

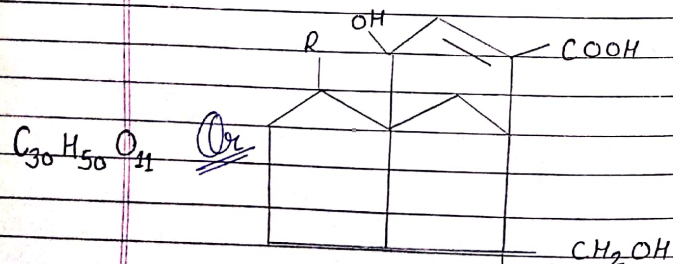
### "Natural Polymer"

Nomenclature of Polymer - Sources of Raw materials, methods of Manufacture, General Characters and Properties, Processing behaviours and applications of natural Polymer such as Shellac Resin, Natural Rubber, Casein.

1. What is Shellac Resin?

- Shellac does not originate from Plants.
- It is produced from the secretion of an insect.
- It is purified from lac and it is most widely known as lac product.
- Lac is produced by larvae of "Karsia lacca".

Chemical Structure:-



Composition:- Shellac is the mixture of tannic Polyhydroxy acid in the form of lacton and esters. It average molecular weight 1000 mole.

Production:-

- The harvested sticklac is crushed and sieved to remove impurities.
- The sieved material is then repeatedly washed to remove insect parts and other soluble material.
- The resulting product is sun dried and is known as seedlac. The prefix seed refers to its pellet shape.

Applications:-

1. Shellac is used as a protective coating material for tablets and capsules.
2. Shellac is used in a electrical application.

Ques → What is Natural Polymer and write the Properties and applications -

Natural Polymer :- Polymer which are isolated from Natural origin is called "Natural Polymer". This polymer found in Plants and Animals.

Exp → Protein, Cellulose, starch, Rubber, Casein etc.

Properties :-

- Biodegradable, biocompatible, non-toxic linear chain
- Very hydrophilic; it adsorbs water making it hygroscopic
- readily soluble in water and produces a gel.

Applications :-

- Ocular delivery - making Contact lenses optical clarity.

• Colon drug delivery -

Degraded by microflora present in human colon which supports colon drug delivery.

• Coating material -

Good film forming property and mucoadhesive property.

Topic - Casein

Introduction :- Milk contain many molecules of a protein is called Casein each casein molecules is a monomer and the polymer you make is made up of many of those casein monomer together a repeating pattern.

Materials :- One Cup whole milk, measuring spoon, white vinegar, empty jar, wax paper.

What to Do :-

- Pour the milk into the measuring spoon
- Add two table spoon of vinegar
- Heat and stirring frequently until the milk boils

The milk will form tiny



lump in a pear liquid.

- Slowly pour of the liquid.
- Add one tea spoon of Vinegar to a Curd and
- Curd will form yellowish slow at the bottom of the jar.
- Place on wax paper and let harden and dry over night.

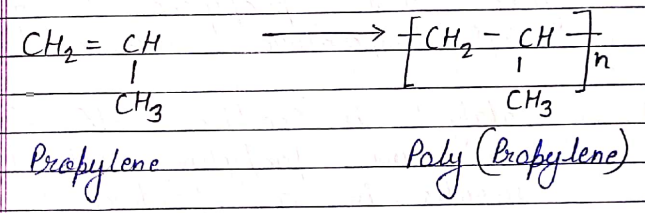
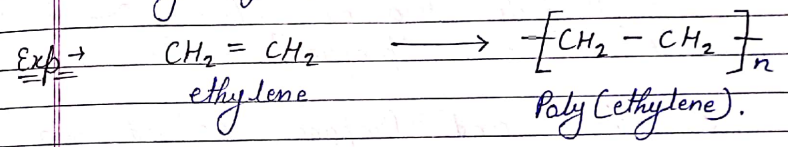
Properties :-

- It is nature friendly material.
- Mechanical properties is poor.
- Limited use in electrical sector.

Application :-

- Colour full button.
- Knife handle.
- Limited use in low voltage electric Plug.
- Dress ornaments.

Nomenclature of Polymer :- The name of the polymer is generated by using the prefix "Poly" followed by the name of the monomer in parentheses. Thus, a polymer made from ethylene is called Poly(ethylene).



