

Ferrous and nonferrous metals, inorganic and organic non metals

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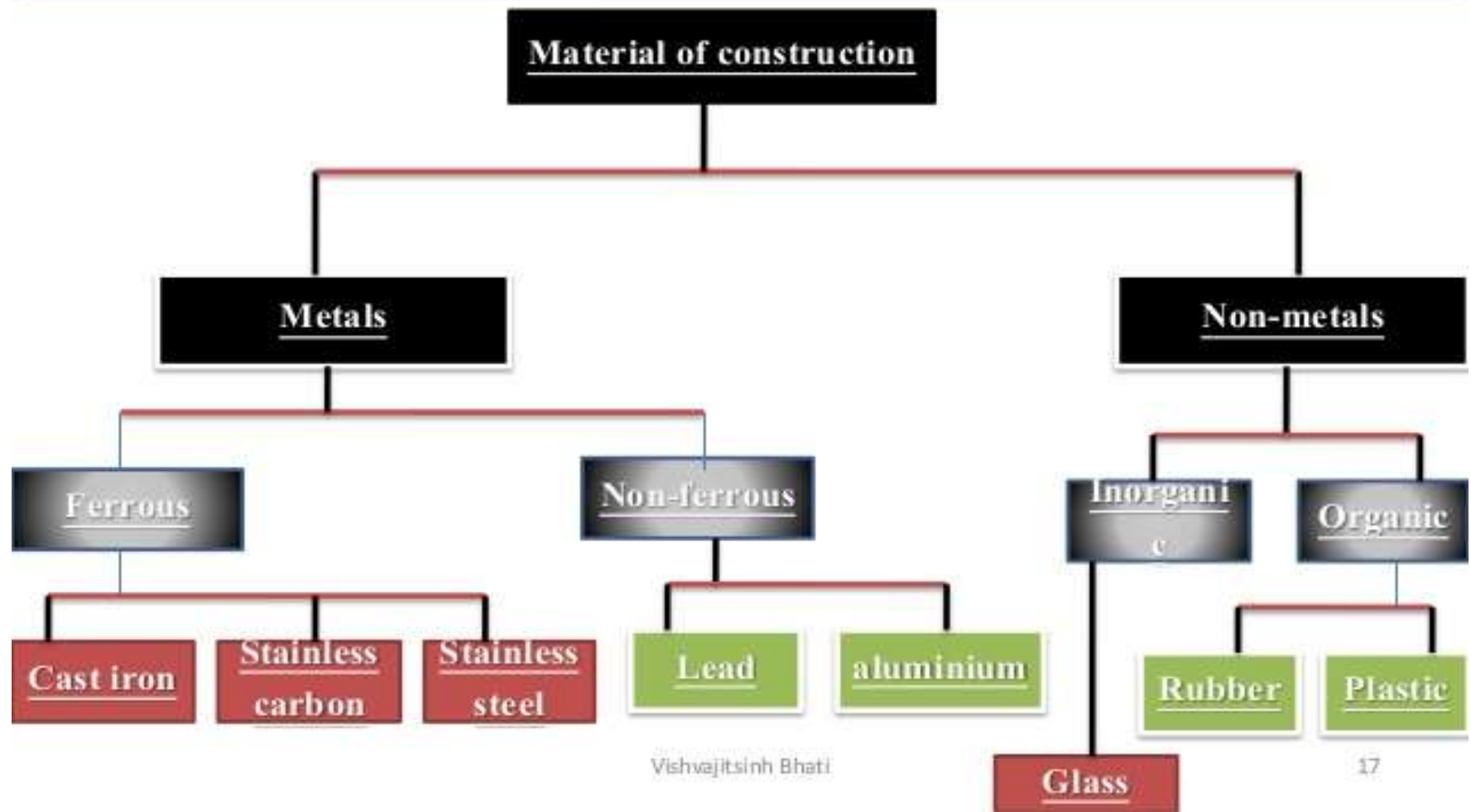
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Classification of Materials for Plant Construction



Ferrous Metals

- Iron metal is one of the widely used materials for the construction of plants because of its mechanical strength, abundant availability and lower cost.
- Some varieties of iron are discussed here,
 1. Cast iron
 2. Steel carbon
 3. Stainless steel

Cast Iron

- Consists : **Fe + carbon** (1.7+5.0%) + **silicone** (Si) + **manganese** (Mn)
- Its property is depend on the amount of carbon present in it.
- Cast iron is abundantly available, inexpensive and widely used.
- There is two type of cast iron.
 - 1) White cast iron
 - 2) Grey cast iron

- 1) White cast iron: upon fracture it gives a white surface.
 - it contains the carbon in the form of the cementite, and is produced by rapid cooling.
 - It is malleable. It is very abrasive and wear resistance. It is used as liner, for grinding balls, dies and pumps impellers.

