INTRODUCTION

Drugs

The word **'drug'** is derived from the French word *drogue* which means a dry herb. In a general way, a *drug may be defined as a substance used in the prevention, diagnosis, treatment or cure of disease in man or other animals. According to* **WHO,** *a drug may be defined as any substance or product which is used or intended to be used for modifying or exploring physiological systems or pathological states for the benefit of the recipient.* An ideal drug should satisfy the following requirements :

(*i*) When administrated to the ailing individual or host, its action should be localised at the site where it is desired to act. In actual practice, there is no drug which behaves in this way. It generally tends to distribute ~~itself any~~ where in the tissues of the host. itself anywhere

(*ii*) It should act on a system with efficiency and safety.

(*iii*) It should not have any toxicity.

(*iv*) It should have minimum side effects.

(*v*) It should not injure host tissues or physiological processes.

(*vi*) The cells should not acquire tolerance or resistance of the drug after some time. In actual practice, the cells which were originally susceptible to the action of a particular drug may after sometime acquire a tolerance of resistance of that drug.

Very few drugs satisfy all the above conditions. However, the search for ideal drug continues.

3) Pharmaceutical drug is classified on the basis of their origin.

1) drug from natural origin → Herbal or plant or mineral, marine origin.

2) drug from chemical as well as natural origin → derived from partially herbal and partially chemical synthesis. like steroid

3) drug derived from chemical synthesis

4) drug derived from animals like hormones and enzymes.

5) drug derived from microbial origin like antibiotics.

6) drug derived ~~from~~ by biotechnology genetic engineering

7) drug derived from radio active substances

A sampling of classes of medicine includes

1) Antipyretics: reducing fever (ibuprofen), aspirin) paracitamol.

2) Analgesics → reducing pain (morphine)

3) Antimaleria → treating maleria,

4) Antibiotics → These are antimicrobial used specially bacteria & virous infection

Classification based on their origin:

1. Drug from natural origin: Herbal or plant or mineral or marine origin
2. Drug from chemical as well as natural origin: Derived from partial herbal and partial chemicals
3. Drug derived from chemical synthesis
4. Drug derived from animal origin
5. Drug derived from microbial origin
6. Drug derived by biotechnology, Genetic-engineering, hybridoma technique
7. Drug derived from radioactive substances.

- Pharmaceutical or drug or medicines are classified in various other groups besides their origin on the basis of pharmacological properties like mode of action and their pharmacological action or activity.
- A drug may be classified by the chemical type of the active ingredient or by the way it is used to treat a particular condition.
- Each drug can be classified into one or more drug classes.
- The World Health Organization (WHO) keeps a list of essential medicines.

Classification based on therapeutic action:

1. **Antipyretics**: reducing fever (pyrexia/pyresis). For eg. Phenacetin, Paracetamol
2. **Analgesics**: reducing pain (pain killers). For eg. Aspirin, Morphin
3. **Antimalarial drugs**: treating malaria. For eg. Chloroquine, Chemoquine
4. **Antibiotics**: inhibiting germ growth. For eg. Penicillin, Streptomycin
5. **Antiseptics**: prevention of germ growth near burns, cuts and wounds. For eg. "Surgical alcohol", Dettol, Hydrogen peroxide solution to clean and deodorize wounds and ulcers.
6. **Mood stabilizers**: It is a psychiatric medication used to treat mood disorders. For eg. Lithium
7. **Hormone replacements**: wherein the patient, in the course of medical treatment, receives hormones, either to supplement or to substitute other hormones for naturally occurring hormones, For eg. Premarin.
8. **Stimulants**: These are psychoactive drugs that induce temporary improvements in either mental or physical functions or both. Examples of these kinds of effects may include enhanced alertness, wakefulness, and locomotion, among others. Examples: Methylphenidate, Amphetamine
9. **Tranquilizers**: It induces tranquillity in an individual. For eg. Diazepam.
10. **Sulpha drugs**: act against micro-organism just like antibiotics. For eg. Sulphanilamide, Sulphadiazine.

ANTIBIOTICS

Introduction

The term antibiotic has been derived from the word **"antibiosis"** which according to the biology concept means survival of fittest *i.e.*, **a process in which one organism may destroy another to preserve itself.** The term "antibiotic" was first of all introduced by Vuillemin in 1889. The term antibiotic was first defined by Waksman (1944) and which was later on modified a little by Benedict Langlykke (1947). However, the modern definition of antibiotic is :

"It is a chemical substance produced by or derived from living cells which is capable, in small concentrations of inhibiting the life processes or even destroying the micro-organisms."

As very low concentrations of antibiotics are essential to bring about their antibiotic action, they are also classified as chemotherapeutic agents. Further, the action of antibiotic is very specific, *i.e.*, a given antibiotic has been found to be effective against certain type of micro-organisms only.

In order for a particular antibiotic to act as a therapeutic agent, it has to satisfy following conditions :

(*a*) It must be effective against a pathogen,

(*b*) It must not cause significant toxic side-effects.

(*c*). Its stability must be appreciably high so that it can be isolated, and processed into suitable forms of dosages which are readily absorbed.

(*d*) It could be stored for a long time period without appreciable loss of its activity.

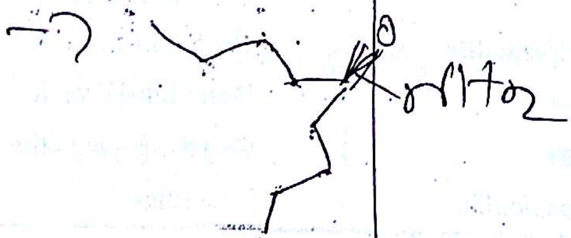
(*e*) The rate of detoxification and elimination from the body must be such that there exists sufficient time interval between two successive dosages and during that period a proper concentration level has to be maintained.

(*f*) The antibiotic should be completely eliminated from the system soon after its administration has been stopped.

