benzene, toluene, and xylenes); and methanol.

Secondary raw materials or intermediates are generally produced by chemical conversion of primary raw materials to form more complicated derivative products. Example of secondary raw materials for petrochemicals include ethylene glycol, polyvinyl acetate, polyvinyl chloride, polyethylene resins, phenol formaldehyde resins, etc.

Final products are obtained from secondary raw materials. Examples are detergents, dyes, cosmetics, solvents, polymers, fertilizers, etc. Final products satisfy our basic needs (clothing, shelter, food, health, etc.) and also provide luxury consumer items.

Feedstock ⇒ Primary petrochemicals ⇒ Secondary petrochemicals ⇒ Final products

22.5.2 Classification of Petrochemical Feedstocks

Petrochemical feedstocks can be classified into three general groups: olefins, aromatics and synthesis gas.

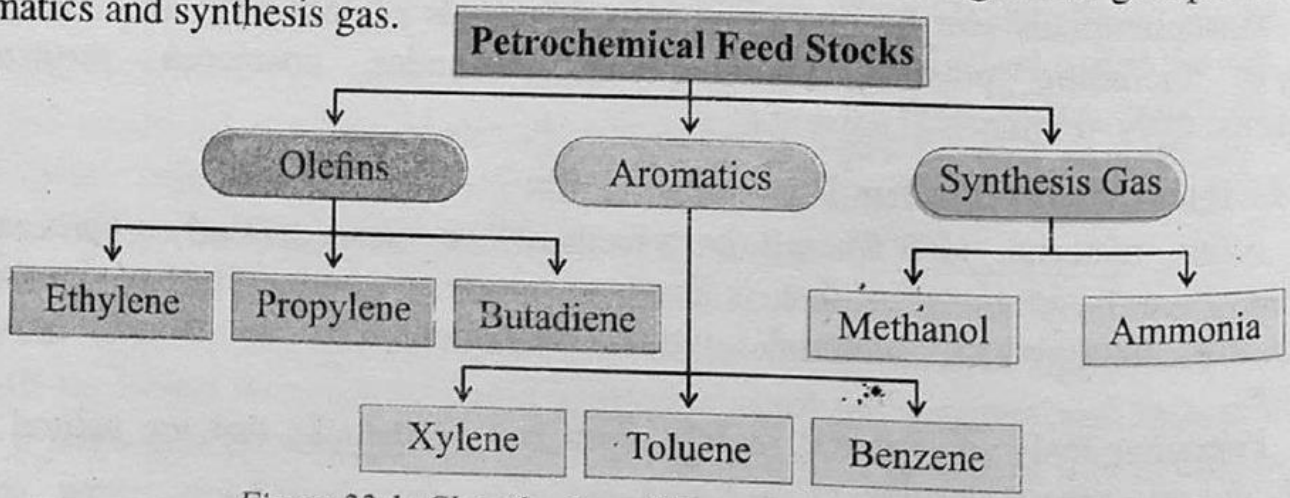


Figure 22.1: Classification of Petrochemical Feed Stocks

Olefins

The major components of olefins are ethylene, propylene and butadiene. Ethylene is used in the manufacture of antifreeze, detergents, plastics and synthetic rubber. Propylene is used in the manufacture of resins, fibres and numerous other chemical products. Butadiene is widely used in the production of synthetic rubbers and polymer resins.

Aromatics

The major components of aromatic hydrocarbons are benzene, toluene and xylene. These aromatic petrochemicals are used in manufacturing of secondary products like synthetic detergents, polyurethanes, plastic and synthetic fibres.

Synthesis Gas (Synthetic Gas)

Synthesis gas comprises of mixture of carbon monoxide and hydrogen. This mixture is used in the manufacture of ammonia and methyl alcohol. The ammonia is further used in the production of urea fertilizer.

22.6 Synthetic Polymers

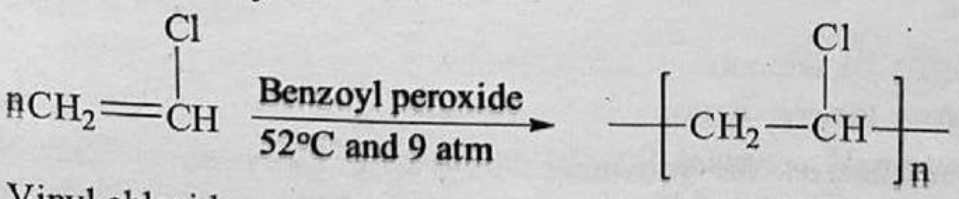
Polymers or so-called macromolecules are high molecular mass compounds which are formed either by the addition of many smaller molecules (monomers), as polyvinylchloride (PVC), or by the condensation of many smaller molecules (monomers) with the removal of water or alcohol, as nylon. The process by which monomers are converted into polymers is called polymerization. Polymers may be divided into two types that are natural polymers and synthetic polymers.