Sources of Polymer :-

- Nature
- Crude Oil
- Natural Gas

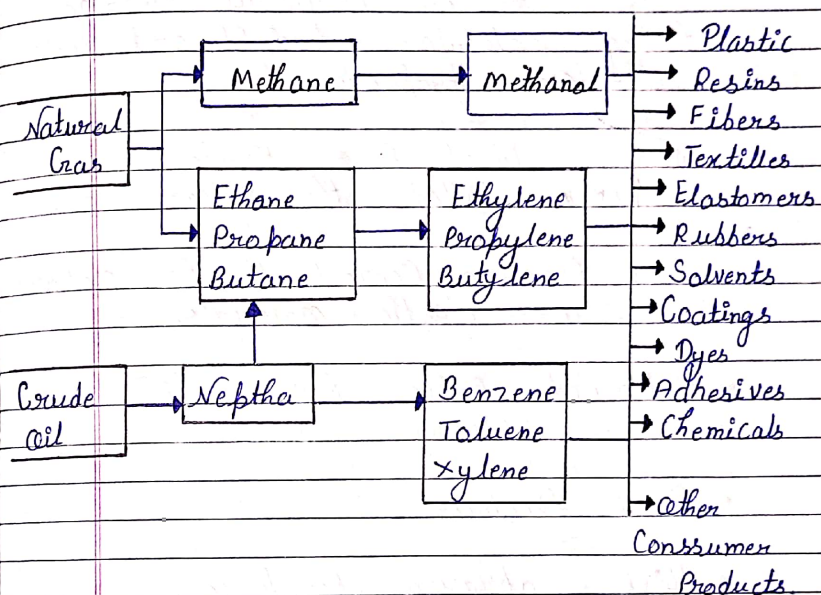
How is Plastic made? -

Plastics are made from petroleum and there is a lot of technical information about how plastics are made but below is a very brief and Condensed 7 step overview

of how petroleum is turned into plastic.

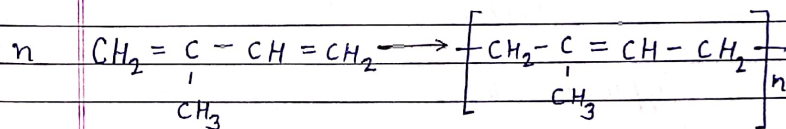
1. Petroleum is drilled and transported to a refinery.
2. Crude oil and natural gas are refined into several petroleum products two of which can be "ethane" and "propane".
3. Ethane and Propane refined into ethylene and propylene using high-temperature furnaces.
4. A catalyst is combined with the ethylene and propylene and this results in a powdered polymer.
5. This powdered polymer is then melted and extruded.
6. It is then cooled and cut into tiny plastic pellets.
7. These pellets are shipped to manufacturers of plastic products.

## Petrochemical



Natural Rubber  $\rightarrow$

Structure  $\rightarrow$



Isoprene  
[2-methylbutadiene]

Natural Rubber  
[cis 1,4 Poly Isoprene]

Sources  $\rightarrow$  The Commercial sources of Natural Rubber, Latex is Para Rubber tree [Hevea Brasiliensis]



Properties: → Natural Rubber is a Natural Polymeric Substances having molecular weight and viscous elastic properties.

- When Natural Rubber reacts with sulphur called the Vulcanization.
- This reaction converts the raw material into an elastic material.
- Vulcanized Rubber having high tensile strength
- Good Hardness
- High abrasion Resistance
- Having unique combination of this properties vulcanized Rubber can manufacture various types of Rubber

Applications: →

- mainly Rubber use in automobile Industry (Tyre,
- Softy Gloves
- Footwear
- Medical Sector
- Ballon
- Baby bottle Nipple
- Eraser
- Belt
- Surgical Gloves
- Foot ball, ball

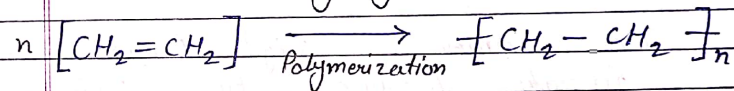
## UNIT-2

### "Commodity Plastics"

Sources of Raw materials, Method of manufacture, General Characteristics and Properties, Processing Behaviour and application of -

Low Density Polyethylene, Linear Low Density Polyethylene, High Density Polyethylene, High molecular weight High Density polyethylene, Polypropylene [Homo and Copolymer], Polystyrene, High Impact Polystyrene, Acrylonitrile Butadiene Styrene, Styrene Acrylonitrile Expanded Polystyrene.

Polyethylene [PE]



Introduction: → Polyethylene has the simple basic structure. Polyethylene is a polymer of ethylene monomer mostly produced by addition polymerization.

The Bulk of ethylene polymer obtained with petrolium it is obtained by high Temperature Cracking.

Date \_\_\_\_\_  
Page 11

of ethane and Propene.

