15CH210 Chemical Process Technology

Unit 5b - Synthetic Organic Chemicals (Plastics and Fibers – Polymers)

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Methanol (CH_3OH)

Methanol, also known as methyl alcohol, wood alcohol, wood naphtha or wood spirits, is a chemical with formula CH_3OH (often abbreviated MeOH).

It is the simplest alcohol, and is a light, volatile, colorless, flammable, liquid with a distinctive odor that is very similar to but slightly sweeter than ethanol (drinking alcohol).

Raw materials

- Synthesis gas (Starting material)
- $KMNO_4$ – removes the traces of ketones, aldehydes and other impurities
- Steam

Methods of production

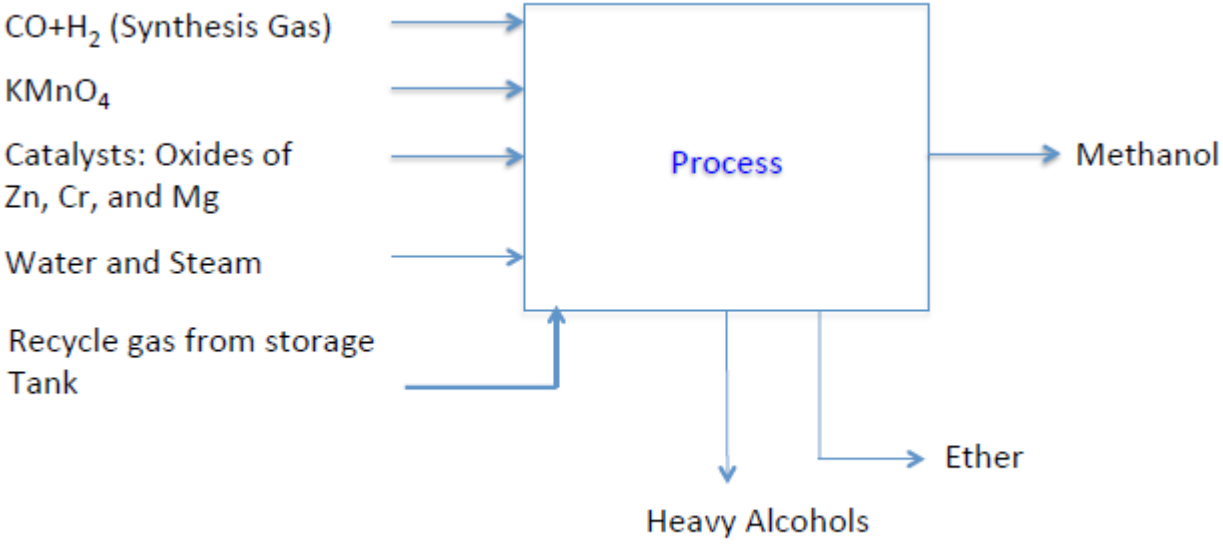
- Catalytic hydrogenation of carbon monoxide (Synthesis gas)
- Oxidation of LPG (Propane and Butane)

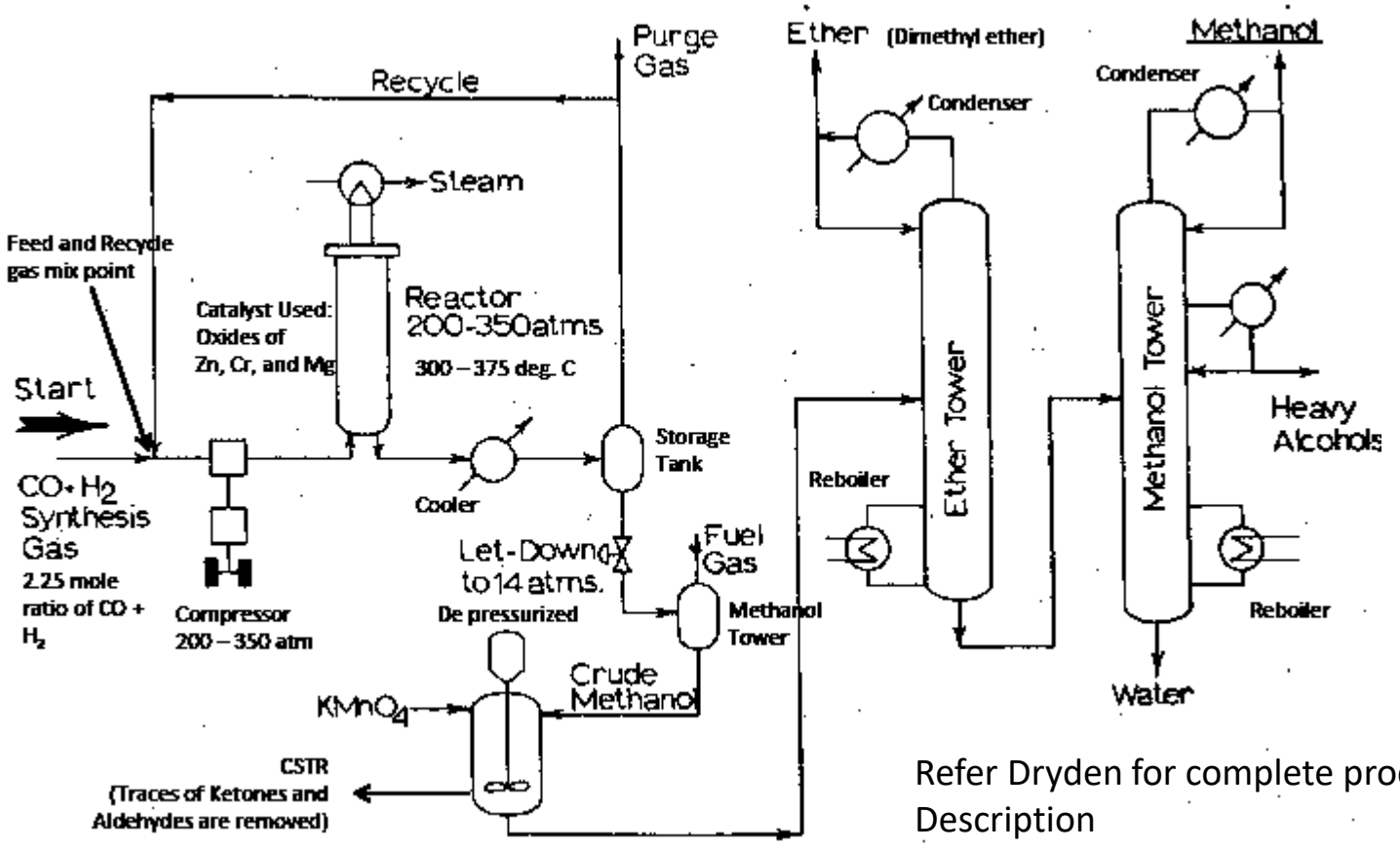
Chemical Reactions (exothermic)

Main reaction : $CO + 2H_2 \longrightarrow CH_3OH$; ΔH = -26.4 kcal

Side reaction : $CO + 3H_2 \longrightarrow CH_4 + H_2O$; ΔH = -50.0 kcal

$2CO + 2H_2 \longrightarrow CH_4 + CO_2$; ΔH = -60.3 kcal


CO+H2 (Synthesis Gas)
KMnO4
Catalysts: Oxides of Zn, Cr, and Mg
Water and Steam
Recycle gas from storage Tank
Process
Methanol
Ether
Heavy Alcohols



Refer Dryden for complete process Description

Uses of Methanol

- Used to manufacture formaldehyde
- Used as solvent in laboratories
- Used to manufacture silicones (Methyl chloride)
- Used in the fuel cells
- Used as an anti-freezing agent in pipelines

Formaldehyde (HCHO or CH_2O)

Formaldehyde is a colorless gas with a characteristic pungent odor.

It is an important precursor to many other chemical compounds, especially for polymers.