- 2) Grey cast iron: it consists less cementite, its carbon occurs in the form of graphite.
 - Grey cast iron is much less hard and brittle than white cast iron.
 - Low in cost and easy to cast

- It has outstanding ability to absorb vibration and wear resistance.
- Uses:
 - Supports for plants
 - Jackets of steam pans
 - Linings with enamel, plastic or suitable protective material.
 - 14% addition of silicon in cast iron a hard and brittle casting alloys is formed, which is resistance to attack by HNO_3 or H_2SO_4 .

- **Advantage:**

- Cheap, it is used in place of expensive plant material with coatings or linings of enamel or plastic.
- It is resistance to conc. H_2SO_4 , nitric acid and dil. Alkalis.
- Since cast iron has thermal conductivity, it is used for the construction of outer surface of jackets of steam pans.

- **Disadvantage:**

- Cast iron is very hard and brittle.
- Cast iron is attacked by dil. H_2SO_4 , dil. nitric acid, and as well as conc. HCL acid.
- Since cast iron has low thermal conductivity, it can't be used for heat transfer in stills.

Carbon Steel or Mild Steel

- Carbon steel is iron alloy, which contains only a small percentage of carbon.
- Variants of carbon steel:- the property of carbon steel can be altered by alloying it with other metals and their properties are...
 - Nickel (Ni):- improves toughness, corrosion resistance and low temperature to oxidation.
 - Chromium (Cr):- increase hardness, more abrasive resistance to oxidation.
 - Silicon (Si):- increases hardness, more abrasive resistance to oxidation
 - Molybdenum (Mb):- provides strength at elevated temp.

- **Uses:**

- Construction of bars, pipes and plates.
- Storage tanks for water, H_2SO_4 , HCL and organic solvent, etc..
- Supporting structure such as grinders and bases for plant vessels.

- **Advantages:**

- Cheapest, therefore it is preferred.
- weldable and frequently used in fabrication.

- **Disadvantages:**

- Limited resistance to corrosion
- Its react with caustic soda, brine water and sea-water.

Stainless Steel

- There are more than 70 standard types of steel.
- S.S-302 Contains – Fe + Cr (18%) + Ni (8%) + C (0.08%)
- S.S-304 Contains – Fe + Cr (19%) + Ni (9%) + C (0.08%)
- The abundant use of S.S is due to the properties such as:
 - Heat resistance
 - Corrosion resistance
 - Ease of fabrication
 - Cleaning and sterilisation
 - Tensile strength

- Depending on the composition, S.S alloys are available in three groups, viz., martensitic, ferritic and austenitic.

<u>Composition</u>	<u>Advantage</u>	<u>Disadvantage</u>	<u>Uses</u>
Martensitic : Chromium 12-20% Carbon 0.2- 0.4% Nickel up to 2.0%	Mildly corrosion resistance, atmospheric & organic exposures.	Ductility is poor	Sinks, bench tops, storage tanks, buckets, mixing elements etc..
Ferritic (α - form) Chromium: 15-30% Carbon: 0.1% Nickel: -	Better corrosion resistance, easy to machine, resistant to oxidation and temp.(upto-800°C)	Not good against reducing agents , HCL	Tower linings, baffles, separator, tower, heat exchanger, tubings, condensers, furnace parts, pumps shafts, valve parts.
Austenitic (γ -forms) Chromium: 13-20% Nickel: 6-22% Carbon: 0.1%<0.25%	Highly corrosion resistant, readily cleaned, sterilizable, ease to weld, non-magnetic	Not easy to machine	Fermentors, storage vessels, evaporators, extraction vessels, small apparatus.