Antimicrobials → that kills or inhibit the growth of microorganism (bacteria, virous, fungue)

5) Antiseptic → prevention of germ growth near burns, wounds, cuts. (These are the antimicrobial substance that are applied to living tissue/skin to reduce the possibility of infection, sepsis.

6) Mood stabilizer – It is a ~~psych~~ psychiatric medicine. used to treat mood disorders. (lithium, valpromide →



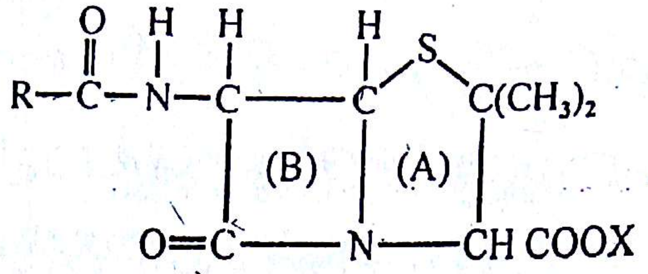
7) Hormone replacements:

8) Oral contraceptives:

9) stimulants are psychoactive drugs. that ~~improve~~ induce temporary improvement either mental or physical or both

Introduction : Penicillin is the name given to the mixture of natural compounds

have molecular formula $C_9H_{11}N_2O_4SR$ and differ only in the nature of R. The general structure of penicillins is



In the above structure of penicillin, the thiazolidin ring nucleus (A) is fused to a β-lactam ring (B) which is attached to a side chain (R—C=O). Any chemical modification of the β-lactam or thiazolidine rings destroys the anti-bacterial activity of the molecule, *e.g.*, Penicillinase breaks the β-lactam ring.

In the above structure of penicillin, X is sodium, potassium, aluminium, procaine, benzathine or free acid. The various salts of penicillins determine the solubility of the antibiotic. The very soluble sodium salt is available for intravenous use, the benzathin salt, very slowly soluble, is absorbed gradually from an intramuscular injection depot over a 2-to 4-week period. On the basis of various values of R, there are at least six naturally occurring penicillins.

Chemical Name	Other names	R
1. Pent-2-enylpenicillin	Penicillin-I-or F	$-CH_2CH = CH\text{-}CH_2CH_3$
2. Benzylpenicillin	Penicillin-II or G	$-CH_2C_6H_5$
3. *p*-Hydroxybenzylpenicillin	Penicillin-III or X	$-CH_2C_6H_4OH$ (1, 4)
4. *n*-Heptylpenicillin	Penicillin-IV or K	$-(CH_2)_6CH_3$
~~5. *n*-Amylpenicillin~~	~~Dihydro-F-penicillin~~	$\cancel{-(CH_2)_4CH_3}$
6. Phenoxymethyl penicillin	Penicillin-V	$-CH_2OC_6H_5$

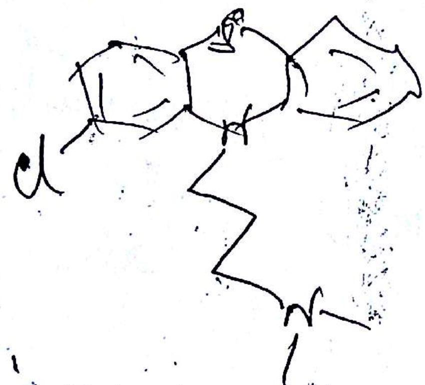
Modification of the prosthetic group R, attached to the 6-aminopenicillanic acid portion of the penicillin molecule, determines the relative stability of the form of penicillin to penicillinase. The more complex prosthetic groups impart a greater degree of stability to hydrolysis by penicillinase.

Activity of penicillin: penicillin is active against Gram +ve bacteria.

Penicillin is a group of antibiotics derived from penicillium fungi.

10) Tranquilizer → is a drug that induces tranquillity in an individual.

Tranquillity means → calmness, worry free. (chlorpromazine, reserpine)



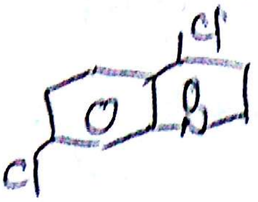
11) Statins — These are class of drugs used to lower cholesterol level by inhibiting the enzyme HMG-CoA reductase

statins (e.g. atorvastatin, fluvastatin)

Antimalarial drugs

Synthesis of some antimalarial drugs

(1). chloroquine.

 + $CH_3CH(NH_2)(CH_2)_3N(C_2H_5)_2$

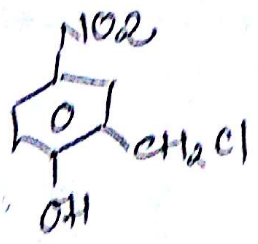
4,7-dichloroquinoline   5-diethylamino-2-amino pentane

↓ C_6H_5OH

$CH_3-CH(NH)-(CH_2)_3N(C_2H_5)_2$

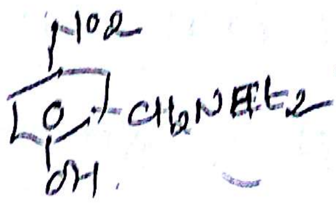
chloroquine.

(2). camoquine

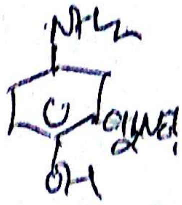


4-nitro-2-chloromethyl phenol

$\xrightarrow{Et_2NH}$

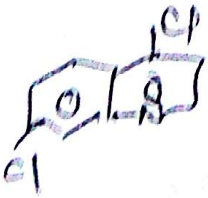


$\xrightarrow{Reduction}$



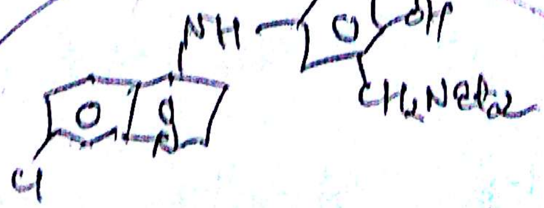
(I)