Raw materials

- Methanol
- Air
- Water

Methods of production

- Catalytic oxidation and dehydrogenation of methanol
- Oxidation of Methane or LPG (Propane and Butane)
- Pyrolysis

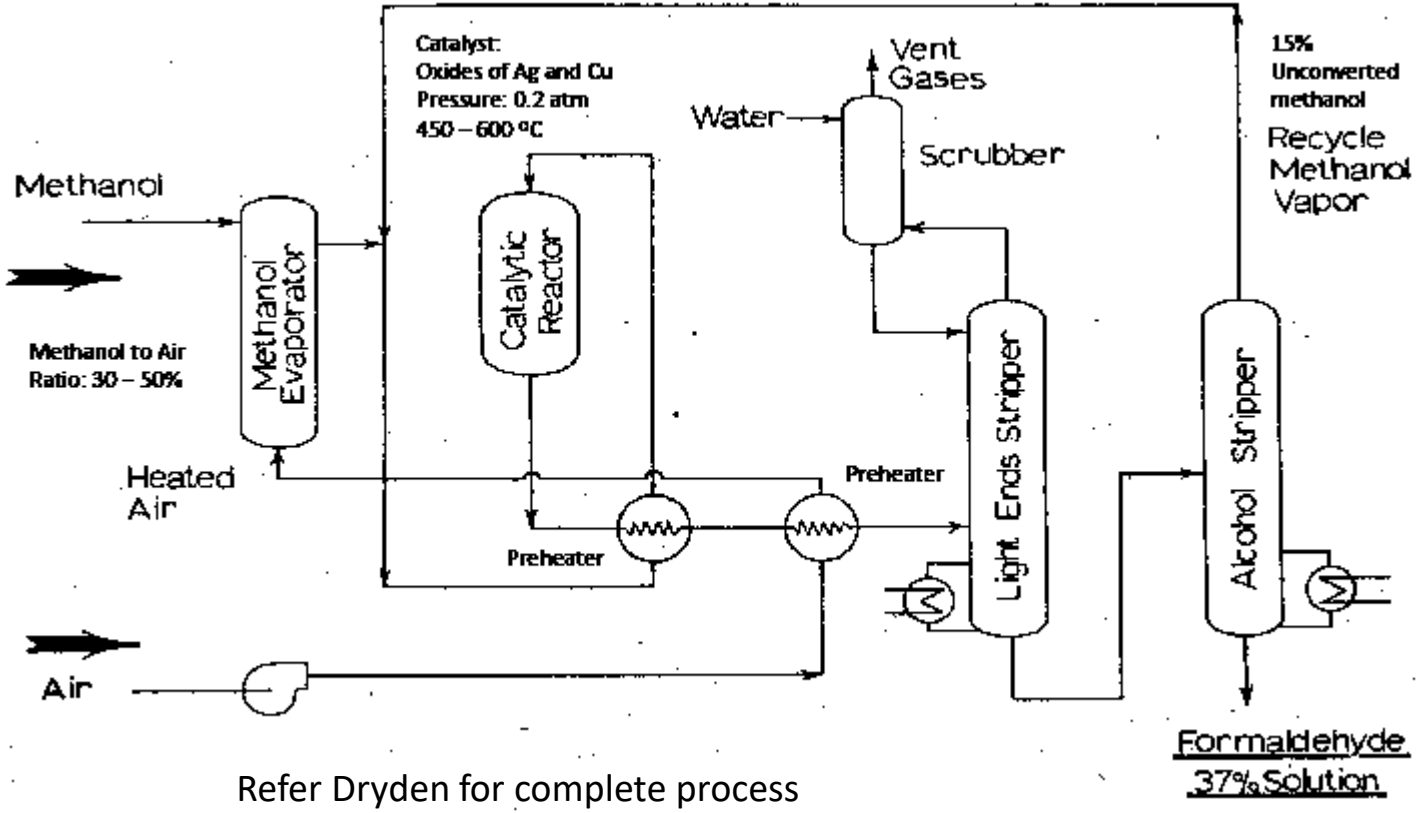
Chemical Reactions (Exothermic oxidation and Endothermic dehydrogenation)

Oxidation : $CH_3OH + \frac{1}{2} O_2 \longrightarrow HCHO + H_2O$; $\Delta H = -37.4$ kcal

Methanol + Oxygen ⟶ Formaldehyde + Water

Dehydrogenation : $CH_3OH \longrightarrow HCHO + H_2$; $\Delta H = +50.0$ kcal

Methanol ⟶ Formaldehyde + Hydrogen



Refer Dryden for complete process Description

Uses of Formaldehyde

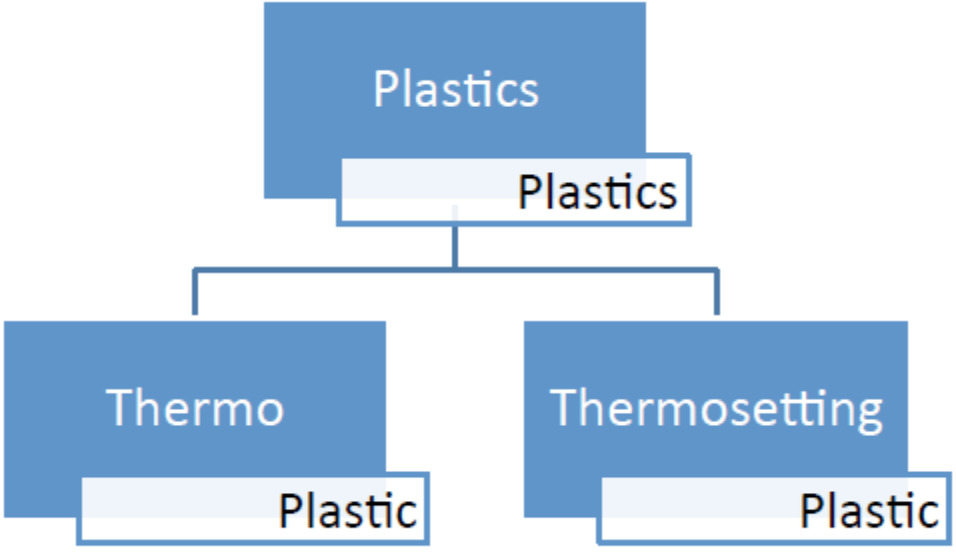
Used to manufacture phenolic resins

Used to manufacture urea

Used to manufacture melamine resins

Plastic

A **plastic** may be defined as material that contains a polymerized organic substance of large molecular weight as an essential ingredient, is solid in its finished state, and at some stage in its manufacture or its processing into finished articles can be shaped by flow.


Plastics
Plastics
Thermo
Plastic
Thermosetting
Plastic

Thermoplastic

Synthetic resins formed by addition polymerization are thermoplastic (heating softens and cooling hardens).

Thermosetting

Synthetic resins formed by condensation polymerization are thermosetting (heat curing produces an infusible or insoluble product).

Finar IL, Organic Chemistry Vol. 1 6th Edition Pearson Education 2009 pp.116-117

Thermo plastics	Thermosetting plastics
Linear polymers which are soluble in many organic solvents	Three-dimensional polymers which are insoluble in any kind of solvent
The process of heat-softening, molding and cooling can be repeated as often as desired and hardly affects of the properties of plastics.	Heat treated only once before their formation, after which heating results in chemical decomposition, and hence they cannot be "reworked".
e.g. Cellulose acetate, nitrocellulose and vinyl polymers such as polyethylene and prespex etc.,	e.g. Phenol formaldehyde, urea formaldehyde, melamine formaldehyde, silicones etc.,

Finar IL, Organic Chemistry Vol. 1 6th Edition Pearson Education 2009 pp.116-117

Polymerization (Simple molecules reacts together to form polymer)

Polymerization is carried out with the objective of building up compounds with predicted properties and since the properties of a plastic depend on the degree of polymerization it is necessary to stop the polymerization when the desired average molecular weight is reached.

This may be done by various means e.g variation of concentration of the catalyst. The average molecular weight of plastics varies from about 20,000 (e.g nylon) to several hundred thousand (e.g. Polyvinyl Chlorides 2, 50, 000).

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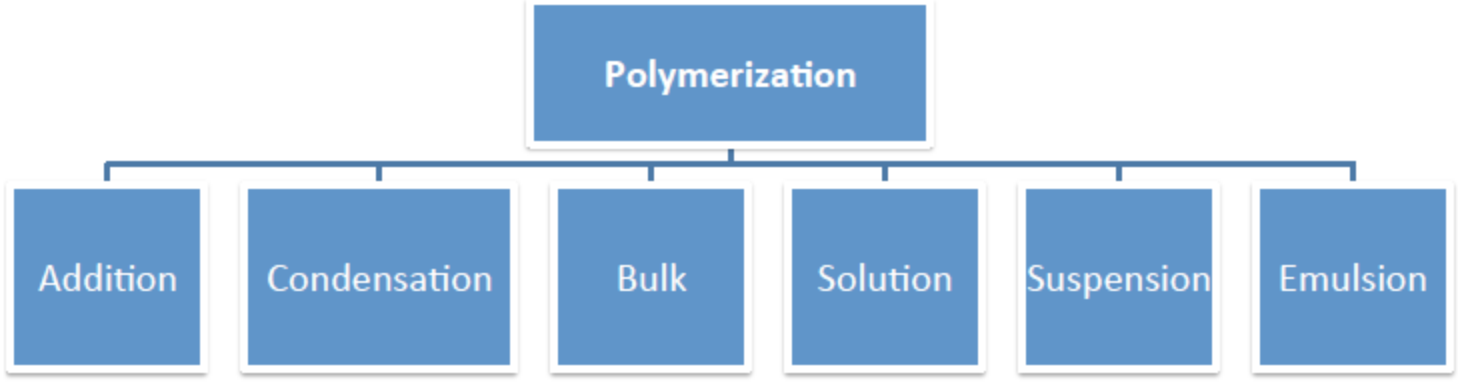
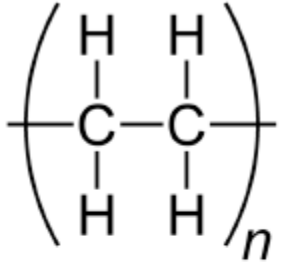