Non-Ferrous Metals

- Copper
- Copper alloys
- Aluminium
- Lead
- Titanium
- Tin
- Silver
- Nickel
- Chromium
- Zirconium
- Tantalum
- Platinum

- But here widely Aluminium, copper and lead is used.

• Aluminium •

- A number of 'Al' items are use in regular day to day life.
- Resone is :-
 - Cheap
 - Light in weight
 - Mechanical strength
 - Easily fabricated
 - Maintenance & cleaning is also easy.

- Aluminium alloys and modifications:-
 - A number of ‘Al’ alloys are available with improved qualities and mechanical properties.
 - ‘Al’ alloys are used in the construction of equipment producing medicinal substance, since aluminium does not affect the salts
 - Aluminium is non-toxic to microorganisms.
 - it has considerable use in biosynthetic process such as the production of citric acid gluconic acid and streptomycin by deep culture method.
 - It is most useful for the construction of containers namely drums, barrels, rail tankers etc...

- **Advantages:**

- High resistance to atmospheric conditions, industrial fumes, vapor and fresh or salts waters. ‘Al’ can be used with conc. HNO_3 acid and acetic acid.
- Thermal conductivity of ‘Al’ is 60% that of pure copper.

- **Disadvantages:**

- The mechanical strength decreases greatly above 150°C .
- Al can’t be used with strong caustic solution.
- Many mineral acids attack aluminium.
- Oxide and hydro-oxide film is thickened by chemical and electrolytic means. These provide so called anodized finishes.

Copper & Copper Alloys

- Properties of copper & Copper alloys
 - It is malleable and ductility, so easily fabricated.
 - It has high electrical and thermal conductivity.
 - It can be hammered, welded, brazed and soldered, but dose not cast well.
 - It is readily formed into tubes and pans.
 - Surface polish is high so it is easy to clean, so good heat transfer surfaces.
 - It resists non-oxidizing agent well.
 - HNO_3 attacks copper readily

- Caustic alkali solution dissolve copper appreciably.
- It attacked by hot conc. HCL, H_2SO_4 And ammonia.
- Many drugs constituents react with it, and for this reason copper is usually protected by a lining of Tin.
- **Applications:**
 - It is used for evaporator, pans, stills, fractionating columns.
 - For piping of cold water, gas, vacuums and low pressure steam.
 - It is widely used for organics and brewing and food industries.

Copper Alloys

- This alloys include with Zn, Al, Si, Ni, Tin etc..
- 1. Copper zinc alloys [**BRASSES**]
 - Their corrosion resistance is less than that of copper so has limited application in pharma. Plants.
 - They are easily worked and their tensile strength is greater than COPPER.
- **Uses**: prepare tubes, valves, nuts, bolts and rods.
- 2. Copper-Tin alloys [**BRONZES**]
 - 2-13% of tin with small quantity of phosphorous and traces of other elements, harder than brass.
- **Uses**: filter gauzes stirrers, valves, pumps, high pressure pipes, special tablet punches and dies.

Lead

- Lead has the lowest cost and is used as collapsible tube material particularly for non-food products such as adhesive, inks, paints and lubes.,
- Lead tubes with internal linings are sometimes used for fluoride tooth-paste.
- Lead chamber process is used in the manufacture of H_2SO_4 .
- **Disadvantage:**
 - Lead has low melting point and hence possesses poor structural qualities.
 - It has high coefficient of expansion. So, temp. strain result in permanent deformation.

- Lead is little used in pharmaceutical practice , because of the risk of contamination even in traces produces toxicity and of cumulative nature.
- **Uses:**
 - It is used in chemical industries.
 - Construction of cold water pipes, waste pipes and dilution tanks for laboratories.
- Lead alloys and modification:-
 - Silver and copper
 - Improvement corrosion resistance
 - Improvement creep and fatigue resistance.
 - Antimony, Tin, Arsenic:-
 - Hardness, still melting point is low.

NON METALS - Inorganic

- GLASS :- a number of glass article are use in daily life. Glass has the advantage of superior protective qualities, attractiveness and low cost.
- It is chemically inert to a large range extent and available in variety of sizes, shape and color.
- Glass containers practically offer excellent barrier against every element except light.
- UV rays and sunlight are harmful to certain ingredients and bring about chemical deterioration.
- Protective action against light can be achieved by amber-colored glass.