Natural polymers also known as biopolymers are derived from natural sources. Examples of natural polymers are silk, rubber, cellulose, wool, starch, proteins, DNA, etc.

Synthetic polymers are man-made polymers and are prepared by a chemical reaction, often in a lab. Examples of synthetic polymers are polyethylene, PVC, synthetic rubber, nylon, etc.

22.6.1 Formation and Uses of PVC

Polyvinyl chloride commonly abbreviated as PVC is formed by the addition of vinyl chloride monomer units at 52°C and 9 atmosphere pressure in the presence of benzoyl peroxide catalyst.



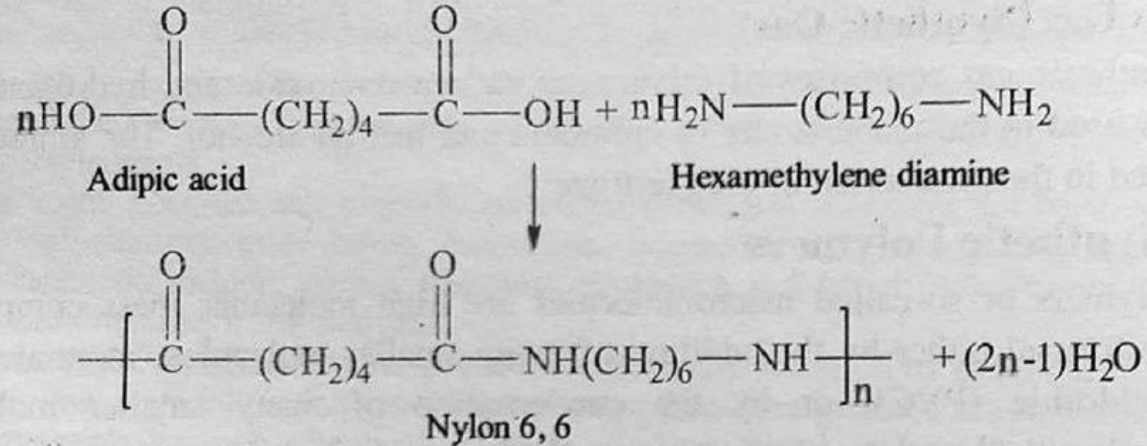
Vinyl chloride

Polyvinyl chloride

PVC is the most widely used plastic after polyethylene. It is used in the manufacture of pipes, floor coverings (tiles), bottles, electrical wiring and cables, window frames, blood storage bags, stationary, seat coverings, packaging, credit cards, synthetic leather, rain coats, shower curtains and many other useful materials.

22.6.2 Formation and Uses of Nylon

Nylons are high molecular mass polyamides. They are of various types such as nylon 4,6; nylon 6; nylon 6,6; nylon 6,12; nylon 12; etc. They are the most popular synthetic polymers. Nylon 6,6 (read as nylon six, six) is the well-known example of nylon. It is prepared by the condensation reaction of adipic acid and hexamethylene diamine at about 252°C.



Nylon 6,6 got its name from its monomers, adipic acid and hexamethylene diamine, each of them providing six carbon atoms.

Nylon has incredible properties. They have high strength, medium stiffness and resistance to high temperature (+85°C), fuel and lubricants and most of the chemicals. It is also used in collaboration of other materials (e.g. with cotton) for more strength and durability of the product and is believed to be as strong as the steel metal.

Nylons are used:

i) In the manufacture of carpets, textile fibres and bristles of brushes
ii) In dress socks, swimwear, activewear, shorts, track pants, windbreakers and bedspreads.
iii) For making elastic hosiery
iv) As a substitute for metals in bearings and gears
v) For food packaging
vi) For making rope.
vii) In tyre cord.

