CHAPTER 11

INDUSTRIAL CHEMISTRY

Teaching Periods	08	Assessment	01	Weightage %	07

Students will be able to:

- ✓ Explain the role of the chemical industries in the economy of Pakistan. (Analyzing)
- ✓ Describe the various pharmaceutical products (Understanding)
- ✓ Enlist different pharmaceutical products with their functions (Applying)
- ✓ Explain the formation and uses of PVC and Nylon. (Applying)
- ✓ Describe the composition and effects of various cosmetics like nail polish, nail polish remover, lipsticks and perfumes (Understanding)
- ✓ Describe the adhesives and their applications. (Understanding)

INTRODUCTION

Industrial chemistry is the branch of chemistry which deals with the conversion of raw materials into useful product through chemical process. The primary objective of industrial chemistry is to investigate new ways and technologies to enhance the efficiency of chemical processes, reduce expenses and increase product yields.

An industrial chemist plays a crucial role in enhancing productivity through the exploration of novel catalysts and optimizing reaction conditions, while also aiming to reduce production costs by utilizing economical raw materials. Their contributions extend to the development of innovative materials and technologies that benefit various industries. Moreover, industrial chemists ensure safety standards, risk assessment, and proper storage protocols.

This multi-disciplinary field of industrial chemistry intersects with other scientific branches, including agriculture, engineering, and pharmaceuticals.

11.1 INTRODUCTION TO CHEMICAL INDUSTRIES

"The term chemical industries refers to all those companies that manufacture chemicals". These industries involves a broad range of activities including, production of chemicals, quality assurance packaging and distribution etc. Several chemical industries are involved in the manufacturing of basic chemicals, including acids, alkalis, salts, gases and more. Chemicals play important role for the production of wide range of products such as dyes, adhesives, cosmetics, synthetic polymers, pesticides, cement, detergents, fertilizers, fibers, glasses, agrochemicals etc.

DO YOU KNOW?

The control and regulation of chemical industries in Pakistan involves a combination of various Government agencies such as:

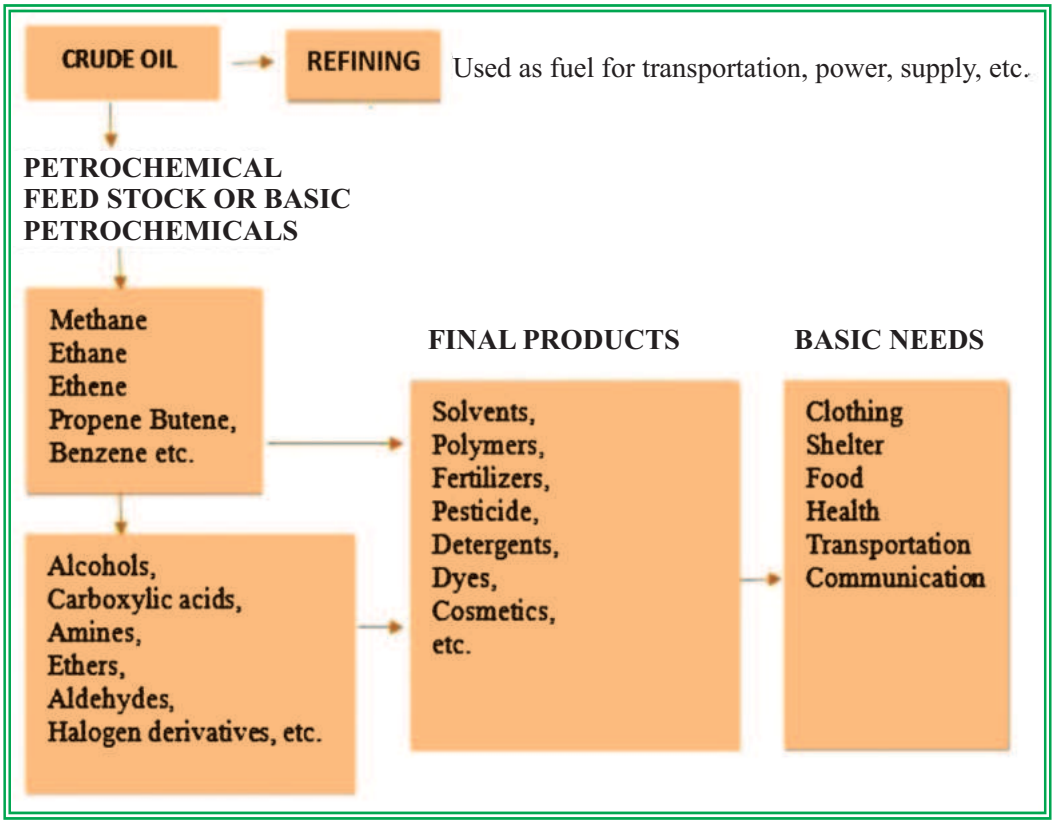
- Pakistan standard and quality control authority (PSQCA).
- Environmental protection agency (EPA).