Polymerization
Addition
Condensation
Bulk
Solution
Suspension
Emulsion

Raw materials used

Ethylene(C_2H_4)
Water
Peroxide catalyst

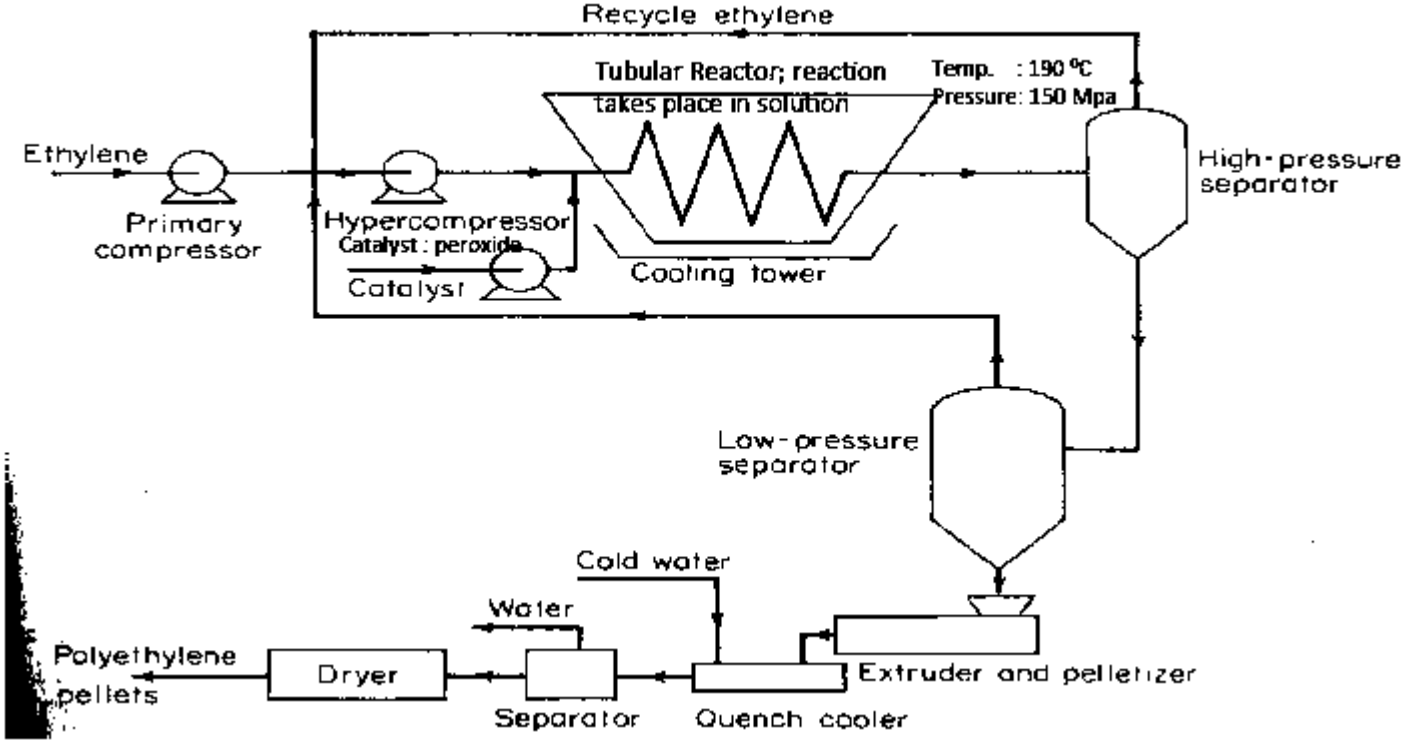
Polyethylene Structure



Methods of production

Low Density Polyethylene (LDPE) by high pressure processing

Low Density Polyethylene (LDPE) by low pressure processing



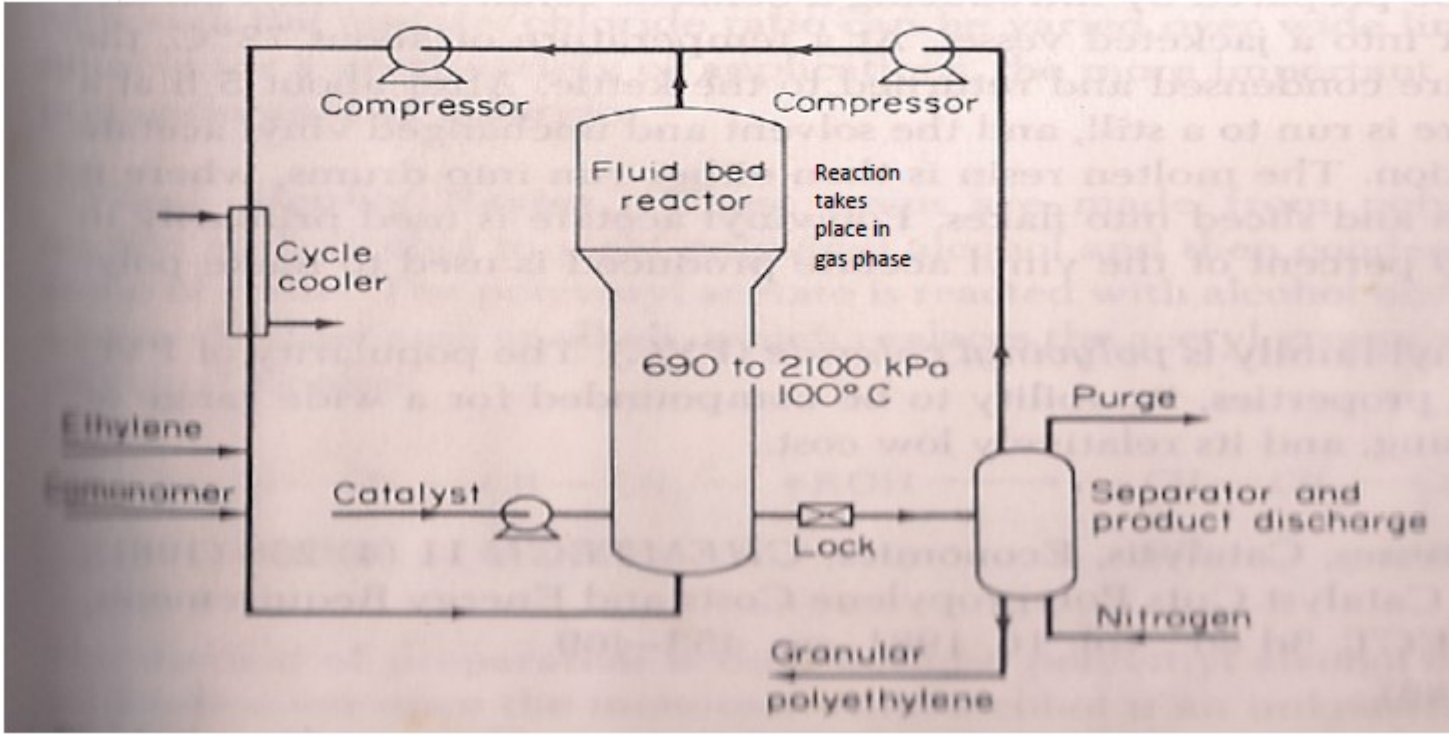
Ref: Shreve's *Chemical Process Industries* for detailed process description