4-amino-2-diethylaminomethyl phenol

I + 

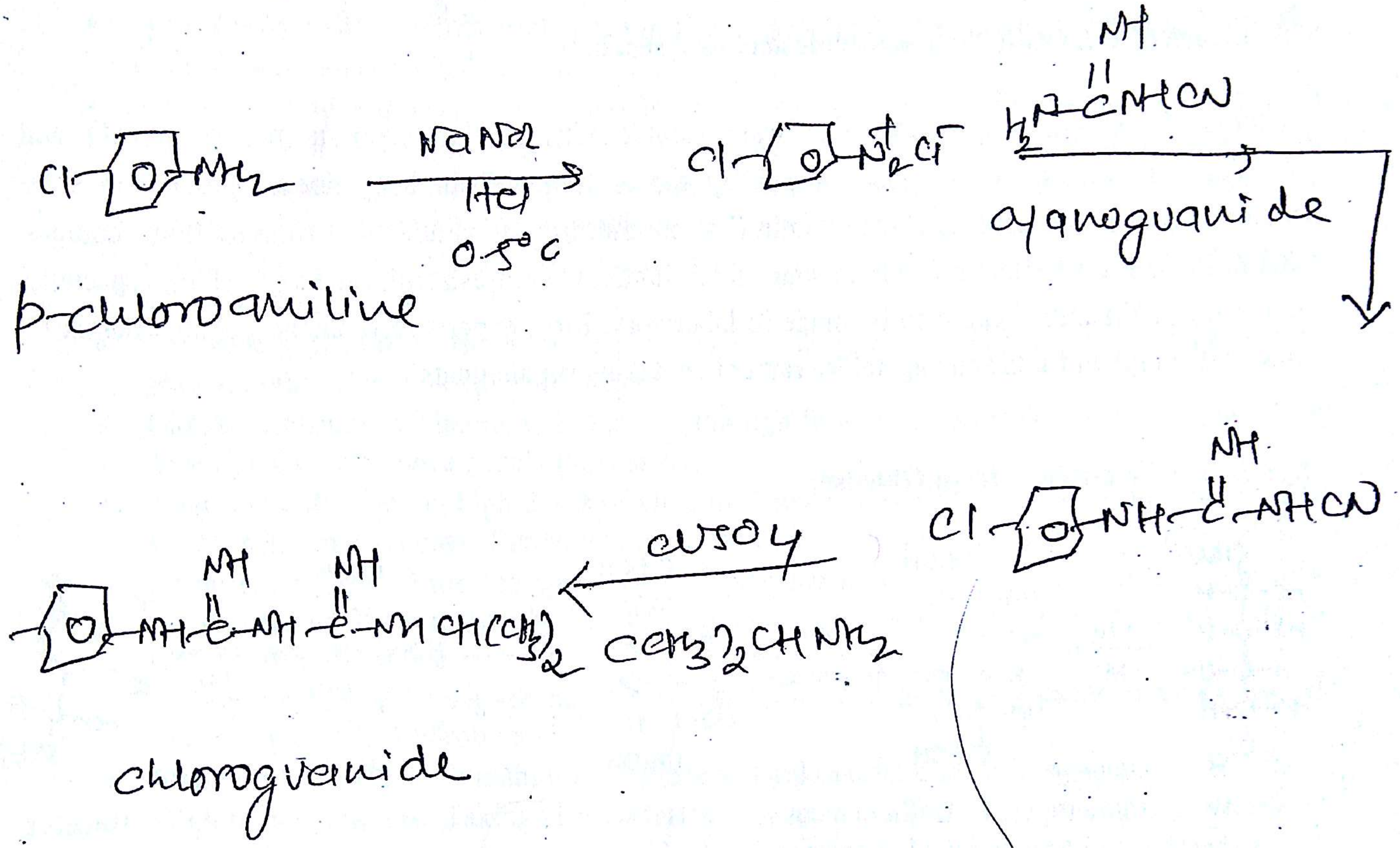
4,7-dichloroquinoline

⟶



camoquine

chloroguanide

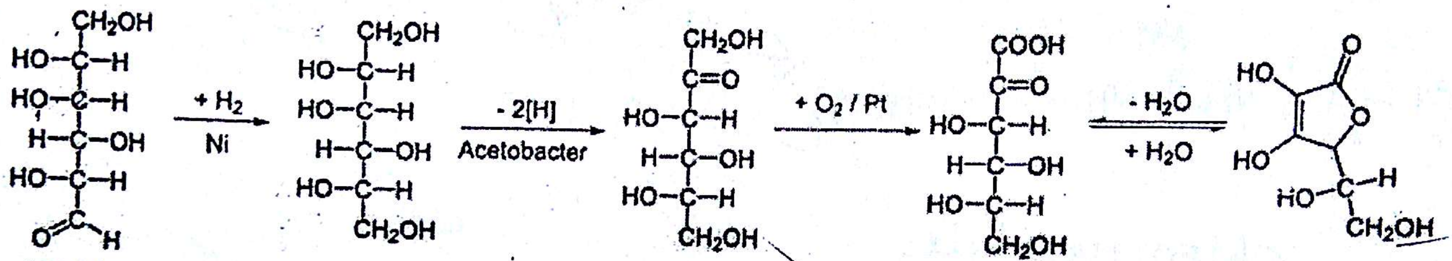


Vitamin C

Structure of Vitamin-C or L-ascorbic acid or Ascorbate:

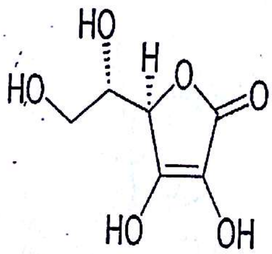
Vitamin C or L-ascorbic acid is a water-soluble vitamin that supports normal growth and development. Vitamin C also helps our body absorb Iron. As our body doesn't produce or store vitamin C, it's important to include vitamin C in our diet from food and other sources. Some animals can make their own vitamin C. Good sources of vitamin C are fresh fruits and vegetables, especially citrus fruits. Vitamin C can also be made in laboratory. Most experts recommend getting vitamin C from a diet high in fruits and vegetables rather than taking supplements.