These industries encompass a wide range of sectors and generate substantial revenue and create employment opportunities. Some well-established chemical industries are given below;

(i) **Petrochemical Industries:** These industries are primarily focuses on the extraction, refining and processing of petroleum and natural gases.

They also produce many other chemicals as by products which then sold as a raw materials several useful substances.

Products of crude oil and its uses



(ii) Fertilizer Industries:

Fertilizer industries are responsible for the production of fertilizers, which are substances used to improve soil fertility and promote plant growth. Fertilizers provide essential nutrients to plants, enhancing crop yields and agricultural productivity. There are two main types of fertilizers: organic fertilizers, which are derived from natural sources, and synthetic fertilizers, which are manufactured chemically. Some common synthetic fertilizers are listed in Table 11.1:

Table 11.1 Examples of some synthetic fertilizers and their uses

Synthetic Fertilizer	Chemical Formula	Nutrients Provided	Uses
Ammonium Nitrate	NH_4NO_3	Nitrogen	Development of roots and maintaining pH soil
Urea	$CO(NH_2)_2$	Nitrogen	Development of leaf, steam and fruits
Diammonium Phosphate (DAP)	$(NH_4)_2HPO_4$	Nitrogen, Phosphorus	Development of early stage of plants growth
Potassium Chloride (MOP)	KCl	Potassium	Help enzyme activities and photosynthesis

(iii) Textile Industries: Textile industries are sectors of the economy that involve the production of fabrics and textiles, including natural fibers like cotton and wool, as well as synthetic materials like polyester and nylon. These industries play a vital role in providing a wide range of products, from clothing and household items to industrial materials (Table.11.2).

Table 11.2 Examples of some synthetic Textitles products and their uses

Synthetic Textile Products	Description	Uses
Polyester	A synthetic fiber made from petrochemicals	Clothing (shirts, pants, dresses, jackets), curtains, bedding etc.
Nylon	A strong and durable synthetic fiber	Stockings, hosiery, swimwears, ropes, parachutes, and various sportswears.
Acrylic	A soft and light weight synthetic fiber.	Sweaters, blankets, faux fur, carpets,

(iv) Paint Industries: The paint industry is a sector that produces liquid or powdered substances used for coating surfaces, providing protection, decoration, and other functional purposes in various applications such as construction, automotive, and industrial sectors (Table.11.3).

Table 11.3 Examples of some synthetic paints and their uses

Paint Products	Description	Common Uses
Water-Based Paint	It is also known as latex. In this paint water is used as a carrier solvent	Interior and exterior walls, ceilings, and various surfaces.
Oil-Based Paint	It contains organic solvents as a carrier.	Woodwork, metal surfaces and surfaces that require durability.
Enamel Paint	A type of oil-based or water-based paint with a hard, glossy finish.	Metal surfaces, kitchen appliances, and surfaces that need high durability.
Epoxy Paint	A two-part paint that consists of a resin and a hardener, creating a tough and durable coating.	Industrial floors, garage floors, marine applications, and metal surfaces.