LLDPE → Linear Low Density Polyethylene

LDPE → Low Density Polyethylene.

HDPE → High Density Polyethylene.

UHMHDPE → Ultra High molecular weight High Density Polyethylene

LDPE is prepared by the high pressure process.

HDPE is prepared by the Ziegler Natta Process.

The Commercial High Polymer are generally produce by under high pressure of 1000-3000 Atmosphere temperature 80-300°C

A free radical Initiator Benzoyl peroxide and Oxygen is commonly used. the principal involve in high pressure Radical of Polymerization is free Radical mechanism.

For the given

Date \_\_\_\_\_  
Page 12

system the higher the temperature the faster the reaction and the lower the molecular weight.

most High Pressure polymer are the lower density range and usually low molecular weight range.

LDPE Contains 40-60% Linear Crystalline. Density 0.915 to 0.94 gram/cm<sup>3</sup>.

### Assignment-1

Q. Write down the few applications of LDPE, HDPE, LLDPE, UHMHDPE

➤ LDPE [Low Density Polyethylene]

- Milk Pouches
- tubing
- Pipes
- Containers making
- moulded laboratory equipment
- many Caps and closures.
- Poly Bags
- Snack Bags
- Toys
- Squeezable Bottles

➤ HDPE [High Density Polyethylene]

- Some Containers
- 3D Printer filament
- Bottle Caps
- Banners
- Ballistic Plates.
- Shampoo bottles





- Toys
- Flower Pots
- Drums
- Recycling Bins

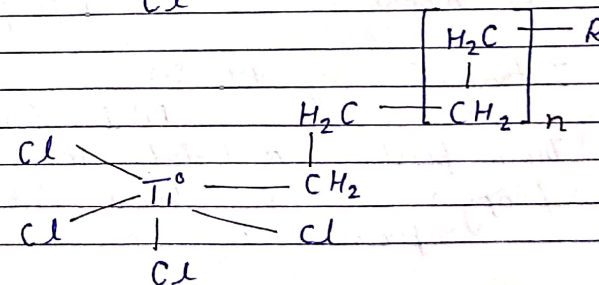
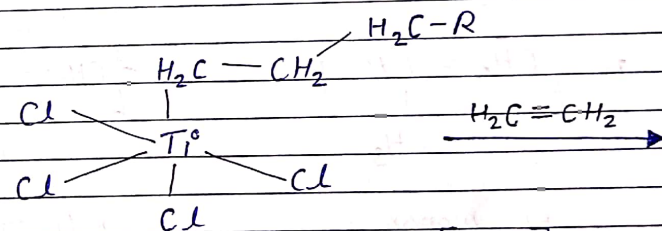
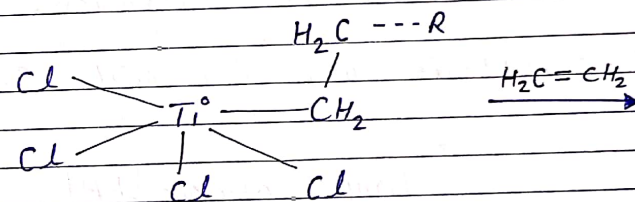
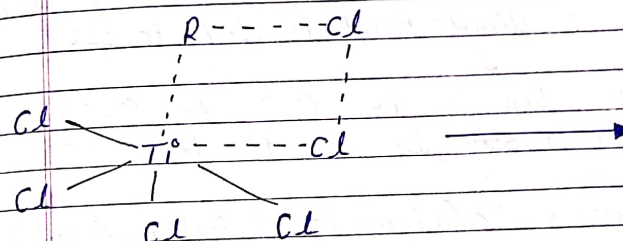
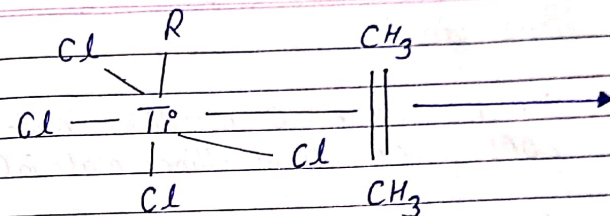
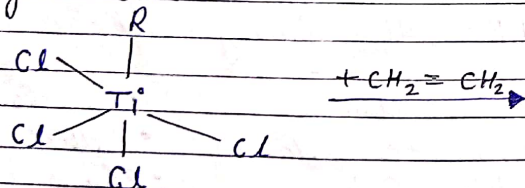
### ➔ LLDPE [Linear low Density Polyethylene]

- Shrink wrap film
- grocery bags
- water Tanks
- Plastic film
- LLDPE Tubing
- Trash Bags
- food Packaging

### ➔ UHM HDPE [Ultra high molecular weight High Density Polyethylene]

- High speed Conveyors.
- Truck bed liners.
- wear strips and guide rails
- Star wheels and idler sprockets
- Packaging machinery Parts
- Food Processing machinery Parts
- Bumpers
- Pile guards
- dock fenders.
- gears.