Synthesis of Vitamin C from Glucose:

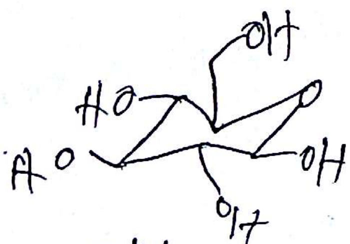


Glucose 2 3 4 Vitamin C

IUPAC name for Vitamin C:



(R)-3, 4-dihydroxy-5-((S)- 1,2-dihydroxyethyl)furan-2(5H)-one



β - glucose

Uses of Vitamin C:

- **Iron absorption.** Administering vitamin C along with iron can increase how much iron the body absorbs in adults and children.
- **Age-related vision loss** (age-related macular degeneration; AMD). Taking vitamin C in combination with zinc, vitamin E, and beta-carotene daily seems to help prevent vision loss or slow the worsening of AMD in patients with advanced AMD. There is not enough evidence to know if this combination helps people with less advanced macular disease or if it prevents AMD. Using vitamin C with other antioxidants, but without zinc, does not seem to have any effect on AMD.
- **Decreasing protein in the urine** (albuminuria). Taking vitamin C plus vitamin E can reduce protein in the urine in people with diabetes.
- **Cancer.** Consuming vitamin C in the diet through fruits and vegetables decreases the risk of developing mouth cancers and other cancers.
- **Common cold.** Taking high doses of vitamin C might shorten the course of the cold by 1 to 1.5 days in some patients. Taking vitamin C is not effective for preventing the common cold.
- **Chronic pain condition** (complex regional pain syndrome). Taking vitamin C after a wrist fracture seems to decreases the risk of developing a chronic pain condition called complex regional pain syndrome.
- **Kidney problems** Taking vitamin C before and after an angiography seems to reduce the risk of developing kidney problems.
- **Gallbladder disease.** Vitamin C help to prevent gallbladder disease in women.
- **High blood pressure.** Taking vitamin C does not seem to affect blood pressure.
- **Lead poisoning.** Consuming vitamin C in the diet seems to lower blood levels of lead.
- **Sunburn.** Taking vitamin C along with vitamin E seems to prevent sunburn.
- **Wrinkled skin.** Skin creams containing vitamin C seem to improve wrinkles in facial skin that is aged by sun exposure.

Deficiency of Vitamin C:

Vitamin C deficiency leads to Scurvy.

In adults,

- Initial symptoms of scurvy include:
- Feeling very tired and weak all the time (fatigue)
- Pain in your limbs, particularly your legs
- Appearance of small red-blue spots on your skin
- Swollen gums, with frequent bleeding

In infants,

- Lack of appetite
- Poor weight gain
- Diarrhea

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT
APPLIED CHEMISTRY DEPARTMENT
B. Tech-I Engg. Chem.

DYES

Introduction:

Definition:

A dye or a dyestuff is usually a coloured organic compound or mixture that may be used for imparting colour to a substrate such as cloth, paper, plastic or leather in a reasonably permanent fashion.

All the dyes may not necessarily be coloured substances. Previously dyes were obtained from animal and vegetable sources. Today most of the available dyes are synthetic dyes prepared from aromatic compounds, which are obtained from coal tar or petroleum.

Requisites of a True Dye

All colored substances are not dyes. However, requisites of true dye are as follows:

- It must have a stable colour.
- It must have an attractive colour.
- It must be able to attach itself to material from solution or to be capable of fixed on it. e.g. azobenzene is coloured but cannot fix itself to a fabric. Therefore, azobenzene is not a dye.
- It must be soluble in water or must form a stable and good dispersion in water. Alternatively it must be soluble in the medium other than water.
- The substrate to be dyed must have a natural affinity for an appropriate dye and must be able to absorb it from solution or aqueous dispersion under suitable conditions of concentration, temperature and pH.
- When a dye is fixed to a substrate it must be fast to washing, dry cleaning, perspiration, light, heat and other agencies.
- The shade and fastness of a given dye may vary depending on the substrate due to different interactions of the molecular orbitals of the dye with the substrate.

Classification of Dyes

Dyes are classified in various ways according to

(1). Dyes classified on the basis of methods of application to the fiber.

(2). Dyes classified on the basis of their chemical constitution.

(3). Dyes classified on the basis of the types of materials to be dyed.

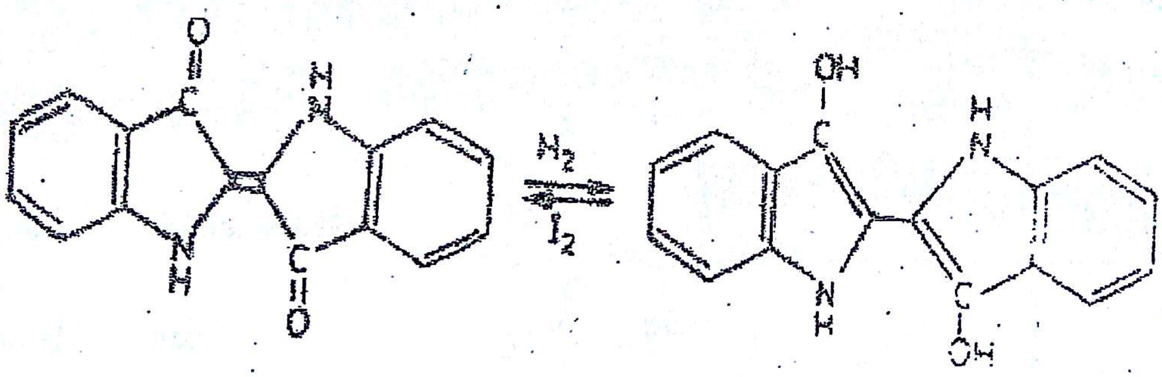
(4). Dyes classified on the basis of the intermediates from which they are prepared.