(v) Detergent Industries: The detergent industry produces cleaning products, typically containing surfactants and other agents, designed for various applications like laundry, dishwashing, and surface cleaning. These products help to remove dirt, stains, and grease for improved hygiene and cleanliness (Table.11.4).

Table 11.4 Examples of some synthetic detergents and their uses

Detergent Products	Composition	Main Uses
Laundry Detergent	Surfactants, builders, enzymes, fragrance, water softeners	Cleaning clothes in washing machines
Dishwashing Detergent	Surfactants, enzymes, fragrance, water softeners	Washing dishes by hand or in dishwashers
All-Purpose Cleaner	Surfactants, solvents, fragrance, water	Cleaning various surfaces and floors
Hand Soap	Surfactants, moisturizers, fragrance, antibacterial agents	Hand hygiene and cleansing

(vi) Cement Industries: The cement industry involves the production of cement, a binding material used in construction, made primarily from limestone, clay, and other raw materials. Cement is a fundamental component of concrete and mortar, essential for building infrastructure and structures worldwide (Table.11.5).

Table 11.5 Examples of some synthetic cement and their uses

Cement Type	Composition	Main Applications
Ordinary Portland Cement (OPC)	Clinker (mainly composed of calcium silicates), gypsum, limestone, and small amounts of other materials.	Infrastructure construction, concrete and production.
Portland Slag Cement (PSC)	Clinker, slag, gypsum and limestone.	Underground construction marine works, and sewage works.
White Cement	Clinker, limestone, and gypsum with low iron content.	Tile grout and other decorative constructions.

Self Assessment

Some chemically industries operating in Pakistan have been mentioned in section 11.1. Do you know some more industries working in Pakistan?

11.2 PHARMACEUTICAL INDUSTRY

Pharmaceutical industries refers to the companies where drugs are manufactured. **"Drug is a substance that is used to treat or cure a disease in**

human or animals". Pharmaceutical industries provide significant contribution to health care sector. They are not only concerned with the manufacturing of medicines for diseases control but also invest in extensive research and development activities to discover new drugs, therapies and treatment approaches.

Classification of pharmaceutical products is based on various factors, such as chemical structure, mechanism of action, therapeutic use and biological activities. Some common drugs are described below.

Analgesics

"A drug that specifically targeted on central nervous system to provide pain relief without consciousness is known as analgesic drug". "Asprin" is the oldest and the most common analgesic drug.

Antibiotics

This drug is produced from certain chemicals of microorganism. **"It suppress the growth or kills microorganisms"**. "Penicillin" was the first discovered antibiotic. Now a days a range of antibiotics are used depending upon doctors prescription.

DO YOU KNOW?

Bayer commercially introduced aspirin in 1899 as pain reliever. Its chemical name is acetyl salicylic acid. However, historically, it was derived from a plant willow bark for medicinal use.

Antipyretic medicines

"A drug which lower the body temperature to normal is known as antipyretic". The most widely used antipyretic medicine is "paracetamol".

Anti fungal medicine

"These drugs use to kill fungi that cause infections on skin". The most common skin infections are ringworm and dandruff. Example of antifungal drug is "fluconazole".

Anti inflammatory medicine

"These drugs helps reduce inflammation, and relieve pain". Ibuprofen (Brufen) is an example of anti inflammatory medicine. However many other options are also available.

Anti allergic medicine

These are also called antihistamines. Histamine is a chemical produce in the body due to decarboxylation of an amino acid known as histidine. **"The administration of these drugs reduces the histamine level in the body"**. A wide range of anti-allergic medicines are available in the market, one example of anti-allergic medicine is "diphenyl hydramine".

Anti malarial medicine

Anti protozoal or anti-Malarial drugs are use to treat mosquito bite infectious diseases such as malaria. Most commonly used anti material drug is chloroquine.

There are hundreds of pharmaceutical industries operating in Pakistan. Health ministry of Govt. of Pakistan play important role in the availability and accessibility of drugs in public sector.

11.3 PESTICIDES

"Chemical which are used to control, repel or kill pets or insects or fungus are known as pesticides".