Raw materials used

Ethylene(C_2H_4)
1- butene (copolymer)
Water
Nitrogen used for purging

Methods of production

Low Density Polyethylene (LDPE) by low pressure processing



Ref: Shreve's *Chemical Process Industries* for detailed process description

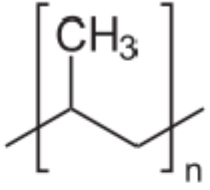
Polyethylene

1. House wares
2. Medical equipment's
3. Electronic components
4. Toys
5. Automobile parts and appliances

Raw materials used

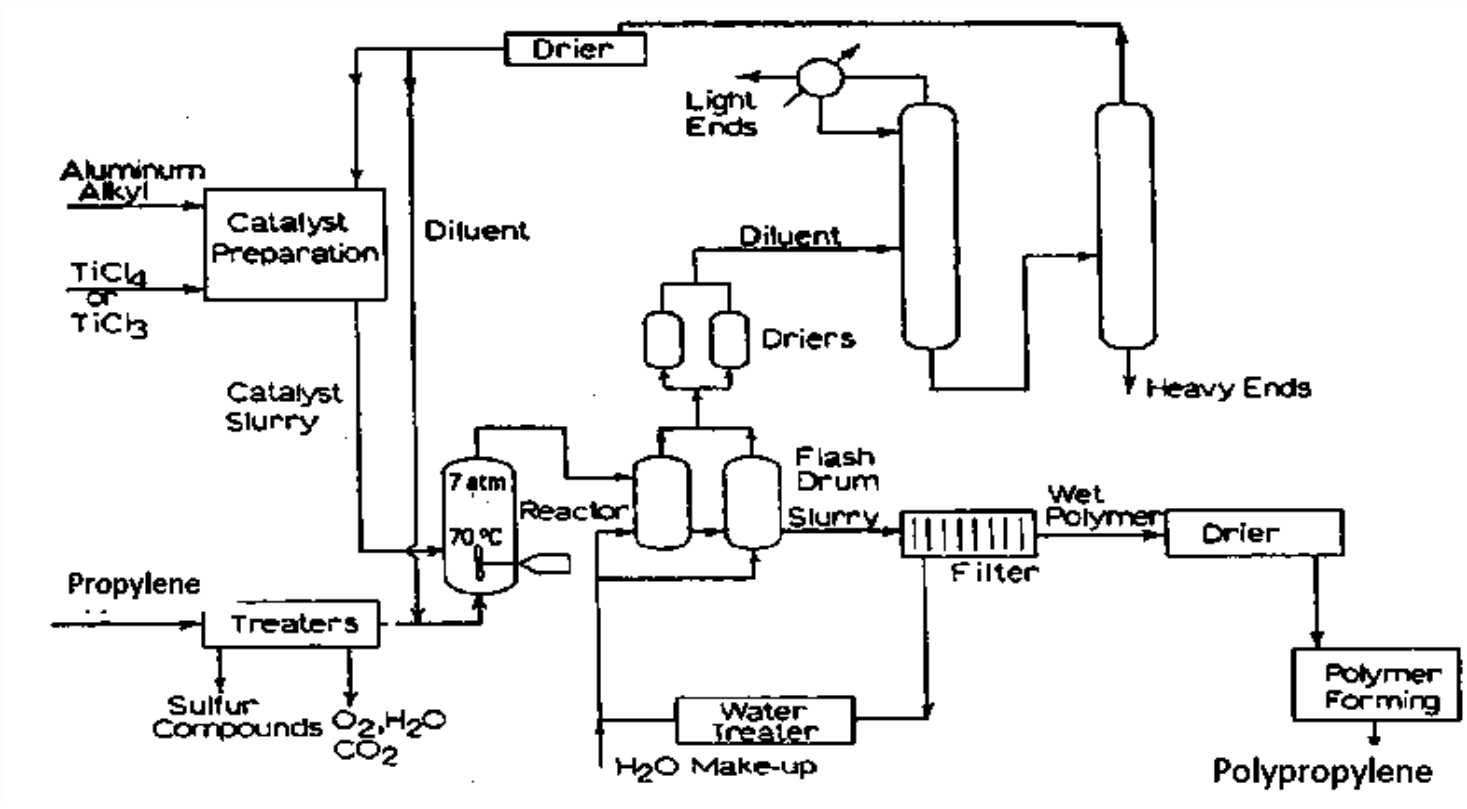
Propylene(C_3H_6)
Water
Aluminum chloride and
Titanium chloride catalyst

Structure of polypropylene



Methods of production

Polypropylene by low pressure process (Ziegler Process)



Refer *Dryden's Outlines of Chemical Technology* for detailed process description

Polypropylene

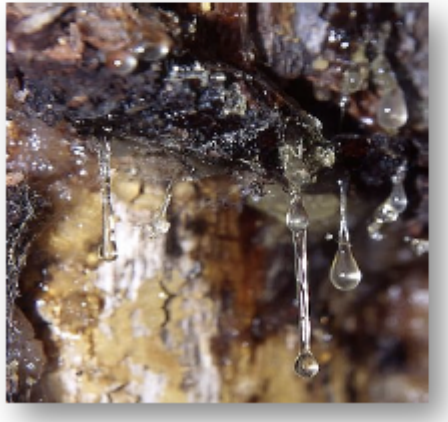
1. Very thin sheets of polypropylene are used as a dielectric within certain high-performance pulse and low-loss RF capacitors.
2. Polypropylene is used in the manufacturing piping systems; both ones concerned with high-purity and ones designed for strength and rigidity (eg. those intended for use in potable plumbing, heating and cooling, and reclaimed water).
3. Used in manufacturing carpets, rugs and mats to be used at home.

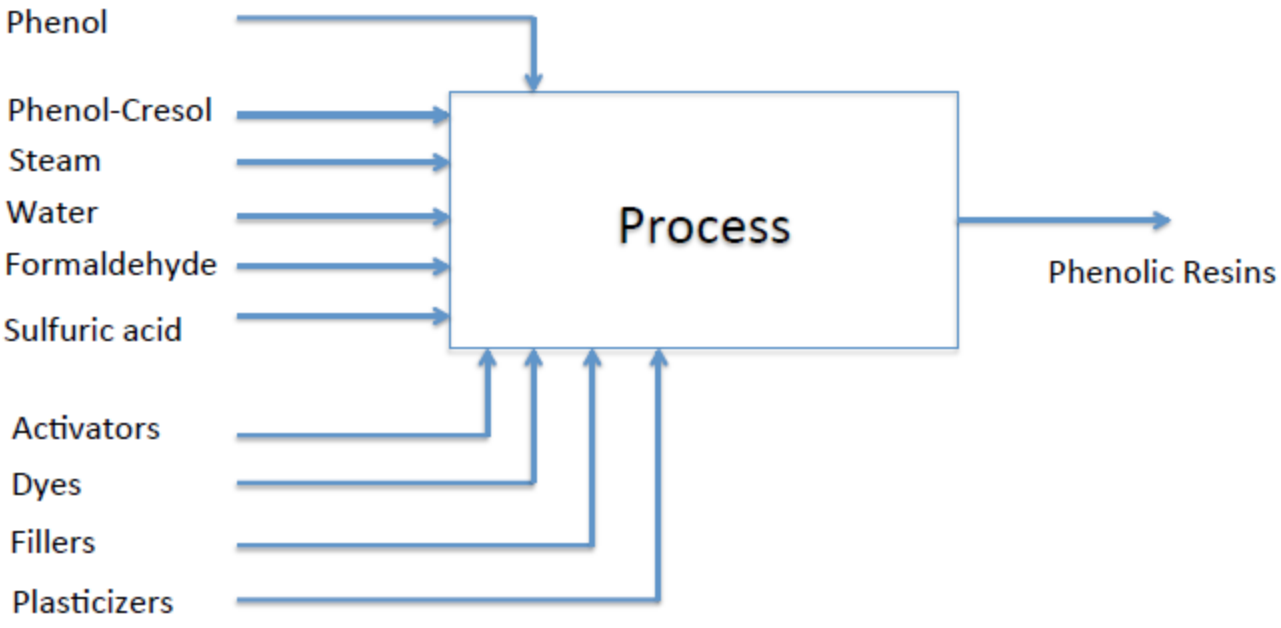
Resin is also hydrocarbon secretion of many plants, particularly coniferous trees. It is valued for its chemical properties and associated uses, such as the production of varnishes, adhesives, and food glazing agents; as an important source of raw materials for organic synthesis.