Ziegler Process  $\rightarrow$



### Properties :->

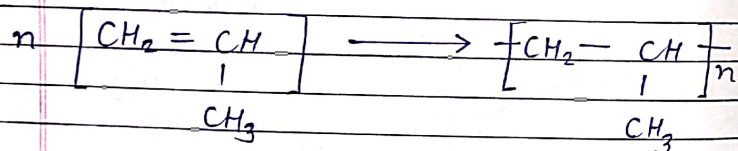
- HDPE more Crystalline material,  
LDPE Low Crystalline material
- HDPE melting Point is  $135^{\circ}\text{C}$  and  
LDPE melting Point is  $106$  to  $112^{\circ}\text{C}$
- HDPE Density is  $0.94$  to  $0.96$   
LDPE Density is  $0.915$  to  $0.935$

Processing Techniques :-

- Injection moulding
- Blow moulding
- Film extrusion.

Note :- LDPE is used for milk Picking.

### Poly Propylene [PP]



PP monomer

Poly propylene.

### Introduction of PP :->

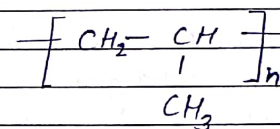
PP is Commodity Thermoplastic material Poly propylene manufactured by various process.

- Ziegler Process ,
- Batch Process ,
- Suspension Process

PP is prepared by using Ziegler type Catalyst " $\text{Ti}^{\text{tri Chloride}}$ " with aluminum tri ethyl, aluminum tri butyl in Naphtha under Nitrogen atmosphere to form slurry consisting of 10% Catalyst and 90% Naphtha.

The Properties of Polymer are strongly dependent on the Catalyst Composition and its particle shape and size. The monomer weight can be controlled by using " $\text{H}_2$ " as a Chain Transfer agent.

### Structure Properties :-



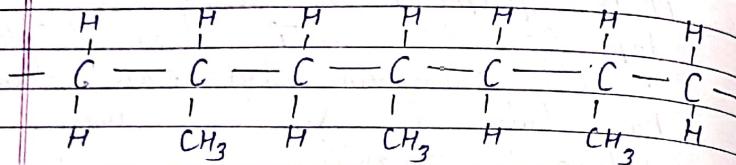
- The  $\text{CH}_3$  group in the chain in Crystalline melting point.

- PP and PE having most of the similar properties



Tacticity :-

### 1. Isotactic -

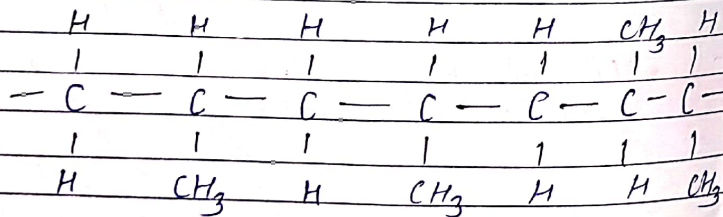


In isotactic all methyl group are on one side of the main chain of the polymer

### 2. Syndio Tactic -

In Syndio Tactic all the methyl group are arranged alternatively of the main chain

### 3. Atactic -



In Atactic all methyl group are arranged randomly.

Properties :-

Isotactic - It is highly crystalline, with a high melting point

Atactic - Material is a Amorphous material and Rubbery material.

General Property :-

PP Burns slowly  
Can identified by and give smell of Crude Oil.

- PP is Tough and having good Impact strength.
- PP has high degree of Crystallinity.
- good Chemical Property Resistance
- Excellent electrical Property.
- High optical Property
- good Surface hardness
- good Scratch and abrasion Resistance
- good glass and Transparency.
- good Puncture Resistance.
- Specific gravity -  $0.903 \text{ gm/cm}^3$
- melting Point -  $164^\circ\text{C}$



Processing Techniques :-

- Injection moulding
- Blow moulding
- Pipe extrusion
- BOPP film.

Application :-

Automotive - Door Pocket, Radiator grille, Mud Flap, Seat Cover, Glove Boxes, Bumpers.