Pets and insects can cause significant damage to crops, leading to their reduced yields and poor quality. In modern agricultural practices, formers utilize pesticides as a preventive measure to safeguard crops from pets and to ensure the maximum yield (Fig.11.1).

Fig 11.1: Pesticide spray on crops with all safety measures

Although, the term pesticides is commonly associated with crop protection, it also encompasses the chemicals use to destroy community pets including cockroaches, mosquitoes, rats, flies etc.

Types of Pesticides

Pesticides are classified into three major classes named as insecticides, fungicides and herbicides.

Insecticides

"Chemical substances which use to kill insects are called as insecticides". The best known insecticide is Dichlorodiphenyltrichloroethane (DDT),

Herbicides

Undesirable herbs often co-exist with crops creating problems for the growth and fertility of crops, by taking away their share of nutrient water and sunlight, these types of herbs are known as weeds. **"Herbicides are the chemicals which either destroy or stop growing weeds"**. A very common herbicide which former prefer to use is 2,4-dichlorophenoxyaceticacid (abbreviated as 2, 4-D).

Fungicides

"Fungicides are chemical substances employed to eliminate undesired fungi that develop within crops". A very common fungicide Mancozeb (Manganese ethylenebis(dithiocarbamate) zinc salt) which is used to control various fungal diseases on crops like potatoes, tomatoes, and grapes.

Toxic effects of pesticides

Despite the prevalent use of pesticides in the modern agriculture, it is crucial to acknowledge and address their harmful impact on health and environment. Pesticides spray on crops can contaminate soil, water and air leading to the toxic effects on human, animals and environment. A high level of pesticides

DO YOU KNOW?

A mosquito repellent, classified as a type of less toxic pesticides provides protection against mosquito bites when a small amount is applied to exposed area of skin.

exposure can cause respiratory and reproductive problems, eye damage and neurological disorder.

Safety Measures

- Fruits, vegetables and other crops should be washed properly before eating.
- Farmers who handle pesticides as a part of their work should follow safety protocols.

11.4 SYNTHETIC POLYMERS

"Polymer is a high molecular mass compound that forms by the combination of a large number of one or more types of molecules of low molecular mass".

Polymers are either obtained from natural source such as rubber, cellulose, starch, etc or synthesized by chemical reactions.

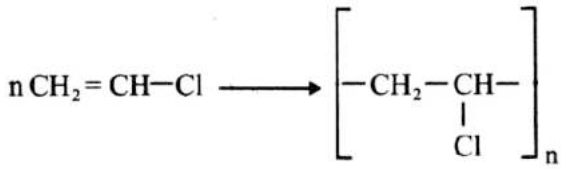
Synthetic polymers are classified into two broad classes on the basis of type of process involved during their preparation.

Addition polymerization involves the self-addition of unsaturated monomers to form a giant molecule, while condensation polymerization links same or different monomers by eliminating small molecules like water or methanol.

Another classification of synthetic polymers is based on their behavior on heating. Thermoplastics soften on heating and regain their original properties on cooling, whereas thermosetting plastics undergo irreversible transformation, becoming hard and rigid upon heating.

Polyvinyl chloride (PVC)

Polyvinyl chloride (PVC) is a widely used thermoplastic due to its versatility and durability. It is known for its excellent electric insulation, light weight and low cost. PVC is an addition polymer of vinyl chloride it is prepared by heating vinyl chloride at 60-70°C in the presence of Hydrogenperoxide (H_2O_2).



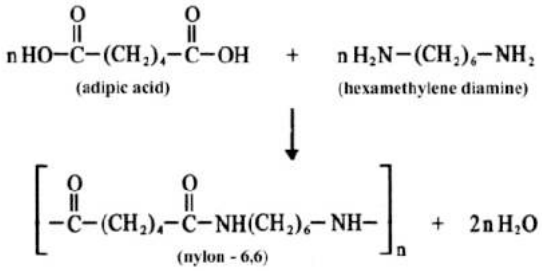
(vinyl chloride) (polyvinyl chloride)

PVC is used in the manufacturing of bottles, pipes, medical tubes, blood bags and insulation material on electric wires.