22.7 Cosmetics

We define cosmetics as: the substances used to enhance your natural beauty and to promote good health. The cosmetics may also be defined as: any substance to

be rubbed, poured, sprinkled, or sprayed on or introduced into or applied to any part of the human body, for cleaning, beautifying, promoting- attractiveness or altering the appearance. Cosmetics are useful for making the skin feel soft, healthy and flawless. Colour cosmetics products are designed to add colour to the skin and thereby enhance the appearance of good health and youth. The colours (pigments) make prominent the cheeks, lips and eyes. These are the colours that make cheeks rosy, lips ruby and eyes smoky. Colour cosmetics applied to the face to enhance its appearance are often called make-up or makeup (For example, lipsticks, eye liners, nail varnish, powder, etc.). Recent research has shown that makeup helps in protection from harmful rays of the sun. The first known people who used cosmetics to enhance their beauty were the Egyptians. Currently cosmetics play an important role for both men and women. Cosmetics are available in the form of creams, lipsticks, shampoos, hair dyes, body wash, eye liners, eye shadows, perfumes, sunscreens, talcum powder, toothpastes, nail varnish and remover, etc.

22.7.1 Lipsticks

Lipstick is one of the inexpensive cosmetic products and is most widely used by women to give an attractive colour and appearance to lips. They are manufactured as moulded sticks. They are made from waxes, oils, pigments and emollients. Other important additives are antioxidants, preservatives and fragrances. The waxes used include beeswax, carnauba, candelilla wax, and ozokerite. Oils used include castor oil, coconut oil, mineral oil, vegetable oil or petrolatum (petroleum jelly). Some of the important emollients that are used in lipsticks are cocoa butter, shea butter, vitamin E, and aloe vera.

The wax gives lipstick its shape and ease of application. Oils are added to reflect light and provide shine. Oils give lipstick the ability to be easily applied, keeping the wax soft enough for it to be spread easily. Pigments are the colours. They give colour to the lipsticks and improve the appearance of the lips. Emollients are used to soften and smooth the surface of lips.

Other important additives are antioxidants and preservatives. Antioxidants are used to prevent the lipsticks from becoming rancid. Preservatives are used to extend the shelf life of lipsticks. Many manufacturers add little fragrance (perfume) to give it a nice smell when it is being applied.

22.7.2 Nail Varnish

Nail varnish is applied to the fingernails or toenails to colour them or make them shiny. It is used mainly by women. Nail varnish protect and beautify the nail plates. The correct name of nail varnish is nail lacquer. However, the terms nail varnish, nail polish, nail enamel, nail paint and nail lacquer are used interchangeably.

These products are sold in liquid form in small bottles and are applied by painting the nail with a tiny brush. Nail varnish is a flexible lacquer that does not easily crack and flake with nail movement. People want brands of nail varnish that are easy to apply, dry quickly, glossy looking and last a long time without chipping.

There is no single formula for nail varnish. Nail varnish is made up of many different chemicals. The four major ingredients in most nail varnish brands are resins, plasticizers, organic solvents and colouring agents.

Resins, types of polymers, are the thickening and hardening agents that serve as colourless nail protector. There are two types of resins that are used in nail varnish, which are hard glossy resins (e.g. nitrocellulose) and soft pliable resins (tosylamide / formaldehyde resin).

Plasticizers (e.g. camphor, dibutyl phthalate, adipates) make the polish more flexible after drying and increase its durability.

Solvents are used to dissolve the ingredients and make the polish spreadable. The most common organic solvents are ethyl acetate and butyl acetate. It must dry quickly to increase the ease of the nail polish application.

Colouring agents (pigments) are used to create the colour of each polish. A combination of naturally occurring and synthetic pigments are mixed together to create varying shades.

Sometimes, nail polish also contains particles such as mica, bismuth, pearl essence (guanine) and aluminium powder as sparkling and reflective particles. These particles are used to give shimmery look to the polish.

22.7.3 Nail Varnish Remover

Nail varnish (or nail polish) remover is a powerful solvent that can quickly remove polish from the nails, cuticles, and surrounding skin. Nail polish remover works by moisturizing the dried nail polish and returns it to its liquid state. Nail polish remover mainly consists of volatile organic solvents such as ethyl acetate (a common solvent for nail varnish itself) or acetone. They may contain oils, scents and colouring. Acetone is one of the main components in nail polish remover. It is found naturally in the environment and is produced in the factories. It is a colourless, flammable liquid that evaporates easily. The nail polish removers that contain acetone work very quickly and effectively. But acetone can be harmful to our nails and skins. Acetone can irritate nose, eyes, throat, lungs and skin. It can cause our nails to become dry and brittle. Acetone can also remove artificial nails made of acrylic or cured gel. It is therefore, necessary to find the mild non-acetone nail polish remover to make sure the strongest, healthiest nails possible. The industry has formulated many acetone alternatives for polish removers that contain a variety of different solvents. Ethyl acetate and butyl acetate are the two most commonly used solvents for nail polish remover currently. Both solvents are colourless, volatile liquids. These solvents are less harsh and toxic than acetone.