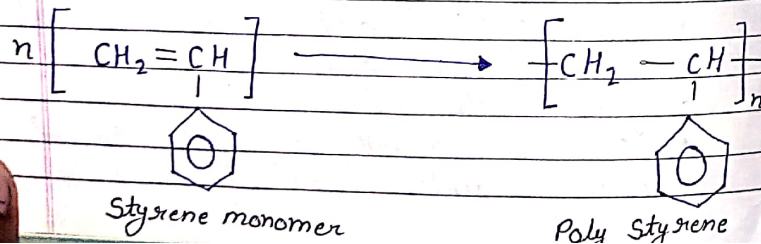
Packaging - Film for Packing Tobacco, Candy, jam, Cosmetic, Contact lens Case, Bottle, drum, Tool Box, film for textile goods.

Electrical / Electronics - Switch gear, Radio and T.V.

Housing, Control Knobs, Industrial light, Cable and wire Coating.

House hold :- Coffi maker, hair dryer, AC Parts, Chair, Table, mug, basket, Bucket, table for soft drink bottle.

Poly Styrene [PS]

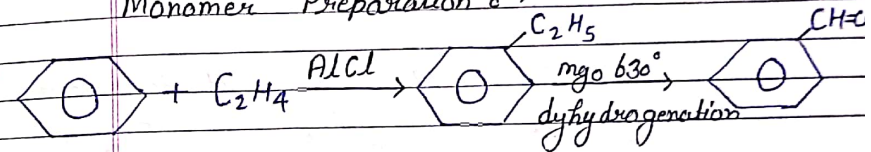


Introduction :- Poly styrene is a low cost material. it is a light weight material. The another name of Poly styrene is "Poly Vinyl Benzene".

Co-Polymer of Poly styrene :-

ABS [Acrylo Nitrile Butadiene Styrene]  
HIPS [High Impact Poly Styrene]  
SAN [Styrene Acrylo Nitrile]

Monomer Preparation :-

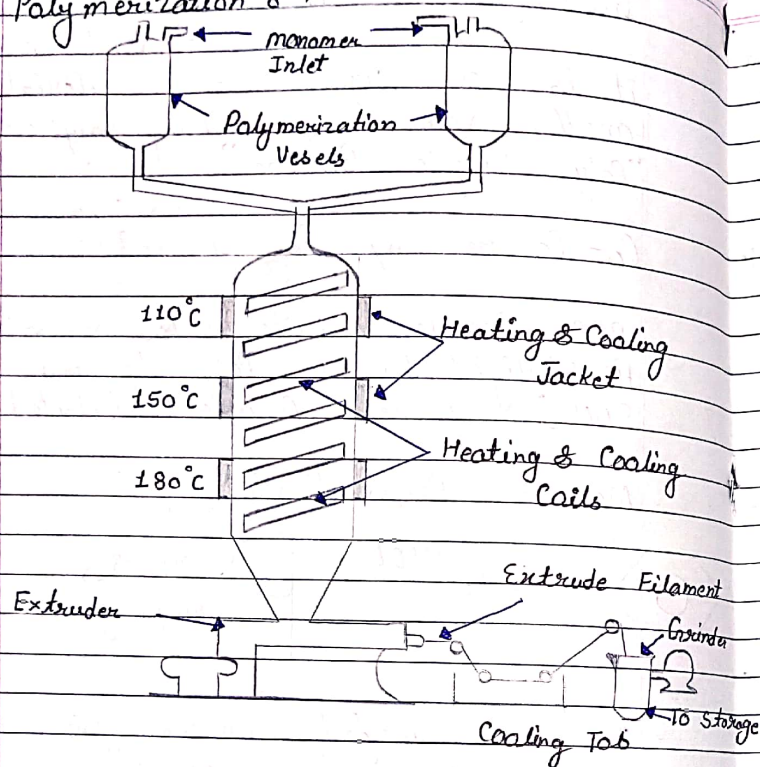


In this method benzene and ethylene to get "ethyl Benzene".

ethyl Benzene prepared by reaction of ethylene and Benzene in the presence of Catalyst as aluminum Chloride.

Styrene is produced from ethyl Benzene by a process of dehydrogenation at  $630^\circ\text{C}$ .



Polymerization  $\rightarrow$ 

This Process is known as "Tower Process" in this process styrene is polymerized by heating at  $80^{\circ}\text{C}$  for two days until 33% to 35% conversion to polymer is reached. The monomer polymer mixture is run into a tower about "25 feet" high.

The Tower is fitted with heating and cooling jacket and melting and cooling coil. The top of

the tower temperature is  $110^{\circ}\text{C}$  at center is  $150^{\circ}\text{C}$  at the bottom of the tower is  $180^{\circ}\text{C}$ .