1. Classification of dyes according to methods of application (modes of application)

Dyes are classified according to application method, for convenience of the dyer.

(1). Vat Dyes

These are insoluble, but their reduced forms which are soluble. These dyes are applied in their reduced forms which are obtained by treating it with reducing agent such as alkaline sodium hyposulphite in large wooden vats from which the name Vat dyes has come.



Indigo blue (insoluble) Indigo white (sc[illegible])

The cloth is immersed in the vat, having a reduced vat dye for sufficient time, then it dried in air, due to oxidation of dye on fiber the original insoluble coloured dye is obtained which is very fast to washing, light and bleaching as well e.g.

These dyes offer excellent fastness; these dyes are most often used on cotton fabrics which are subjected to the severe conditions of washing and bleaching. It can also be used for dyeing wool silk and cellulose acetate

(2). Acid Dyes

These dyes are usually the sodium salts of the colour acids which may contain sulphonic acid or phenolic group. These dyes give very bright colour and have a wide range of fastness properties.

Acid dyes are used to dye fibers having basic groups, such as wool, silk and polyamides and are applied under acidic condition that causes protonation of the basic groups.

$Dye^{--} + H^{+} + Fiber \longrightarrow Dye^{-} — H^{+} — Fiber$

Generally the acid dyes can be removed by washing. The rate of removal depends on the rate at which the dye can diffuse through the fiber under condition of washing and the rate of diffusion depends on temperature, size & shape of dye molecule and number & kind of linkage formed on fibers. E.g. Orange – I, Orange – II etc.

Dyes And Dying

> "It's not whether you get knocked down, it's whether you get up."

1 INTRODUCTION

For adding beauty, attraction and distinction to foods, fabrics, paper and other objects, we employ chemical substances, known as dyes. ~~This is done by imparting colour to them with the help of dyes. In fact,~~ people of different culture and different socio-economic status prefer to use objects of different shades of their choice. For example, they put on clothes of different colours and shades on different occasions and seasons. Psychologists attach special significance to the choice of the colour by a person and to his state of mind. In this chapter, we will discuss about the dyes, their classification and process of dying.

2 DYES

A coloured chemical substance which is capable of attaching itself to the material (say textile fibre) from its solution (*i.e.*, it is capable of easy fixation) for imparting its colour to the material dyed is known as *dye*.

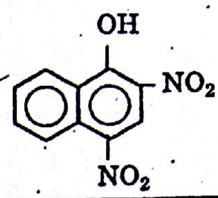
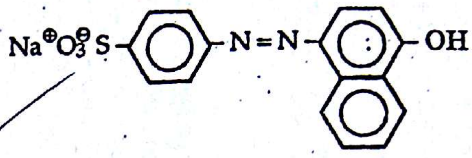
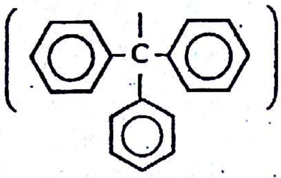
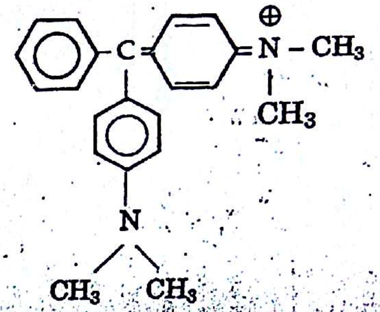
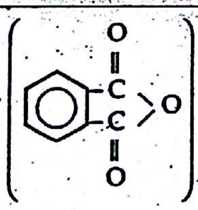
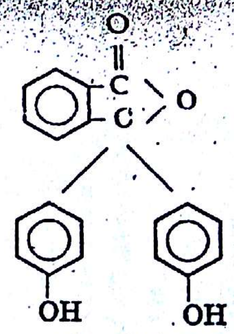
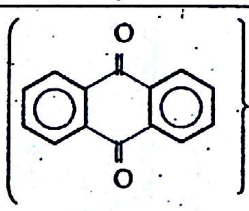
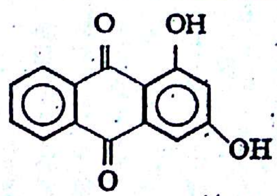
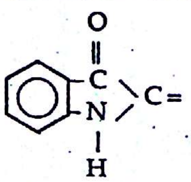
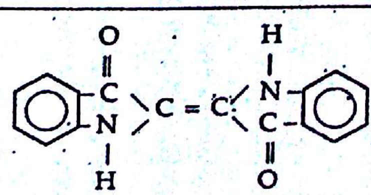
It is to be noted that the resultant colour which is imparted to the material is fast to water, soaps & detergents, dry-cleaning solvent and light.

A *colour imparted by a dye is due to* its interaction with light. During this interaction, some frequencies in the visible region of electromagnetic spectrum (400 – 750 nm) are absorbed, some are transmitted and some are reflected back. The colour we observe is due to the transmitted frequencies which are complementary to the absorbed frequencies.

For example, if a dye absorbs the light in the frequency region corresponding to orange, then it will appear blue, which is the complementary colour of orange.

Any dye cannot be used to impart colour to all types of objects. The chemical constitutions of both the dye and the object are vital.

Classification Based on Chemical Composition

S. No.	Dyes	Structural Unit & Group	Examples
1.	Nitro dyes	$\left(-\overset{\overset{\displaystyle O}{\|}}{N} \rightarrow O\right)$ Nitro	 Martius yellow
2.	Azo dyes	$(-N=N-)$ Azo	 Methyl orange
3.	Triphenylmethane dyes	 Triphenylmethane	 Malachite green
4.	Phthalein dyes	 Phthalein	 Phenolphthalein
5.	Anthraquinone dyes	 Anthraquinone	 Alizarin
6.	Indigoid dyes	 Indigoid	 Indigo

3.2 Classification Based on Applications

Different types of dyes are :

- Acid dyes
- Basic dyes
- Direct dyes
- Disperse dyes
- Fibre reactive dyes
- Insoluble azo dyes
- Vat dyes
- Mordant dyes

These dyes are briefly discussed below :

(i) *Acid dyes.* Acid dyes are those dyes which contain salts of organic acids such as sulphonic acid ($-SO_3H$) or carboxylic acid ($-COOH$) and nitrophenols. These dyes are mostly used for dying wool, nylon and natural silk. However, they cannot dye vegetable fibres (like cotton) at all.