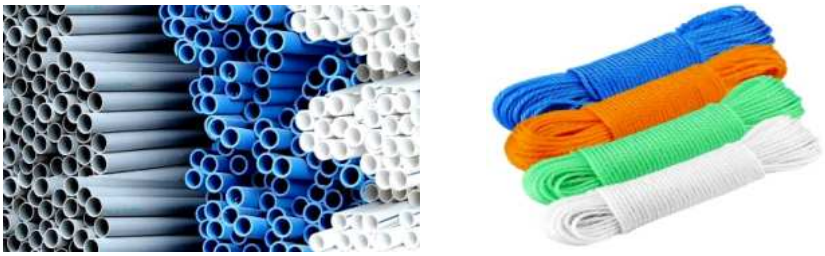
Nylon 6, 6

Nylon 6, 6 is a type of synthetic polymer. It is known due to its high strength, light weight and excellent mechanical properties.

Nylon 6, 6 is chemically a polyamide and prepared by the process of condensation polymerization between hexamethylenediamine and adipic acid (hexanedioic acid) with the elimination of water molecules.



Nylon 6, 6 is used in making tents, parachutes, ropes, fish net, bristles of brushes and tires etc (Fig.11.2).



(a) (b)

Fig 11.2: Product of (a) PVC (b) Nylon 6, 6

11.5 COSMETICS

The word cosmetic is derived from the Greek word "kosmetiko" meaning beautifying complexation of skin.

"Cosmetics are the products that are used to enhance or alter the appearance of face, body, nails or hairs". Thousands of cosmetic products are manufactured in the industries, few very common are briefly described below.

DO YOU KNOW?

Glycerine is commercial name for glycerol. It is an organic oily liquid. It is widely used in moisturizers and lotions. It is commonly used for healing mouth ulcers.

(i) **Lipstick: "Lipstick is a chemical used to colour, moisturization and protection of the lips"**. It is a type of makeup that usually available in a stick and is applied directly to the lips. Lipstick is typically made from a mixture of oils, waxes, pigments, fragrance and moisturing agent.

(ii) **Nail Polish:** It is a type of lacquer that is used to enhance the appearance of nails in women. It comes in a variety of colours including red, pink, brown and others. The basic components of nail polish include pigments, resin, plasticizers and film former.

(iii) **Nail Polish Remover:** It is an organic solvent such as "acetone" along with some other ingredients such as scent.

(iv) **Hair Dyes:** These are chemicals that change the colour of hairs. Hair dyes are classified into temporary and permanent hair dyes. Temporary hair dye last for a short period of time, typically a few washes. It is available in various form such as spray, gels and shampoos.

Permanent hair dye refers to a colouring product that last for long period of time. It mainly consists of colourent and developer. The developer is an oxidizing agent generally, hydrogen per oxide is used as developer.

(v) **Perfumes:** These are complex mixtures of aromatic compounds, solvents, and fixatives that create pleasant and distinctive scents. They typically consist of top, middle, and base notes, which work together to provide a well-balanced and long-lasting fragrance.

(a) (b) (c) (d)

Fig 11.3: Various cosmetics (a) Lipsticks (b) Nail polishes (c) Hair dyes (d) Perfume

11.6 ADHESIVES

"Adhesives or glue are chemical substance that use to stick materials together". They are liquids or semi solids. They create a bond between the two surface through either physical or chemical processes. A wide variety of adhesive are available, each possessing unique properties and appropriate applications. Some of frequently used adhesive are described below.

Starch

It is a natural adhesive and prepared by heating starch suspension in water. It has low adhesive strength but widely used because it is easily prepared and low cost. Starch is used as a thickening agent in various food products and as a raw material for the production of biodegradable plastics.

Epoxy Resins

These are strong synthetic adhesives and commonly used for bonding metals, plastics, glasses and ceramic items.

Silicon Resins

These are known with their high strength, high thermal stability and water repellent ability. These are use in sealing of engines, gasket making, bonding of optical instruments and medical instruments.