Resins

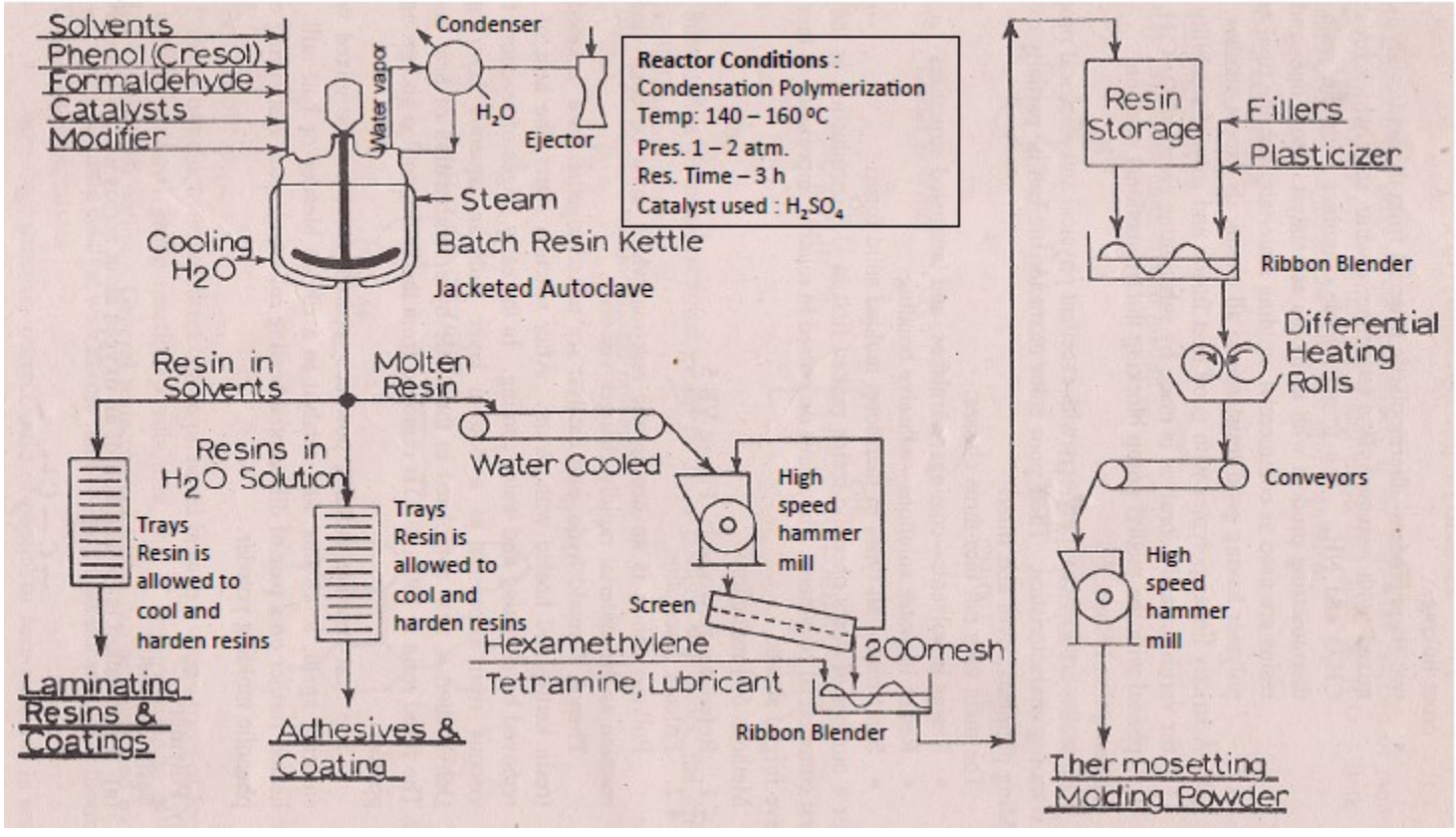
On the basis of derivation, plastics can also be grouped as

1. Natural resins
2. Synthetic resins
3. Cellulose derivatives
4. Protein products




Phenol
Phenol-Cresol
Steam
Water
Formaldehyde
Sulfuric acid
Activators
Dyes
Fillers
Plasticizers
Process
Phenolic Resins

Unit 5 Synthetic Organic Chemicals – Manufacture of Phenol Resin



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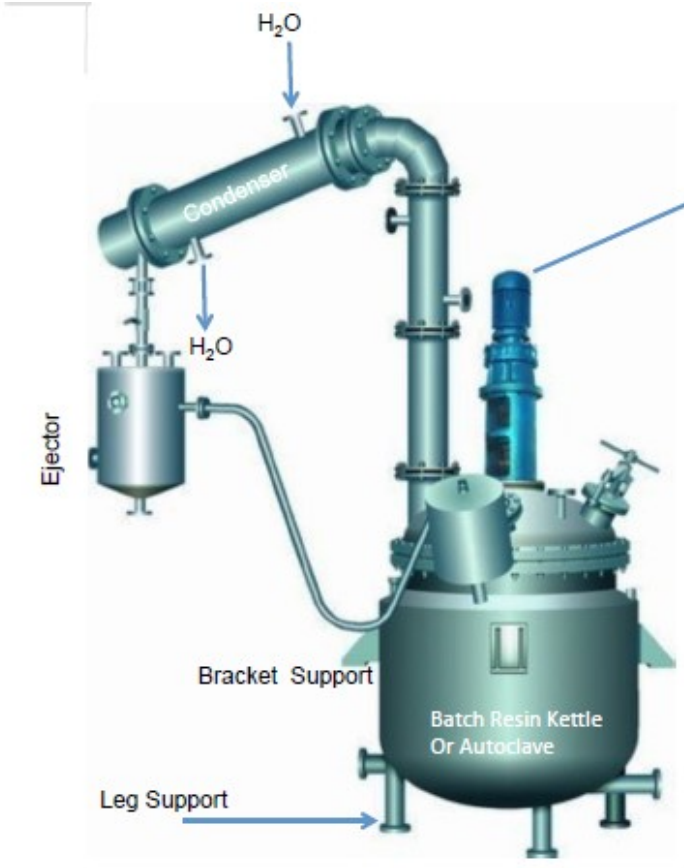
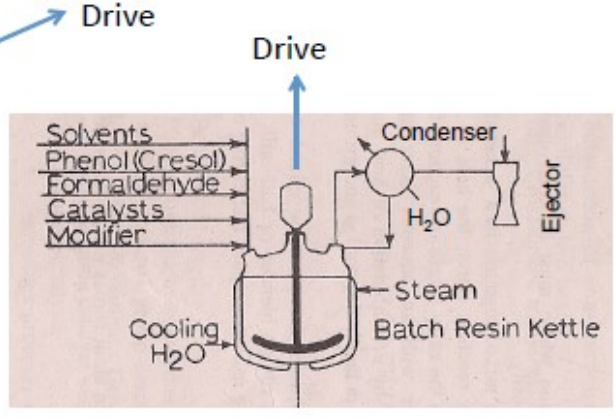
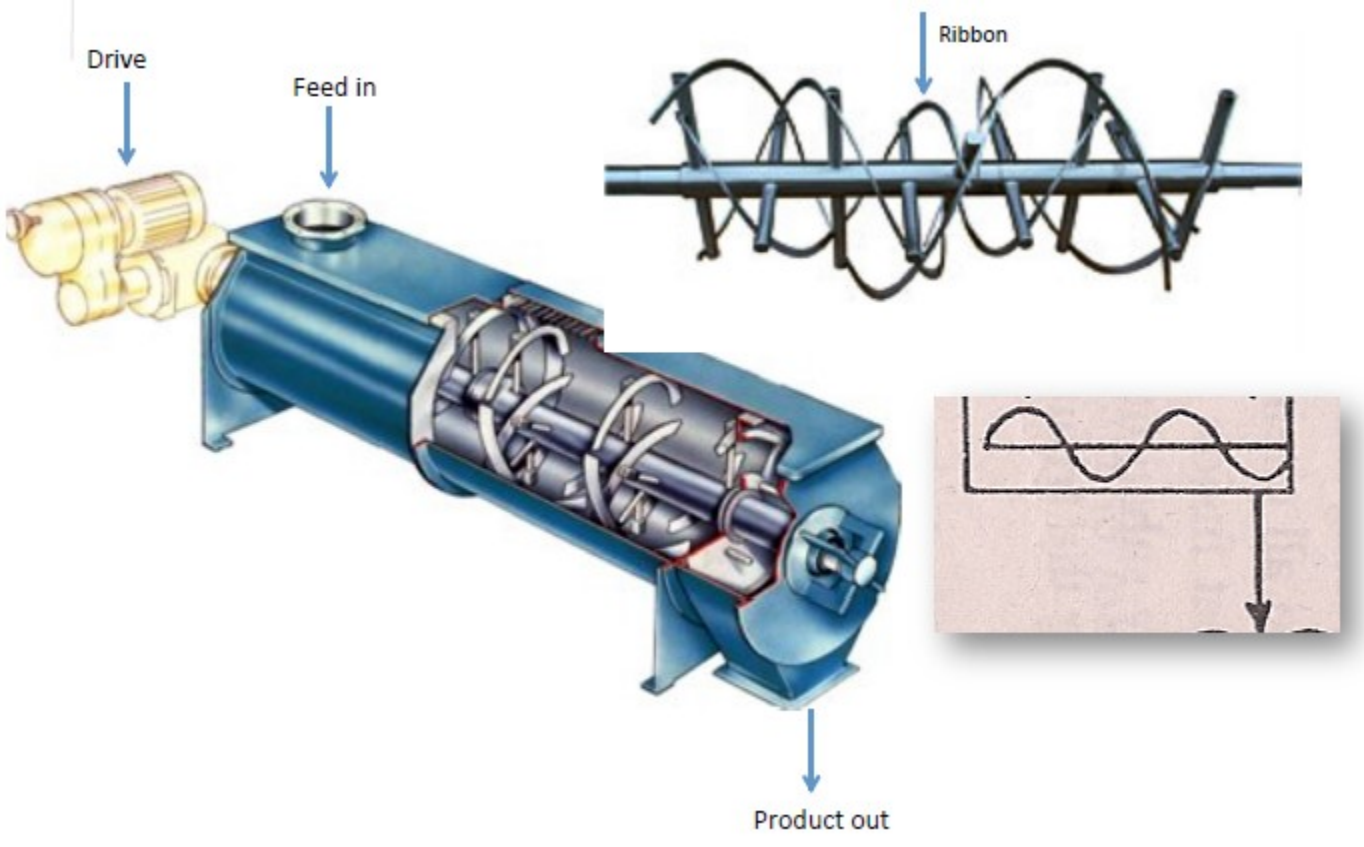
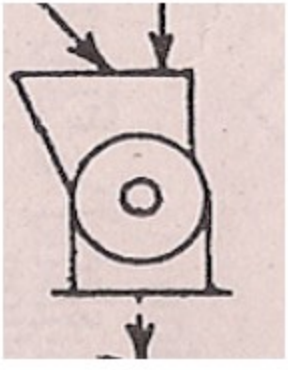