Examples : Martius yellow, Naphthol yellow and Methyl orange.

(ii) *Basic dyes.* Basic dyes are those dyes which contain salts of organic bases such as amino groups ($-NH_2$ or $-NR_2$). These dyes attack anionic sites present on the fabric, thereby get attached to them. These dyes are used to dye nylon and polyesters. These dyes can also dye vegetable fibres (like cotton) after they have been mordanted.

Examples : Malachite green and Aniline yellow.

(iii) *Direct dyes.* Direct dyes can be directly applied to the fabrics from their aqueous solutions. These are suitable for those fabrics whose constituents can form hydrogen bonds with the dye, *e.g.*, Nylon, rayon, silk, wool and cotton.

Examples : Congo red and Martius yellow.

(iv) *Disperse dyes.* Disperse dyes can be applied to the fabric only in the form of dispersion of the finely powdered dye in the soap solution in the presence of a stabilizing agent (*e.g.*, cresol, phenol, benzoic acid). These dyes are employed for dyeing synthetic fibres like polyacrylonitrile, nylon and polyesters.

Examples : Anthraquinone dyes (*e.g.*, celliton fast pink B).

(v) *Fibre reactive dyes.* Fibre reactive dyes chemically react with the hydroxy or amino groups present on the fibre by an irreversible reaction for attaching themselves on the fabrics. This irreversible chemical reaction results in the development of a colour on the fabric which is retained for a long time. Dyeing by these dyes is 'fast'.

Example : 2,4-dichloro-1,3,5-triazine.

(vi) *Insoluble azo dyes.* Insoluble azo dyes are obtained by coupling a phenol with diazonium salts. These dyes act upon the fibres by adsorption. The colours imparted by the dye on the fabric is not very fast. For example, a cloth is first soaked in alkaline solution of β-naphthol and then dipped into a diazonium salt solution. An azo dye is produced in and on the fibre by coupling between the two.

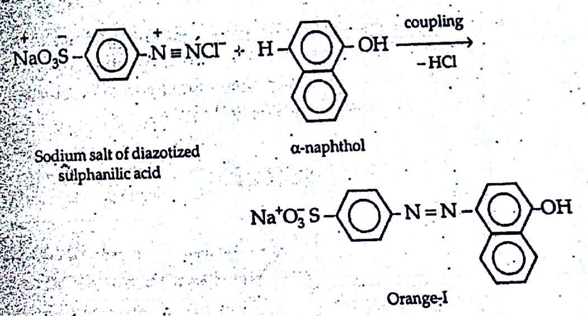
Examples : aniline yellow and methyl orange.

Notes : (1) azo dyes impart non-fast colour to the fabrics due to two reasons :

(*a*) These dyes undergo decomposition on exposure to sunlight and

(*b*) These dyes impart colour through surface adsorption.

(2) Orange-I (an azo dye) is made by coupling sodium salt of diazotized sulphanilic acid with α-naphthol.



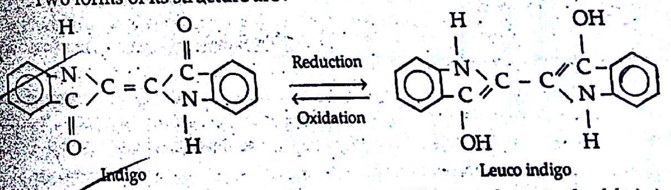
(vii) *Vat Dyes.* Vat dyes are water insoluble coloured compounds which upon reduction give soluble (leuco form) product. The reduction products have affinity for specific fabrics. On exposure to the air, the coloured insoluble dye is reformed which remains firmly fixed on the fabric.

Examples : Indigo and benzanthrone.

Dying with vat dyes. In applying a vat dye to the fabric, the dye is reduced with suitable reducing agent (sodium hydrosulphite). The fabric is dipped in tank containing soluble form of the dye. The dye attaches itself to the fabric. Reoxidation is then done by its exposure to air or any other oxidising agent. Coloured insoluble dye is reformed which remains firmly fixed in the fibre.

Note. Indigo is oldest dye known and is a vat dye.

Two forms of its structure are :



(viii) *Mordant Dyes.* Mordant dyes impart different colours to the fabric in the presence of different metal ions (called as mordants). These dyes produce wash-fast colours, when applied after treating the fabric with mordant.

For example, alizarin is a mordant dye. It gives a blue colour to the fabric already treated with barium salt solution. But alizarin imparts rose red colour to the fabric which is treated with aluminium salt solution.

Dye and mordant	Alizarin and Ba^{2+}	Alizarin and Al^{3+}	Alizarin and Fe^{3+}
Colour	Blue	Red	Violet

Dying with Mordant dyes. Fabric is first impregnated in mordant solution (say aluminium hydroxide solution in presence of wetting agent). When the cloth mordanted with aluminium salt is dipped in a tub containing dye, the mordant coordinates to the basic (or acidic) group in the fabric and then combines with acidic (or basic) dye. This is responsible for imparting wash-fast colour to the fabric.

In fact, chelation is responsible for the alteration in the energy levels of dye, that's why same dye can give different colours in the presence of different mordants.

For example, alizarin (a vat dye) and aluminium hydroxide (mordant) binds the fibre through coordinate bond, resulting in chelation.

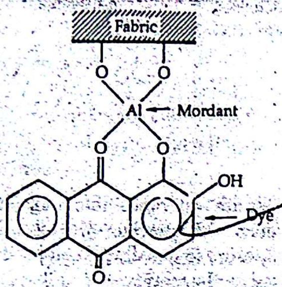


Fig. 1. The structure of the dyed fabric.