22.7.4 Hair Dyes

Hair dyes (also hair colours) are chemicals that are used to change the hair colour. The preferred professional term for hair dye is hair colour.

The first safe commercial hair colour was created in 1909 by French chemist, Eugene Schuller, using the chemical paraphenylenediamine. This compound is present in all colouring products along with ammonia and peroxide in varying proportions. Most hair dyes, in general, contain dyes, modifiers, antioxidents, alkalizers, soaps, ammonia, wetting agents, fragrance, and a variety of other chemicals used in small amounts that impart special qualities to hair (such as softening the texture) or give a desired action to the dye (such as making it more or less permanent). The dye chemicals are usually amino compounds. Metal oxides, such as titanium dioxide and iron oxide, are often used as pigments as well.

Types of Hair Dyes

Hair dyes are classified by the types of colour molecules used and the length of time that they last. There are three main types of hair dyes and they are temporary hair dyes, semi-permanent hair dyes and permanent hair dyes.

Temporary Hair Dyes

These dyes only coat the surface of the hair. They cannot penetrate into the hair shaft. They are easily removed with one or two washings. Temporary hair dyes do not contain ammonia, meaning the hair shaft is not opened up during processing and the natural colour of hairs is retained once the product washes out.

Semi-permanent Hair Dyes

Semi-permanent hair dyes have smaller molecules than those of temporary hair dyes and so can penetrate the surface of the hair into the cuticle layer. These dyes are generally not formulated with ammonia, so they should not require any development. These dyes will last for five to ten washings and so last longer than temporary dyes.

Permanent Hair Dyes

The most common hair colour is permanent hair colouring. These involve a change in hair colour that is "permanent" or at least until new hair grows. They contain ammonia and hydrogen peroxide. Ammonia opens the cuticle and hydrogen peroxide used as developer. The dyes used are actually dye precursors. Their molecules are monomers and are smaller than that of semi-permanent and permanent hair dyes. They are able to penetrate into the hair all the way to the cortex. The shades of permanent hair dyes are often more natural-looking. However, permanent hair dyes can be more damaging to your hair. The chemicals used are stronger and the mixture usually has to be left on for a longer period of time.

Permanent 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.

Side Effects of Hair Dyes

The chemicals used in hair dyes remain at safe levels. However, some of the ingredients found in hair dye such as resorcinol and parabens are suspected to be endocrine-disrupting chemicals.

22.7.5 Adhesives

An adhesive, also known as glue, is a substance that is applied to one surface, or both surfaces, of two separate objects that binds them together and resists their separation. You use an adhesive to pack gifts, re-join broken materials, connect parts of toys, mend shoes, or paste a photograph into an album. Adhesives have been used successfully in a variety of applications for centuries. Currently, adhesives are more important than ever in our daily lives, and their usefulness is increasing rapidly.

Types of Adhesives

There are two types of adhesives on the basis of origin: natural adhesives and synthetic adhesives.

Natural Adhesives

Natural adhesives are those adhesives that are produced or extracted from natural resources such as plants or animals. Examples of natural adhesives are starch, dextrin, casein glues, blood albumin glue, natural gums, bees wax and resin (tree sap). They are inexpensive, easy to apply and have a long shelf life. They develop tack quickly but have low strength properties. Natural adhesives have been used since earliest times. Ancient Egyptians used flour paste in the making of papyrus (paper reed) and glue made from animal skin and bones for woodworking. Natural adhesives are still popular and useful but have been replaced for most applications by synthetic adhesives. Natural adhesives are still used in corrugated board, envelopes, bottle labels, book bindings, cartons, furniture, and laminated film and foils.

Synthetic Adhesives

Synthetic adhesives are those that are not found in nature and are designed and manufactured by chemists in the laboratory or factory. Synthetic adhesives can be classified on the basis of chemical composition as thermosetting, thermoplastic, elastomeric or alloys (hybrid) of these.