- Protection against IR rays can be obtained by using green glass.
- The disadvantages are its fragility and weight.
- Glass is considered as super-cooled, through it is seen in solid state. The constituents are present in amorphous state.
- Glass is composed of the following constituents...
 - Sand – silica pure(SiO_2) – based material
 - Soda ash – sodium carbonate(Na_2CO_3) – improves the properties
 - Lime stone – calcium carbonate(CaCO_3) – improves the properties
 - Cullet – broken glass – fusion agents
- Some varieties of glasses are given in table

No	Type	Composition	Remarks ³⁸	Application
1	Type-1 (Borosilicate Or natural or Pyrex)	SiO ₂ – 80% Al ₂ O ₃ – U.W% Na ₂ O – 7% K ₂ O – 0.5% B ₂ O ₃ - 12% CaO – 1%	-Heat resistant -Chemically inert than soda- lime glass -High hydrolytic resistance -Leaching of NaOH only 0.5PPM per yr -Difficult to melt and mould -Very costly	-Chemical glass ware -Ovenware -Container for alkali sensitive preparation
2	Type-2 Treated soda lime glass (soda-glass with surface treatment, sulphured containers)	SiO ₂ – 75% Al ₂ O ₃ – 2% Na ₂ O – 0-10% K ₂ O – 0-0.5% B ₂ O ₃ - 3% CaO – 10%	-High hydrolytic resistance due to surface treatment -Softer than borosilicate easy to mould -Cheaper than borosilicate	-Containers for Alkali sensitive preparations -For food blood, plasma and infusion fluids -Parental -Used once only.

No	Type	Composition	Remarks	Application
3	Type – 3 Soda-lime glass ordinary glass	SiO_2 – 75% Al_2O_3 – 2% Na_2O – 15% K_2O – 0-0.5% B_2O_3 - 3% CaO – 12%	-Moderated hydrolytic resistance -Easy to mould -Yield alkali to water -Flakes separate out -Loss of brilliance -Cheapest	-Medicated bottle -Only for non-aqueous liquid preparation -For powders for injection -Not for alkali sensitive products -Not for Parental -Used once only
4	Type-NP (Non-Parental)	-	- General purpose soda-lime glass	- Use for oral and topical preparation

No	Type	Composition	Remarks	Application
5	Colored glass	- In addition of glass composition metal salts are added carbon and sulphur OR iron and manganese for Amber color.	- Do not allow the U.V rays to pass through.	-Used for sunlight sensitive product -Do not use for parenterals unless specified
6	Lead free glass	-	- As lead monoxide is used in manufacturing of glass causes lead poisoning	-Used for liquid preparation -Used when preparation-ment for lead poisoning e.g. Na. E.D.T.A.
7	Silicone treated	- Surface is treated with dimethyl siloxane	- As hydrophobic in nature do not wetted so product do not cling to surface	-

Glassed Steel

- Glassed steel is an organic product of fusion, which is cooled to a rigid condition without crystallizing.
- It requires special consideration in its design and use.
- These surface are applied to heavy vessels.
- Normally, several coating are fused in furnace, glassed steel combines the corrosion resistance of glass with the working strength of steel.
- Uses:- glass lined steel is used for strong acid, alkalis and saline solutions. For small-scale manufacture and pilot plant work, glassed steel vessels are used.

- Advantages:-

- It has excellent resistance to all acids except hydrofluoric acid and hot conc. H_2SO_4 .
- It can be attacked by hot Alkaline solution. Particularly suitable for piping when transparency is desirable.
- It is brittle and gets damaged by thermal shock. Hence it is protected using glass lined with epoxy polyester fiber glass.

- Glass lining are resistant to

- All conc. Of HCl acids up to $120^\circ C$.
- Dil. Conc. Of H_2SO_4 up to the boiling point.
- All conc. Of HNO_3 up to boiling point.
- Acid resistance glass with improved alkali resistance (up to pH 12).