EXERCISES

1. (*a*) What are dyes ?
   (*b*) How are they classified ?
2. Write short notes on :
   (*a*) Vat dyes, (*b*) Mordant dyes.
3. Differentiate between :
   (*a*) Acid and basic dyes, (*b*) Direct and disperse dyes.
4. Describe the process of Dying a fabric with :
   (*a*) Vat dyes, (*b*) Mordant dyes.
5. Give the structural unit and examples of following dyes :
   (*a*) Nitro dyes, (*b*) Azo dyes, (*c*) Indigoid dyes, (*d*) Phthalein dyes.
6. Why the colours imparted by azo dyes are non-fast ?

14

Insulators

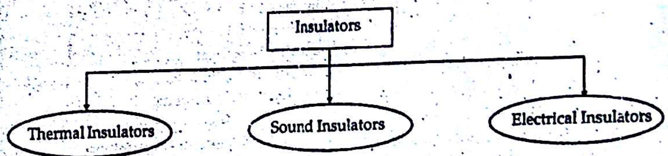
"You are what you think you are"

1 INTRODUCTION

Insulators : Definition and Classification

The substances which are capable of retarding or prohibiting the flow of heat or electricity or sound through them are known as ***Insulators*** or ***Insulating materials.***

Insulators can be broadly classified into three categories *viz.*



These are briefly discussed below :

2 THERMAL INSULATORS

The substances having extremely low thermal conductivities are known as *Thermal Insulators* and they are used to prevent the loss of heat which takes place by conduction, convection or radiation.

Uses : (*a*) When the equipments or plants like refrigerators, cold storages etc. are operated at low temperatures, then thermal insulators prevent flow of heat from the outside environment to them. (*b*) Ovens, boilers, steam carrying pipes etc. need thermal insulators because they prevent loss of heat to the outer environment.

Characteristics : The important characteristics of a good thermal insulator are :

(*a*) Its thermal conductivity is extremely low ;

(*b*) It should be fire proof ;

(*c*) It should resist moisture absorption and hence it should be water proof ;

(*d*) It should have low density ;

(*e*) At the working temperature, it should be physically and mechanically stable ; *i.e.,* it should be capable of bearing the load applied on it during working ;

(*f*) It should be chemically stable to surrounding conditions of high temperature. Moreover, it should be chemically inert to surrounding environment, moisture etc. at high temperature ;

(*g*) During the use, it should be odourless as far as possible ;

(*h*) It should be easily available at economical price.

The presence of unsaturation is essential o chromophore.

The presence of lone pair is essential for Auxochrome.

(a) *Independent chromophores.* This type includes such chromophores when a single chromophore is sufficient to impart colour to the compound. Examples of such chromophores are —N=O, —NO_2, —N=N, —N=N→O, —N=N—NH, *p*-quinonoid, etc.

(b) *Dependent Chromophores.* This type includes such chromophores when more than one chromophore is required to impart colour. Examples of such chromophores are >C=O, >C=C<, etc. This type is exemplified by various examples. For example, acetone, containing one carbonyl group, is colourless while biacetyl, containing two carbonyl groups, is yellow. A single C=C group does not produce colour in the compound but if a number of them are present in conjugation, the colour usually appears. For example, ethylene, $CH_2=CH_2$ is colourless while $CH_3(CH_2)_8CH_3$ is yellow.

$$CH_3-\overset{\overset{O}{\|}}{C}-CH_3 \qquad CH_3-\overset{\overset{O}{\|}}{C}-\overset{\overset{O}{\|}}{C}-CH_3$$

acetone biacetyl

Diphenylpolyenes provide another example. The formula of these is Ph $(CH=CH)_n$Ph. When $n=0$, 1 or 2, the compound is colourless. However, when *n* is 3, the compound becomes yellow and when *n* is further increased, the colour gets deepened, *i.e.*, when *n* =5, the colour is orange, when *n* is 7, the colour is copper-bronze and when *n* is 11, the colour is violet-black.

The shade of the colour is also influenced by the proximity of the chromophores. If these are separated by other groups, the compound becomes colourless. For example,

$$CH_3-\overset{\overset{O}{\|}}{C}-\overset{\overset{O}{\|}}{C}-CH_3$$ is yellow in colour while

$$CH_3-\overset{\overset{O}{\|}}{C}-CH_2-CH_2-\overset{\overset{O}{\|}}{C}-CH_3$$ is a colourless compound.

Compounds containing a chromophoric group were called as chromogens by Witt.

$CH_2=CH-CH=CH-CH=CH-CH=CH-CH=CH-CH=CH_2$

→ Chromogens

(b) Auxochromes. A chromogen may be coloured but it does not represent a dye. Witt pointed out that the presence of certain groups in a chromogen leads to a deepening of the colour though these groups are not chromophores themselves and do not impart colour to the compound when present without the chromophores. Witt called these groups as auxochromes (Greek *auxein*-increase, and *chroma*-colour).

Witt had listed a number of auxochromes which are given in Table 2.3.

Scanned by CamScanner

Some Typical Auxochromes

Name	Group	Name	Group
Amino	$—NH_2$	Chloro	$—Cl$
Methylamino	$—NHCH_3$	Methyl	$—CH_3$
Dimethyl amino	$—N(CH_3)_2$	Methoxy	$—OCH_3$
Sulphonic acid	$—SO_3H$	Cyano	$—CN$
Hydroxy	$—OH$	Acetyl	$—COCH_3$
Carboxylic acid	$—COOH$	Acetamido	$—CONH_2$

The auxochromes serve two functions, namely.

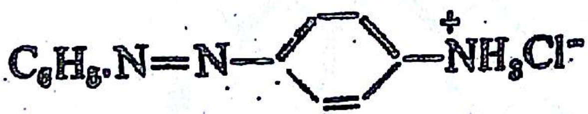
(*a*) *They increase the intensity of the colour.* This is illustrated by the following example :

(*i*) Benzene (no chromophore) is colourless.

(*ii*) Nitrobenzene ($—NO_2$ as a chromophore) is pale yellow.