The Base of the tower an extrude from melt material passes from cooling channel the material cut by the grinder after that storage the material in to the packets.

Properties  $\rightarrow$ 

- Specific Gravity of PS is 1.054
- PS is amorphous in nature.
- PS is linear hydrocarbon polymer being thermoplastic in nature.
- PS has extremely good electrical insulation properties.
- PS has good dielectric and optical property.
- available as low cost, excellent colour range and transparency.
- low water absorption.

Processing Techniques :-  
• Injection moulding  
• Thermo forming

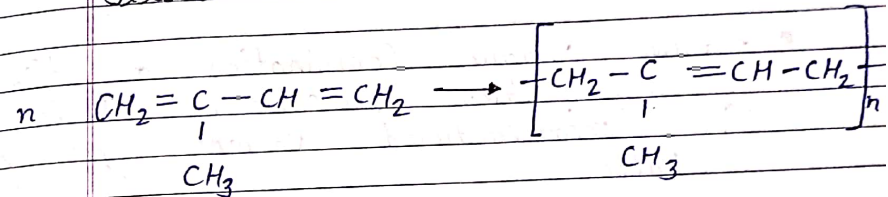
Applications :-

- Household - Boxes, gift articles, Toys, Ball Pen, water Jug
- Automobile - Display sign, Reflector, Panel Cover.
- Electrical - Battery Cases, CD, Floppy storage Box.
- Medical - Disposable Syringe
- Packaging - Bottle Cap, Bottle, Containers, Flower Packing, utility Box.

## Assignment - 1

Ques what is natural Rubber write application and properties -

Structure :-



Isoprene [2-methylbutadiene]      Natural Rubber [cis 1,4 Poly Isoprene]

Sources :- The Commercial Sources of Natural Rubber, Latex is Para Rubber tree [Hevea Brasiliensis]

Properties :- Natural Rubber is a Natural Polymeric Substances having molecular weight and visco elastic properties.

- When Natural Rubber reacts with Sulphur called the Vulcanization.
- This reaction convert the raw material into a elastic materials.



- Vulcanized Rubber having high tensile strength
- Good Hardness.
- High absorption resistance.
- Having Unique Combination of this properties Vulcanized Rubber can manufactured various types of Rubber.

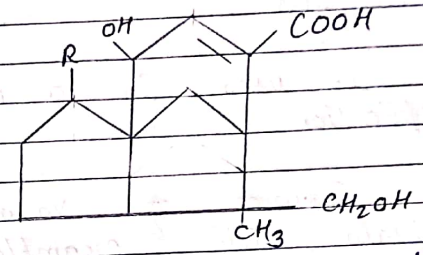
Applications :-  
• mainly Rubber used in automobile Industry

- Softy gloves
- Footwear
- medical Sector
- Ballon
- Baby bottle nipple
- Eraser
- Belt
- Surgical gloves
- Foot ball, ball
- Rubber Band etc.

Ques what is Shellac write Properties and applications.

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- It is produced from the secretion of an insect.
- It is Purified from of lac and it is most widely known as lac Product.
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Applications :-

- Shellac is used as a Protactive

Coating material for tablets and Capsules.

- Shellac is used in a electrical application

Ques Write Source of Natural Polymer Explain with example.

Natural Polymer  $\Rightarrow$  Polymer which are Isolated from Natural origin is called "natural Polymer"

This polymer found in Plants and Animals.

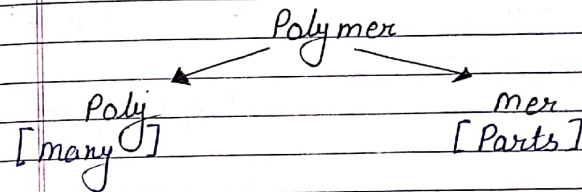
Exp  $\Rightarrow$  Protein, Cellulose, starch, Casein etc.

Properties  $\Rightarrow$

- Biodegradable, biocompatible, non toxic linear chain.
- Very hydrophilic, it absorbs water making it hygroscopic.
- readily soluble in water and produces a gel.

Ques what is Polymer, write Nomenclature of Polymer.

Polymer  $\Rightarrow$  The Polymer is high molecular weight Compound form by the combination of low molecular weight Compound.