NON METALS - Organic

- Mainly 2 material are widely used in plant construction of this group...
 1. Rubber
 2. Plastic
- Other is...
 - Wood/Timber
 - Carbon/Graphite
 - Silica ware

RUBBER

- Rubber is used as such or as lining material for the construction of plant. Both natural and synthetic rubber are used.
- **Types of RUBBER..**
 - I. Natural rubber
 - II. Soft rubber
 - III. Hard rubber
 - IV. Synthetic rubber
 - a. Neoprene
 - b. Nitrile rubber
 - c. Butyl rubber
 - d. Silicon rubber
 - e. polyisoprene

Ideal Quality of Rubber for Closure

1. Softness and elasticity
2. Impermeable to air and moisture
3. Provide air tight closing
4. Compatible with product
5. Do not migrate any additive to the preparation
6. Negligible extraction of preparation ingredients
7. Withstand sterilization temp.
8. Good ageing qualities
9. Oil resisting for oily preparation
10. Do not yield any fragments.

Natural Rubber

- :- natural rubber is a naturally occurring polymer, which is obtain as latex from rubber tree.
- It is common example of an elastomer.
- Elastomer is a substance that can be stretched readily and when released, rapidly regains its original form.

Soft Rubber

- the naturally occurring polymer is known as *soft rubber*.
- it is a polymer of monomeric isoprene (C_5H_8).
- its **advantage** is resistant to dilute mineral acids, dil. Alkali and salts.

- It **disadvantage** is that soft rubber can be attacked by oxidizing media, oils and organic solvents.
- **Uses**:- lining materials for plants, as it can bond easily to the steel.
- After addition of carbon black to the soft rubber gives hardened rubber. It is used for making tyres, tubes and conveyor belts.

Hard Rubber

- when soft rubber is mixed with sulphur, warmed and set into a given shape, it retains its form. The sulphur combines with the polymeric chains of rubber and cross-links between them. This process is called vulcanization.
- Soft rubber with **25%** or more sulphure is known as hard rubber.

- Its **advantages** is hardness and strength.
- **Uses:-** for making gloves, bands, tubes and stoppers.

Synthetic Rubber

- Synthetic rubber has taken greater importance over natural rubber due to its superiority in properties such as resistance to oxidation, solvents, oils and other chemicals.
- Here some type of synthetic rubber are describe in table..

Sr. no	Synthetic rubber	Properties	uses
1.	Neoprene (Polychloro-prene)	<ul style="list-style-type: none"> •Dose not burn readily like natural rubber •Stable at high temp. 	<ul style="list-style-type: none"> •Insulating material in electric cables, conveyor belts in coal mines, making hoses in the transportation of oils. Rubber stoppers, cap-lines, dropper assemblies for eye drops etc.
2.	Nitrile rubber	<ul style="list-style-type: none"> •Resistance to oil and solvents. 	-
3.	Butyl rubber	<ul style="list-style-type: none"> •Resistance to.. - minerals acids & alkali - conc. acids 	<ul style="list-style-type: none"> •Used for closures of freeze dried product containers bcoz of its low water vapor permeability.

Sr. no	Synthetic rubber	Properties	uses
4.	Silicon rubber (Poly-siloxanes)	<ul style="list-style-type: none"> •Resistant to.. - high and low temp. - attack to aliphatic solvents, oils and greases. 	-
5.	Polysoprene	<ul style="list-style-type: none"> •Stable at high temp., translucent, flexible. 	-

- Synthetic rubber is thermoplastic, but when mixed with sulphur, warmed and set into a given shape, it retains its form.
- Vulcanization of rubber is possible. It is used for making gloves, bands and tubes, caps for vials.

- Rubber is soft material, but can be hardened by adding carbon black.
- Hardened rubber is **used** for making tubes, tyres and conveyor belts.

PLASTIC

- Plastic is use in various way, and It is cheap and light in weight so it is easily transpiration is easy.
- These available in variety of shapes implying that it can be easily fabricated.
- Plastic material is used for storing a number of substance such as inorganic salts and weak mineral acids.

- in machines, plastic material are preferred whenever moving parts are present indicating that it offers less friction.
- These have better resistance to environmental factors, in similar manner, plastic materials also used in the construction of plants.
- Plastic are synthetic resins contain long chains of atoms linked to form giant macromolecules. They have molecular weight. (10^3 to 10^7).
- Generally **Advantages** of PLASTIC.
 - I. Low thermal and electrical resistance
 - II. Excellent resistance to weak mineral acids.
 - III. Unaffected by inorganic salts.
 - IV. Resistance to slight changes in pH.

- Plastic have **disadvantage** like that....