Super Glue

It is chemically named as cyanoacrylate. It is fast acting adhesive that bond quickly of broken items such as jewellery, toys, automotives etc.

Wood Glue

It is chemically named as polyvinyl acetate. It is a water based adhesive. It form a strong and durable bond between pieces of woods when compressed them under high pressure.

(a) (b) (c)

Fig 11.4: Various adhesives (a) Starch (b) Silicon glue (c) Wood glue

SOCIETY, TECHNOLOGY AND SCIENCE

Development and use of synthetic fibers

Polyester is a well-known fiber utilize in fabric production. It is prepared by the reaction between terapthalic acid and ethylene glycol. When polyester is blended with cotton in the ratio of 65% polyester and 35% cotton it makes poly-cotton fiber (tropical fabric) which is known for its light weight nature, ease of ironing and soft texture. Poly-cotton fabric is widely used is the production of all types of clothing, including shirts, trousers bed sheets etc.

SUMMARY

- Industrial chemistry is the branch of chemistry which deals with the conversion of raw materials into useful product through chemical process.
- Drug is a substance that is used to treat or cure a disease in human or animals.
- A drug that specifically targeted on central nervous system to provide pain relief without consciousness is known as analgesic drug.
- A drug which suppress the growth or kills microorganisms is known as antibiotics.
- A drug which lower the body temperature to normal is known as antipyretic.
- A drug which is used to kill fungi that cause infections on skin is known as anti-fungal.
- Chemical which are used to control, repel or kill pets or insects or fungus are known as pesticides.
- Polymer is a high molecular mass compound that forms by the combination of a large number of one or more types of molecules of low molecular mass.
- Cosmetics are the products that are used to enhance or alter the appearance of face, body, nails or hairs.
- Adhesives or glue are chemical substance that use to stick materials together.

EXERCISE

Multiple Choice Questions

(i) Super glue is chemically named as:
(a) Cyano acrylate (b) Polyvinyl acetate
(c) Epoxy resins (d) Polyurethane

(ii) DDT is a chemical which commercially known as:
(a) Insecticide (b) Herbicide
(c) Pesticide (d) Fungicide

(iii) Nail polish remover is mainly consists of:
(a) Pigments (b) Acetone
(c) Diethyl ether (d) Ethyl alcohol

(iv) Antimalarial drug among the following is:
(a) Ibuprofin (b) Chloroquine
(c) Paracetamol (d) Diphenyl hdramine

(v) Asprin is a pain reliever, its chemical name is:
(a) Ascorbic acid (b) Nicotinic acid
(c) Acetyl salisylic acid (d) Benzoic acid

(vi) Nylon 6, 6 is a condensation polymer of hexamethylene diamine and:
(a) Benzoic acid (b) Adipic acid
(c) Pthalic acid (d) Valeric acid

(vii) Which of the following is not a synthetic plastic:
(a) Nylon (b) Teflon
(c) Cellulose (d) Polyethene

(viii) Drugs that lower the body temperature to normal are known as:
(a) Antibiotics (b) Antipyretic
(c) Antiallergic (d) Anti histamins

(ix) Which of the following chemical is used as an oxidizing agent in permanent hair dyes:
(a) Acetone (b) Hydrogen peroxide
(c) Polyvinyl acetate (d) Resorcinol

(x) An example of thermosetting plastic is:
(a) Polyethene (b) PVC
(c) Nylon (d) Bakelite

Short Questions

1. Give the scope of pharmaceutical industries in Pakistan.
2. What is antihistamine drug? Give the symptoms in which it is used.
3. Write the names of two synthetic and two natural polymers.
4. Write the name of four main components of Nail polish?

Descriptive Questions

1. How can you define Cosmetics? Describe four cosmetics which are commonly used.
2. What are pesticides? Explain various types of pesticides along with their specific use.
3. Describe the preparation, properties and uses of Nylon and polyvinyl chloride.
4. What are adhesives? Explain the significance of super glue and silicon resins.