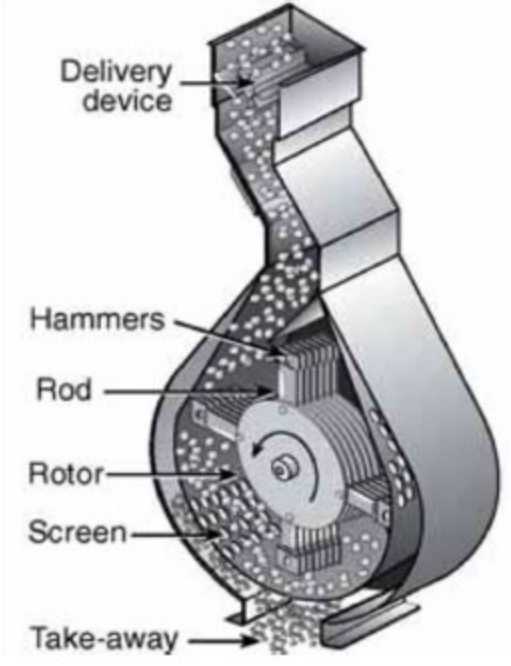


Schematic Representation

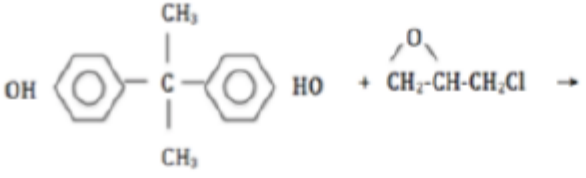

Drive
Feed in
Ribbon
Product out

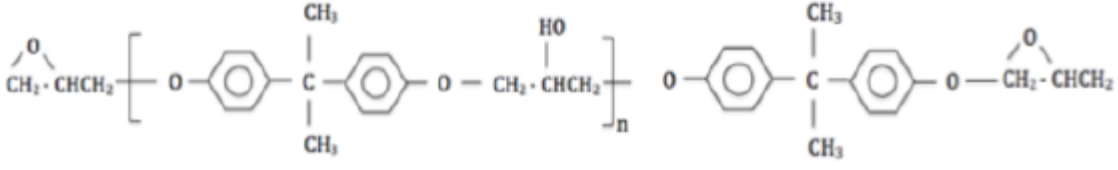

Hopper
Hammer mill




Delivery device
Hammers
Rod
Rotor
Screen
Take-away

Bisphenol A + Epichlorohydrin ⟶ Epoxide groups or polymer





Resin Types	Properties	Applications
Phenolics	Good strength, heat stability, and impact resistance, high resistance to moisture penetration and chemical corrosion	Electrical components, structural boards, Laminates, glues, and adhesives
Epoxies	Excellent chemical Resistance, good electrical and thermal properties adhesion properties, strong and tough with low shrinkage	Laminates, Adhesives, Floorings and linings

Binder: This is usually a resin or cellulose derivative added to increase strength.

Fillers: Cellulose, Cotton fibers, Glass fibers or fabrics may be added to increase strength.

Plasticizers: Plasticizers are organic chemicals added to synthetic plastics in order to

(I) Improve the workability during fabrication

(II) Reduces the viscosity of the resin and also impart flexibility to finished product

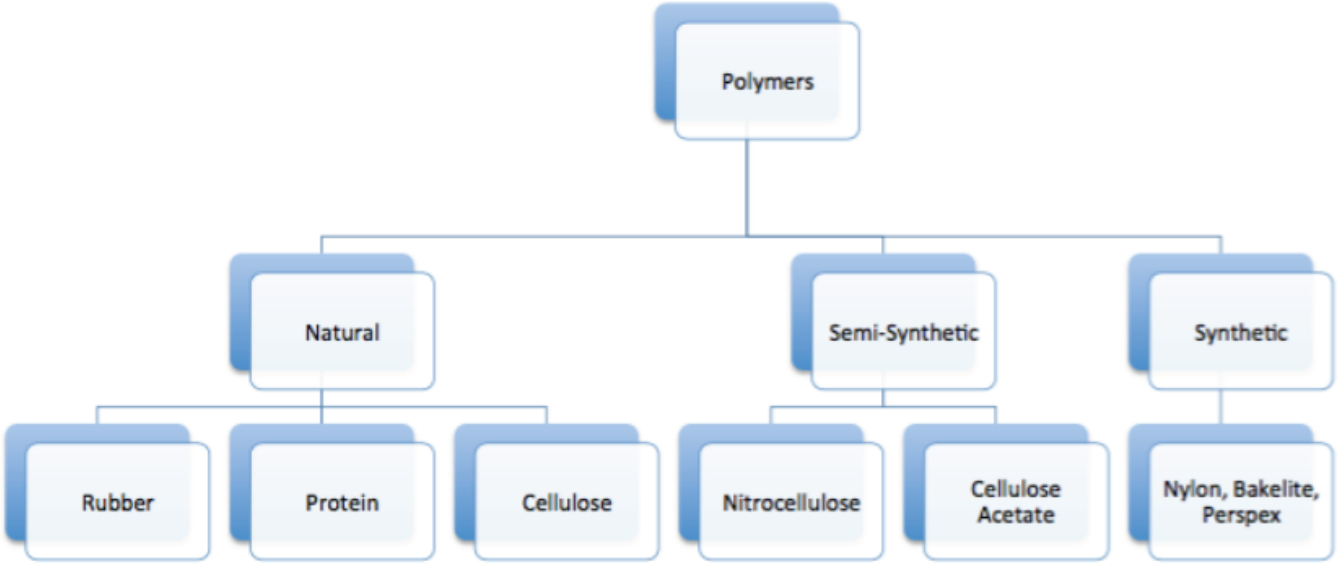
Lubricants: Lubricants such as stearates and other metallic soaps are used particularly in cold-molding compounds to facilitate the molding operation

Engineering plastics are high-strength; high performance materials that can be substituted for many metal uses.

There are wide variety of engineering plastics available. Each one has its own special properties, and thus care must be taken in choosing a resin of particular use.

These materials are often the usual plastics but have been carefully manufactured to posses extra quality properties. These materials shows better resistance towards wear impact and corrosive chemicals and have excellent electrical properties.

Some of the uses of engineering plastics are automobile bumpers and dash boards, pumps, valves and gears, drive shafts and transmission in heavy duty equipment.



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A polyamide is a polymer containing **monomers of amides**.

They occurs both **naturally and artificially**.

Polyamides are commonly used in **textiles, automotives, carpet and sports wear.**