- I. Low thermal and electrical strength.
- II. High expansion rates.

➤ Basically, two type of plastic are used in pharma. Industry.

1) **Thermosetting** plastic

- Its can be formed under heat and pressure but these can't be softened or remolded, once hardened.
- Some are made from Phenolic and Urea resins.

2) **Thermoplastic** plastic

- Its also made up from heat and pressure but these are softened and remolded. This is a specific advantage.

- Some thermoplastic materials and their **uses** are given below..
 - Polyethylene - cables, buckets, pipes
 - Polypropylene – milk cartons, ropes
 - Polyvinyl chloride – gloves, water proof garments
 - Teflon – gaskets, coatings
- Based on the utility of plastic in plant construction, these can be categorized as:
 - I. Rigid materials
 - II. Flexible material
 - III. Metallic material
 - IV. Plastic cements
 - V. Special case plastic

Rigid Materials

- These are phenolic resins with various inert fillers. These are used in the fabrication of a number of items. For e.g. kibosh is a rigid material and used for gears, bearing etc..It is light in weight. Some of its application are... pumps, ducts, fittings, etc..
- **Disadvantage** :- these are resistant to corrosion except oxidizing substance and strong alkalis.

Flexible Materials

- These material is can be rigid or flexible depending upon the amount of plasticizer added. **Used** in fabrication..tanks, buckets, funnels, pipes..

Metallic Surfaces

- Plastic of polyethylene or polyvinyl chloride type are used along with plasticizer for the coating of metallic surfaces.
- These are used in the protect the metal from corrosion. And it applied on tanks, vessels, stirrers, fans.

Plastic Cements

- Used in spaces btwn acid resistance tiles and bricks.

Special Cases

- Used as guards for moving parts of machinery. Nylon and PVC are use for aseptic screening.

- we discuss types of thermoplastic..

1. Polyolefin's

- a) Low density polyethylene [LDP]
- b) High density polyethylene [HDP]
- c) Poly propylene [PP]

2. Polystyrene

3. Polyvinyl chloride [PVC]

- a) Plasticized
- b) Unplasticized

4. Polycarbonate

5. Polymethyl - methacrylate [PMMA]

6. Poly amides [NYLONS]

7. Polytetrafluoro Ethylene [PTEE]

Overall plastics is used as:

- Containers for transfusion solution and retention enemas.
- Containers for Eye and Ear drops, nasal sprays.
- Eye ointment tubes.
- Spray bottles – squeeze bottle.
- Suppositories pack.
- Flexible packing.
- Bottles, jars and closures.

Advantages of Plastics

- Unbreakable, tough, flexible, durable.
- Light in weight and easily transported.
- Molded into various shapes and sizes.
- Cheaper.
- Readily and easily manufactured on large scale.
- Pleasant to touch.
- Suck-back feature.
- Odorless.
- Good chemical resistance.

Disadvantages of plastics

- Poor conductor of heat – for heat sterilization.
- Attacked by organic solvents and oils.
- Plastic contains – antioxidant, plasticizer and stabilizer – these substance can be leached to product preparation.
- Chemical binding adsorption of ingredients [Drugs +Additives] of product with chemicals of plastic so loss of....

– Preservatives

– Antioxidants

– Flavors

.. and hence loss of stability of product.

- Permeability of moisture and gases CO_2, O_2 , known as breathing.
- Chemical reaction of products ingredients with plastic ingredients.
- Alternation of physical properties of plastic or products.

Drug-Plastic Consideration

In selecting a plastic container consideration must be given to..

- Composition of material
- Its mechanical and chemical properties.
- Its ease of fabrication and printability.
- Requirement of rigidly or flexibility.
- Acceptance of plastic ingredients by F.D.C.

Depending on the type of plastic, the total constituents may include the following..

- Basic polymer
- Residual monomers
- Plasticizers
- Accelerators
- Slip or antislip additives
- U.V. absorbers
- Modifiers
- Stabilizers
- Filters
- Lubricants
- Antioxidants

- A packaging system must protect the drug without in any way alternating the composition of the product until the last dose is removed.
- Drug-plastic consideration have been divided into five separate categories.
 1. Permeation
 2. Leaching
 3. Sorption
 4. Chemical reaction
 5. Alternation in the physical properties of plastic or products