(*iii*) *p*—Nitroaniline (NO_2 as a chromophore and—NH_2 as an auxochrome) is dark yellow.

(*b*) *They make the chromogen a dye by fixing it to the fabric or the material to be dyed either by associatian or by salt formation.* The fixing of the dye to the fibre is generally due to the formation of chemical bond between the fibre and the auxochrome. This is best illustrated by the following example :

C_6H_6 $C_6H_5.N{=}N.C_6H_5$ 

benzene — azobenezene (coloured - but not a dye) — p-aminoazobenzene hydrochloride (a dye, aniline yellow)

Auxochromes are mainly of two types :

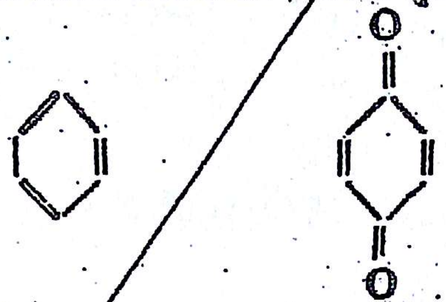
(*a*) **Bathochromic auxochromes.** These are the groups which increase the depth of the colour. These shift the absorption maxima from the violet towards the red and thereby bring about the deepening of the colour. It is called *red shift*. When the hydrogen atoms in an amino group -NH_2 are replaced by R, a bathochromic effect is produced.

(*b*) **Hypsochromic auxochromes.** These are the groups which decrease the depth of the colour. These shift the absorption maxima from the red to violet and this results in the fading of the colour. It is called *blue shift*. When the hydrogen atom in a hydroxyl group —OH or in an amino group, $-NH_2$ by an acetyl group produces hypsochromic effect.

Witt's theory has proved to extremely useful empirical guide in developing many of the dyes.

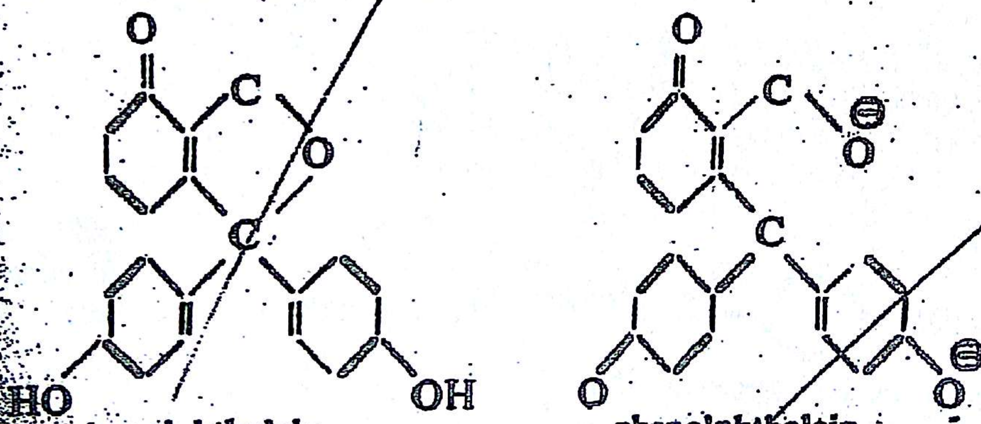
2. Armstrong's theory (Quinonoid theory). According to this theory, all the coloured compounds could be represented by the quinonoid structures (*o*-or *p*-). Thus, if a quinonoid structure could be assigned to a compound, it would be coloured otherwise not. On the basis of this theory, it could be possible to explain the colouring properties of some of the important compounds. For example,

(*i*) Benzene is colourless whereas benzo-quinones are coloured.



benzene (colourless) — *p*-benzoquinone (yellow)

(*ii*) If phenolphthalein is present in benzoquinone structure, it is coloured. On the other hand, if phenolphthalein is present in benzenoid structure, it is colourless.



phenolphthalein (*colourless*) — phenolphthalein (*red coloured*)

Limitations: (*i*) Armstrong's theory could not explain the colouring characteristics of all of the compounds. For example, although iminoquinone and di-iminoquinone have a quinonoid structure, yet they are colourless.

iminoquinone — di-iminoquinone

Reasons

Q-1: Explain: Acetone is colorless whereas Biacetyel is yellow.

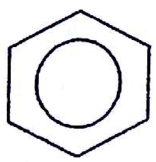
Ans: The structural formulas for these compounds are:

CH_3-C-CH_3 ‖ O	CH_3-C-C-CH_3 ‖ ‖ O O
Acetone	Biacetyl
(Colourless)	(Yellow)

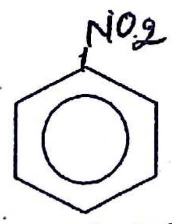
According to Witt's theory, there exists relation between color and chemical structure of a compound. Further a colored compound is made up of two parts (a). chromophores and (b). auxochromes. Chromophores are unsaturated groups responsible for imparting color. There are two type of chromophore (1).Independent chromophore and (2).Dependent chromophore. In acetone as well as biacetyl, dependent chromophore (-C=O-) is present and according to Witt, more than one dependant chromophores are required to impart colour to a compound. In the first compound (acetone) there is one carbonyl group, which is dependent, and hence it is colourless, whereas in biacetyl there are two carbonyl groups keeping proximity and hence biacetyl is Yellow in colour.

Q-2: Explain why Benzene is colourless, nitrobenzene is pale yellow and P-nitro aniline is dark yellow.

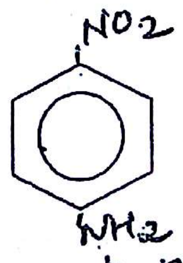
Ans: The Structures of these are given as below.



Benzene



Nitrobenzene



p-nitroaniline

According to Witt's theory, there exists relation between color and chemical structure of a compound. Further a colored compound is made up of two parts (a). chromophores and (b). auxochromes. Chromophores are unsaturated groups responsible for imparting color. Auxochromes increases intensity of colour when present along with chromophores.