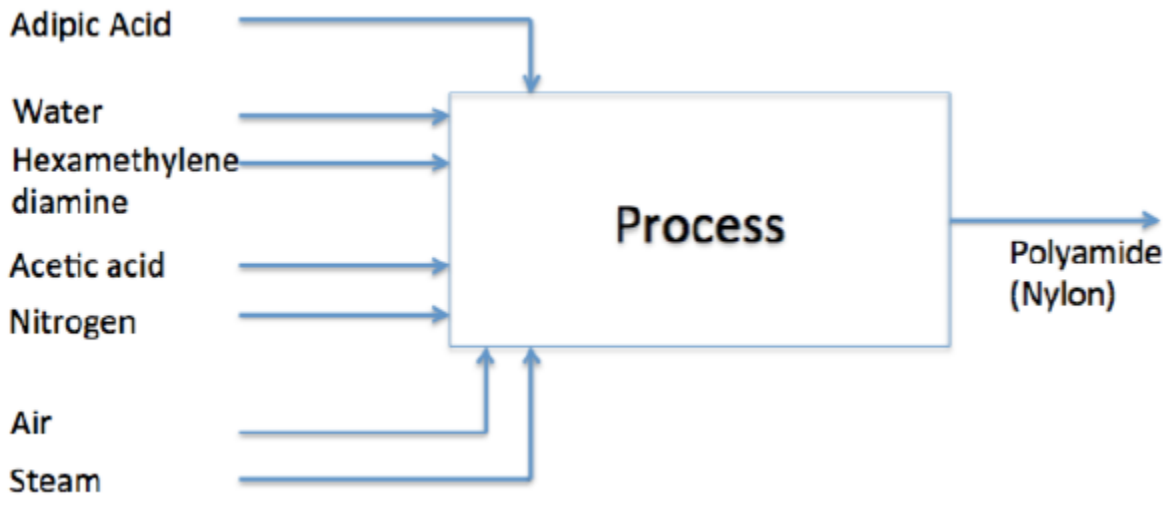
Adipic acid

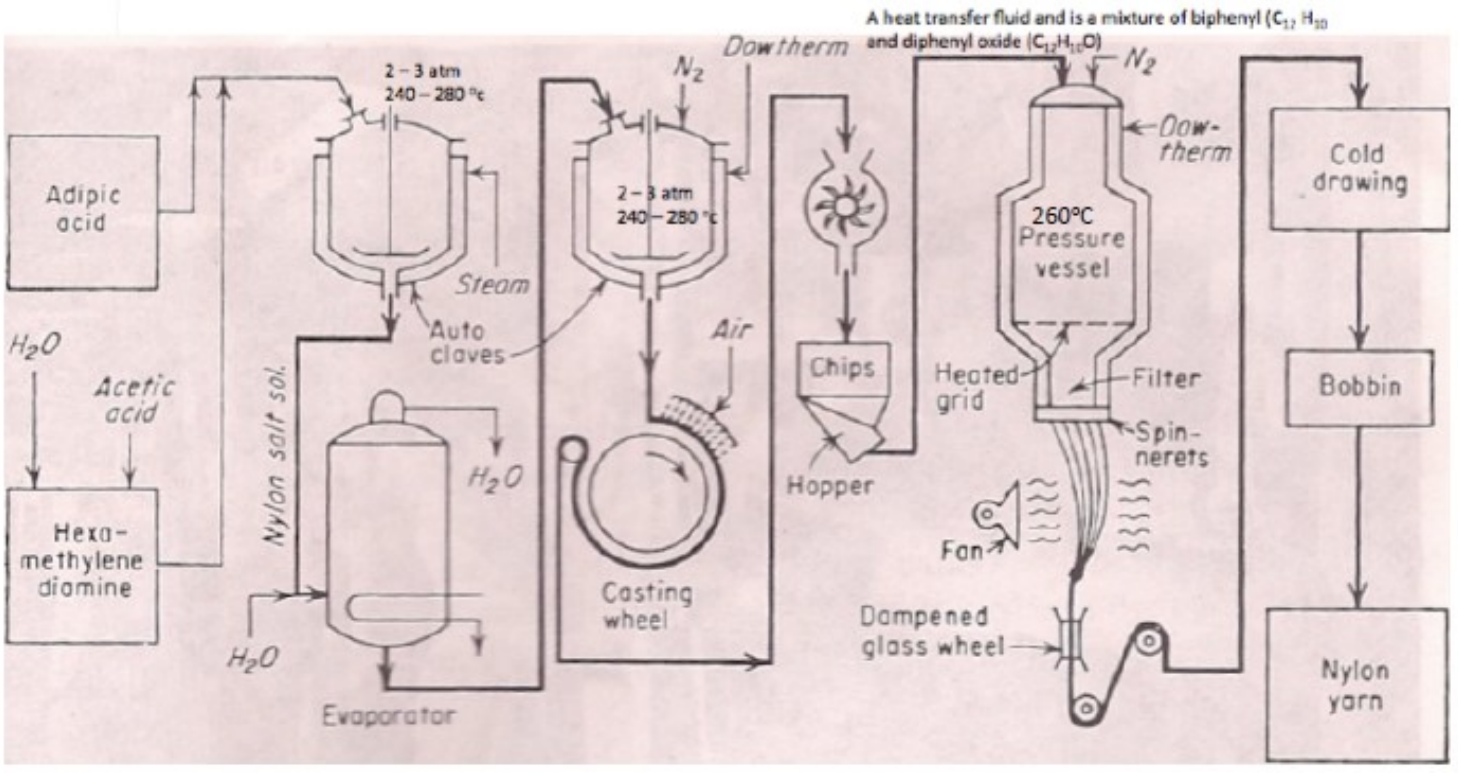
+

Hexamethylene diamine ⟶

Hexamethylene diammonium adipate (or)
nylon salt ⟶

Poly(hexa methylene adipamide) or Nylon


Adipic Acid
Water
Hexamethylene diamine
Acetic acid
Nitrogen
Air
Steam
Process
Polyamide (Nylon)



Ref: Shreve's *Chemical Process Industries* for detailed process description

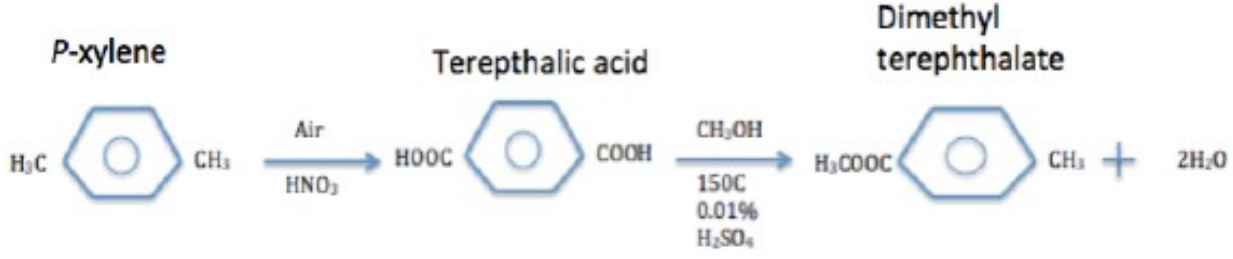
Used in the manufacture of

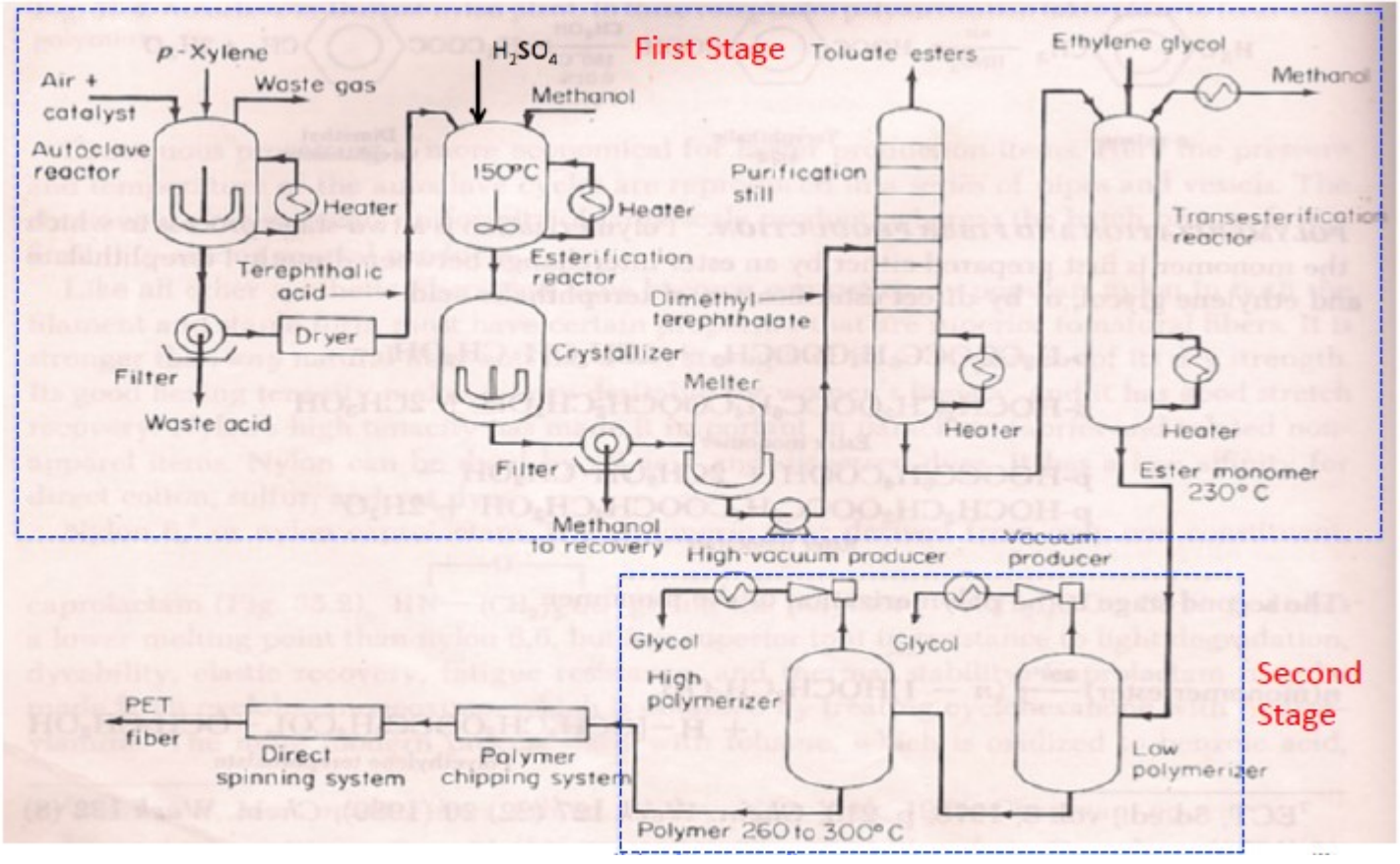
1. Unlubricated or non lubricated bearings
2. Bags
3. Fabrics
4. Ropes
5. Fishing line or net