Thermosetting adhesives

They are essentially infusible and insoluble. They show good heat and solvent resistance. These materials have good creep (flow-under-load) resistance. They show little elastic deformation under load at elevated temperature.

Thermosetting adhesives are recommended for use at temperatures from 93–260°C. They are used for high load assemblies and severe service conditions such as heat, cold, radiation etc. Examples are epoxies, polyesters, polyamides and phenolics. Most materials can be bonded with thermosetting adhesives, but the emphasis is on structural applications. These adhesives are usually available as solvent-free liquids, pastes and solids. They are available as one-part and two-part systems. The two part systems have longer shelf lives.

Thermoplastic Adhesives

They are fusible and soluble. They can soften or melt when heated without undergoing any chemical change. These material have poor creep resistance and fair peel strength (measure of the bond strength of a material). They hardens upon cooling from a melt state, or by evaporation of a solvent. Wood glues are thermoplastic emulsions that are common house hold items. They harden by evaporation of water from an emulsion.

Thermoplastic adhesives are not usually recommended for use at above 66°C, although they can be used up to 90°C in some applications. They are normally used for low load assemblies under mild service conditions. The materials most commonly bonded are non-metallic materials, especially wood, leather, plastics and paper. They are not usually used for structural applications. Examples are polyvinyl alcohol, polyvinyl acetates (PVA), cellulose acetate, polyamides, cyanoacrylates and polyacrylates. They are available as one-part system.

Elastomeric Adhesives

Elastomeric adhesives are based on synthetic or naturally occurring polymers. They have great toughness and elongation. These adhesives are made from polymeric resins that are capable of high degrees of extension and compression. They return rapidly to their initial dimensions and shape after the load is removed. They are generally used for their high degree of flexibility and good peel strength. Their bond strengths are relatively low, but flexibility is excellent. These adhesives are used in unstressed joints on lightweight materials, so they cannot be considered structural adhesives. Most of these adhesives are modified with synthetic resins for bonding rubber, fabric, foil, paper, leather and plastic films. They are also used as tapes. Elastomeric adhesives may be

Keep in Mind

Peel strength is the measure of the bond strength (adhesive strength) of two bonded materials such as tape, rubber, plastic, textile, wood, paper, foil, plastic films and leather. The strength of bond is calculated through a peel test. Peel test is used to measure the average force required by the unit width to separate bonded materials at a constant speed. Peel tests can be performed with different angles. Peel tests at 90° and 180° are commonly used. Special equipment such as force measurement instruments and materials testing machines are used to perform these tests. The peel tests can be done on pockets, trays, cans, jars, and pouches.

supplied as solutions in organic solvents, water dispersions, pressure-sensitive tapes and single or multiple part solvent-free liquids or pastes. Examples are natural rubber, nitrile rubber, neoprene, polysulphide and silicones.

Hybrid Adhesives

Adhesive hybrids are made by combining thermosetting, thermoplastic, or elastomeric resins into a single adhesive formulation. The thermoset resin chosen for its high strength is plasticised by the second resin which is usually a thermoplastic or elastomer, thus making the alloy tougher, more flexible and more resistant to impact. These adhesives are generally stronger over wider ranges of temperature than other adhesives. They are suitable as structural adhesives and are used where the highest and strictest end-use conditions must be met (irrespective of cost), such as in military applications. Materials bonded include metals, ceramics, glass and thermosetting plastics. They also have a tendency to bond well to oily substrates. It is believed that the oil on the substrate is adsorbed into the formulation and acts as another flexibilizer in the adhesive system. Examples are epoxy-phenolics, epoxy-nylon, epoxy-polysulphide and nitrile-phenolic.

Summary of Facts and Concepts

- Industries form the backbone of economy of a country and is directly related with the prosperity of a nation.
- An important point in establishing an industry is that the cost of the product must be low so the consumers find it easy to use it.
- To keep the cost low, the raw materials used in industries should be cheap and available easily.
- The chemical industry provides the material and chemical for most of the other industries.
- Many of the chemicals and materials (like cement, fertilizers, drugs, polymers etc.) are needed in bulk and are provided by the chemical industry sector.
- A chemical dye is a substance that is used to colour the different commercial products which makes it attractive, so the buyers like them.
- The chemical dye molecule consists of two parts, one of the part is a substance which produces the colour and is called the **"Chromogen"**, and the second part of molecule which regulates the solubility of the dye called **"Auxochrome"**.
- The pesticides are the chemicals which are used to control pests, insects, weeds, fungus and even the rodents to increase the yield of agriculture products.
- Petrochemicals are chemical derived from petroleum products. Examples of petrochemicals are rubbers, plastics, fibres, detergents, solvents and paints.