Exp  $\Rightarrow$  Poly propylene [PP]

Poly ethylene [PE]

Poly styrene [PS]

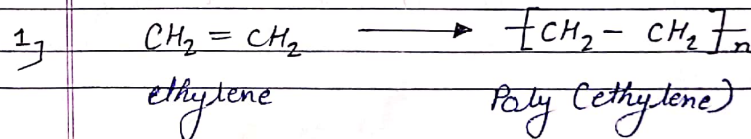
High Density Poly ethylene [HDPE]

Low Density Poly ethylene [LDPE]

Poly vinyl Chloride [PVC]

Nomenclature of Polymer  $\Rightarrow$

The name of Polymer is generated by using the prefix "Poly" followed by the name of the monomer in parentheses. Thus, a polymer made from ethylene is called "Poly (ethylene)"







- Excellent surface quality.
- High dimensional stability
- Elevated temperature
- Good chemical resistance
- Poor flame resistance
- Lack of transparency
- Poor weathering resistance
- The materials burn with a smoky yellow flame.

Specific gravity  $\rightarrow$  1.03 1.06 gm/cm<sup>3</sup>

Processing Techniques  $\rightarrow$

- Injection moulding
- Thermoforming
- Electroplating.

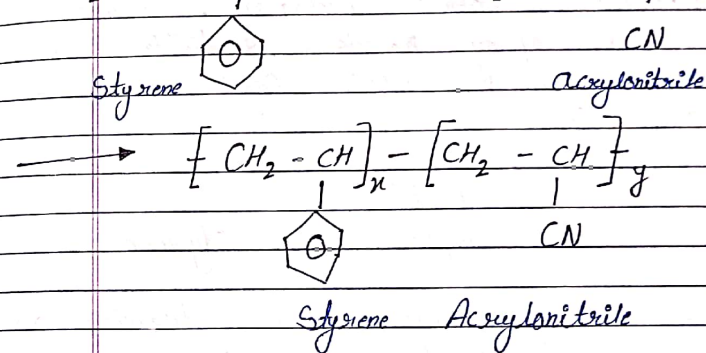
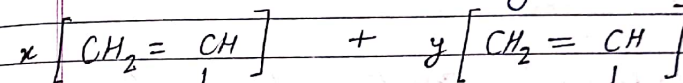
Applications  $\rightarrow$

- Automobile :- Helmet, seat belt, mirror housing, door handle, radiator grill, head light housing, door knobs.
- Households :- Coffee maker, ABS mixture housing, Refrigerator liner.
- Packing :- ABS used in luggage case, oil (Petrol, kerosene) containers, container for carbonated beverages etc.
- electronics :- meter box, T.V. Remote.

SAN

Styrene acrylonitrile

SAN is manufactured by the addition polymerization techniques of styrene and acrylonitrile monomers. It is produced by three different polymerization techniques like emulsion, suspension and continuous mass polymerization.



Properties  $\rightarrow$

- Excellent dimensional stability
- Good impact strength
- Good abrasion resistance
- Very high creep resistance
- High chemical resistance
- High glass
- High heat resistance
- High softening point
- Excellent tensile and flexural strength



### Applications :-

- Industrial - Battery Cases, Plumbing knobs, toilet seats, Paint jars, window panels, storm door panels.
- Electrical and Electronics - Key Caps, Calculator printer stands, telephone parts, thermal boxes and Radio knobs.
- Packaging :- Cosmetic Packaging, Closures, spray nozzles, display racks and boxes, lipstick cases, bottles and caps.

### HIPS

#### High Impact Poly Styrene

HIPS is manufactured by dissolving an unsaturated rubber in styrene monomer and polymerization polymerising the monomer in a solution or mass suspension process.

#### Properties :-

- Electrical Properties are similar to GPPS
- Good dimensional stability.
- Good toughness
- Ease to processing
- High elongation at break

- Ignites in Contact with flame
- Dissolved by alcohols, esters, ketones etc.

#### Applications :-

- Electrical and Electronics - Radio Cabinets, Portable T.V. Cabinets, transistor Cabinets, Refrigerator grills, knobs and lining, air Conditioner Cabinet.
- House hold - Coffee sets, jugs, dishes, egg cups, cake - dish covers, plates, utensils, gift sets, mirror body, Pencil Box, Picnic Box, Disposable cups.
- Packaging - Dairy Containers, venting and portion cup lids, plates and bowls.
- Industrial - machine housing, helmets, masks, insulated drainage, textile and machine parts etc.