The common polyester fibers are polymers of **the ester formed from dimethyl terepthalate and ethylene glycol**

Production steps

1. Preparation of intermediates
2. Polymerization of ester monomers





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Used in the manufacture of

1. Fabrics
2. Wrinkle free fabrics
3. Hoses
4. V belts
5. Pillows
6. Carpets

Major Steps

1. Alkali Conversion

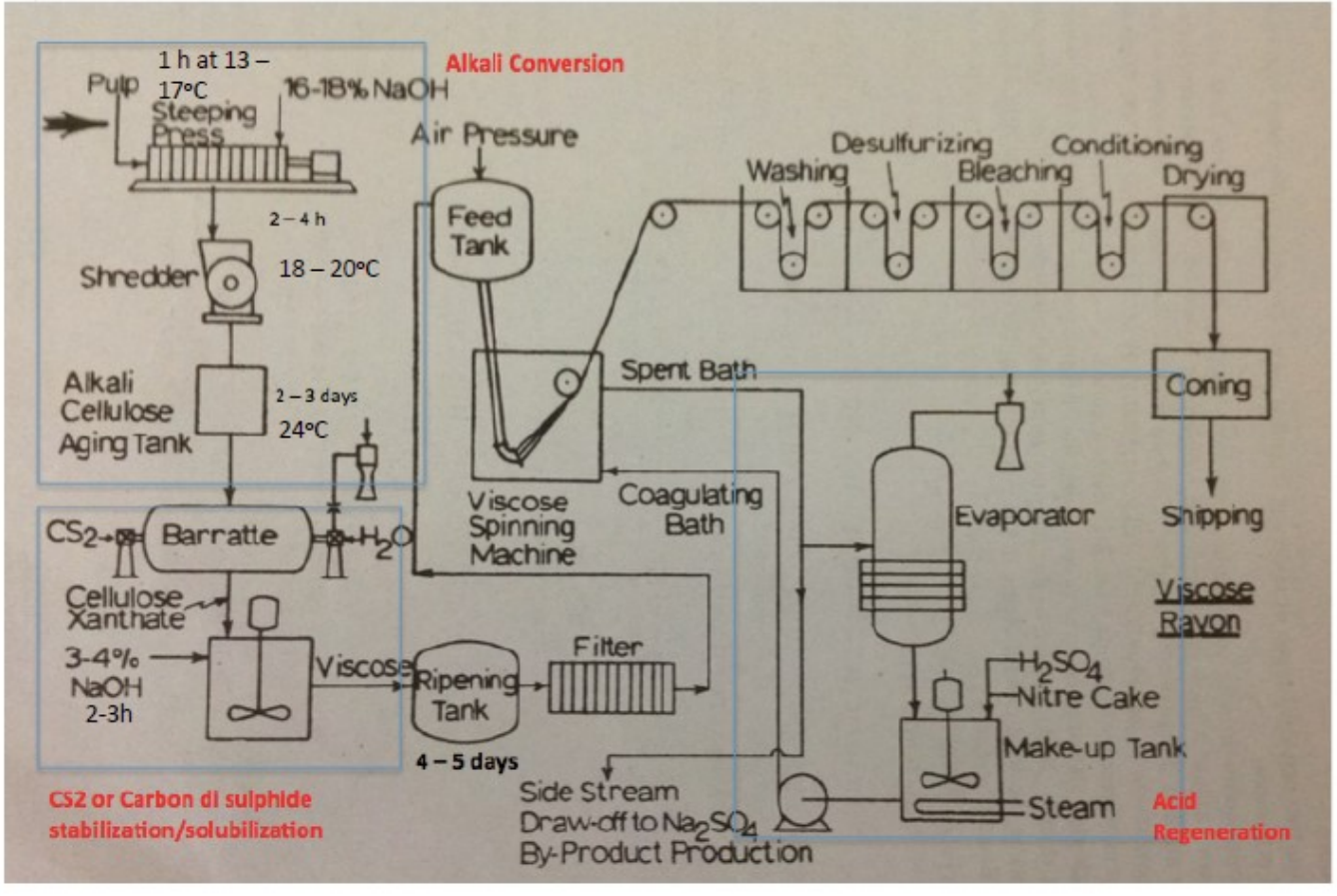
   Cellulose + NaoH = Alkali Cellulose + Water

2. CS_2 Stabilization/Solubilization

   Alkali Cellulose + Carbon disulphide = Sodium Cellulose Xanthane

3. Acid Regeneration

   Sodium Cellulose Xanthane +Sulfuric Acid = Rayon + Carbon disulphide + Sodium bisulphate



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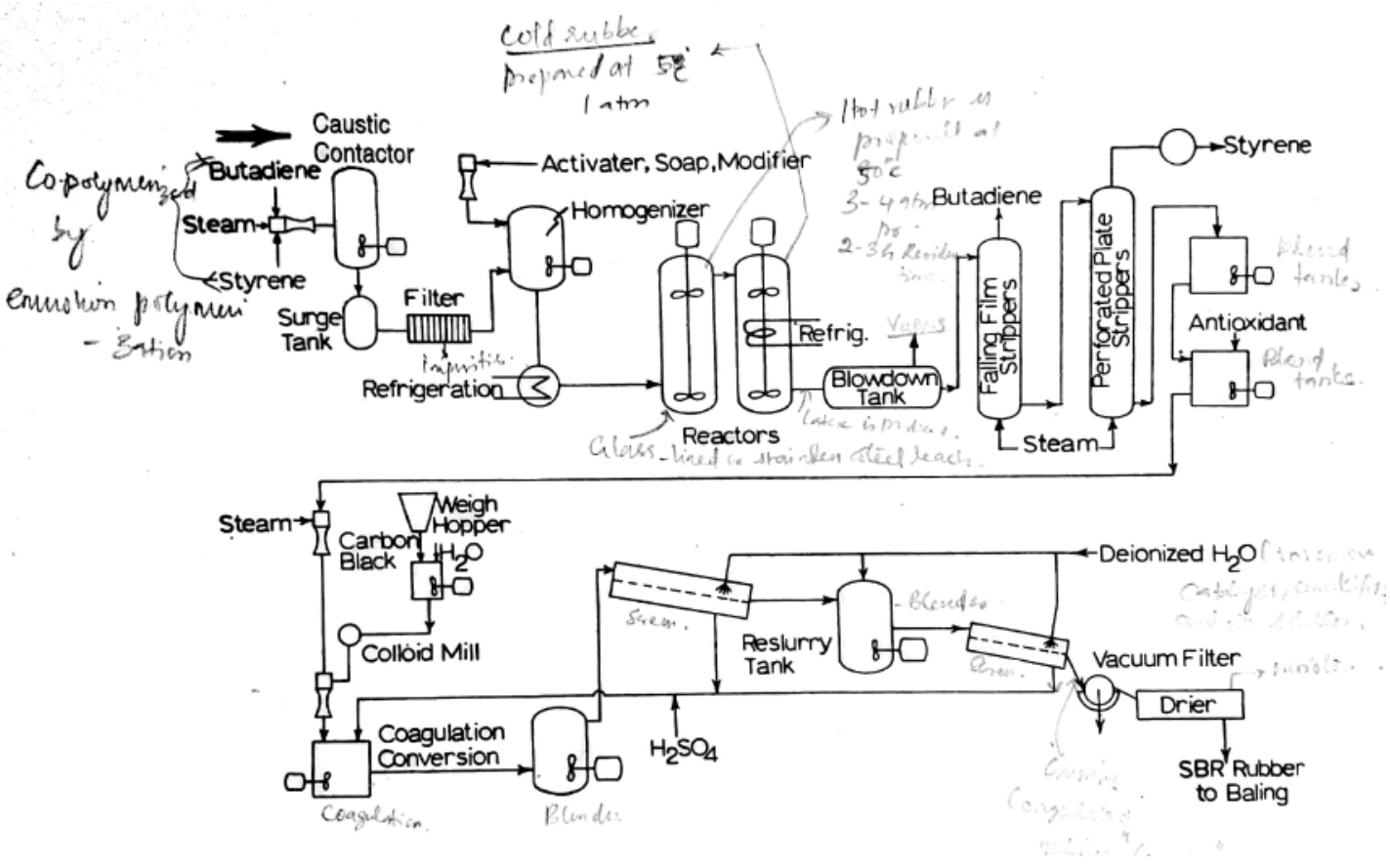

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Reference s

1. Dryden C. E, *Outlines of Chemical technoloy – for the 21st Century*, 3rd edition, East-West Press (2004)

2. Austin G. T, *Shreve's Chemical Process Industries*, 5th edition, Mc Graw Hill International editions (1984)

3. Finar IL, Organic Chemistry Vol. 1 6th Edition Pearson Education 2009 pp.116-117