- The prosperity of a nation is also determined by the use of its petroleum products.
- Fibres from the natural sources only cannot meet the needs of humans and artificial fibres are prepared to meet their needs.
- Polymers are the compounds which are formed by the large number of smaller repeating units called monomers.

Multiple Choice Questions

Q. Select one answer from the given choices for each question:

i) Which one of the following statements is true regarding chemical industries?
(a) Chemical industries provide medicines and drugs for saving life of peoples
(b) Chemical industries are located near automobile industries
(c) Chemical industries provide fish and plants to the farmers
(d) Chemical industries provide infra structure for industries

ii) Which of the following statements is/are correct?
(a) Herbicides are used for killing unwanted plants
(b) Nylon was first introduced as an early substitute for silk
(c) Excessive use of fertilizers is good for the fertility of soil
(d) Cotton is an artificial fibre of almost pure cellulose

iii) Adhesive that become soft on heating are:
(a) Thermosetting (b) Thermoplastic
(c) Elastomeric (d) Hybrid

iv) Natural adhesives are also known as:
(a) Bioadhesives (b) Synthetic adhesives
(c) Spray adhesives (d) Fabric adhesives

v) Which one of the following is a synthetic fibre?
(a) Wool (b) Cotton
(c) Silk (d) Polyester

vi) What is the fuel that is mostly used to run the buses, trucks and trains?
(a) Petrol (b) Diesel
(c) Kerosene (d) Bitumen

vii) Ethylene is used in the manufacture of:
(a) Fertilizers (b) Plastics
(c) Silks (d) PVC

viii) Nail polish remover contains:
(a) Benzene (b) Acetone
(c) Acetic acid (d) Benzoic acid

ix) Henna usually gives you a shade of:

(a) Golden yellow (b) Bluish green

(c) Reddish brown (d) Light pink

x) The term petrochemical refers to the chemicals derived from

(a) Gasoline oil only

(b) Natural gas only

(c) Crude petroleum only

(d) Natural gas liquids and oil refinery streams

Short Answer Questions

Q.1. What do you know about chemical industry?

Q.2. Where do colour dyes come from?

Q.3. How do pesticides affect human health?

Q.4. What are the most commonly used pesticides?

Q.5. What are the four major ingredients in nail varnish?

Q.6. What are primary and secondary raw materials?

Q.7. Write down the name of three main fossil fuels?

Q.8. Give some of the important examples of synthetic and natural polymers.

Q.9. Name the four most commonly used cosmetic products.

Q.10. What type of nail polish remover works quickly and effectively?

Q.11. Define resins. What are the different types of resins used in nail varnish?

Q.12. Why is wax used in lipstick?

Q.13. Is there any other name for nail polish?

Q.14. What chemicals make up nail polish?

Q.15. Give names of less harsh and toxic nail polish removers.

Q.16. Name the four different types of synthetic adhesives.

Q.17. What is the difference between glue and adhesive?

Long Answer Questions

Q.1. What is industrial chemistry? Discuss the importance of industrial chemistry.

Q.2. What is the role of chemical industries in the economy of a country?

Q.3. Discuss various raw materials that are used in chemical industries.

Q.4. Explain how the lithosphere is an important source of natural raw materials for the chemical industry?

Q.5. How chemical process safety can be managed in industries?

Q.6. What are dyes? What is the chemical composition of dyes? How are they classified on the basis of origin?

Q.7. What are pesticides? Describe its types.

Q.8. What is meant by petrochemicals? Describe different types of petrochemicals in detail.

Q.9. What are polymers? What are natural and synthetic polymers?

Q.10. Write down the formation and uses of PVC and Nylon?

Q.11. What are cosmetics? Explain the role and uses of cosmetics.

Q.12. Describe preparation and applications of lipsticks.

Q.13. Describe preparation and applications of nail varnish and nail varnish remover.

Q.14. What are hair dyes? What ingredients are most commonly used in hair dyes?

Q.15. Discuss types and applications of hair dyes.

Q.16. What are adhesives? Explain different types of adhesives.

Q.17. Explain types and applications of synthetic adhesives.