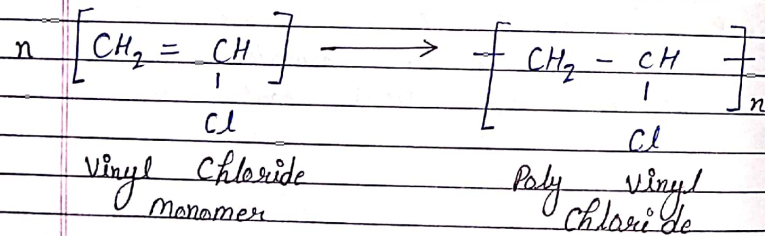
## UNIT-3

"Commodity Plastics - Vinyl and Cellulosic Plastic"

Sources of Raw material, method of manufacturing, General Characteristics and Properties, Processing Behaviour and applications of -

Poly vinyl Chloride and Chlorinated Poly Vinyl Chloride, Poly vinylidene Chloride, Poly vinyl Acetate, Poly vinyl alcohol, Cellulose Nitrate, Poly methyl methacrylate, Poly acrylonitrile, Thermoplastic Elastomers, Cellulose Acetate, Cellulose Acetate Butyrate, Regenerated Cellulose.

PVC  
Poly Vinyl Chloride

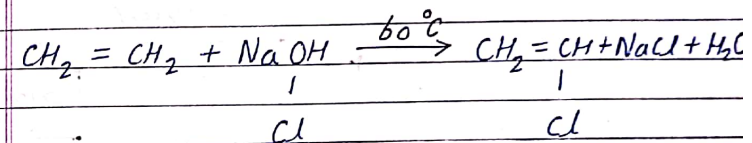


Poly Vinyl Chloride is the most versatile Thermoplastic with a wide range of application than any other plastic.

It plays an important role in every field such as irrigation, electrical, House roof, Agricultural and many other field.

Vinyl Chloride was first synthesized by Reghauit in 1835. The full scale of PVC Resin began in 1931 in Germany.

Preparation of Monomer  $\rightarrow$  Lab Method -



Vinyl Chloride is a gas in  $14^\circ\text{C}$  and prepared in lab by using adding ethylene di-chloride in drop to a warm 10% solution of Sodium Hydroxide [NaOH] in ethyl alcohol - water mixer method (1:1). Previously it was a method of Commercial interest but the main disadvantage was the half of the chloride of ethylene di-chloride is consumed in the manufacturing of Common Salt [NaCl].

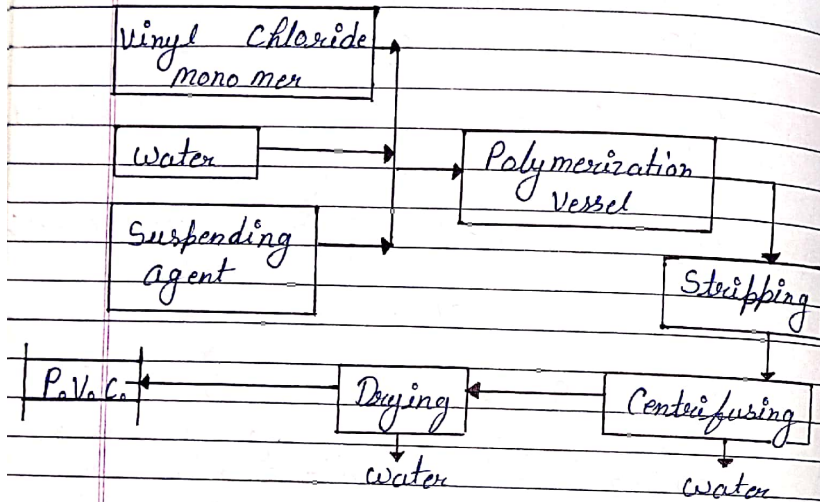
Commercial method  $\rightarrow$  1,2 di-chloro ethane is washed



with NaOH solution, Purified and dried by distillation.

The dry 1,2 di-chloro ethane is ~~take~~ Cracked to give vinyl chloride monomer.

Polymerization :-



PVC Polymerization can be followed by Suspension or emulsion Polymerization.

PVC Polymerization [Suspension] :- A Suspension of monomer Droplet form by vigorous agitation in a sealed pressure reactor which contain a monomer Soluble free radical

Initiator is polymerized at a temperature range 40 - 75°C under the below pressure to reaction temperature at 80°C, 1.5 MPa [mega pascal] The Heat Reaction is Exothermic and exs temperature is rise prevented. use of chld water when some of 80-90% monomer has been converted to polymer the reaction is stop from the reactor.

The resulting Slurry or Polym in water is free from the remaining monomer by evaporation. This operation is known a "stripping".

In the next phase Centrifusing to remove free water and deged by hot air.

Properties :-

- PVC is Polar in nature due to presen of C-Cl dicol having high "di-electric" Constant and Power factor.
- Good Insulation Property

- Surface Hardness
- Good out door weathering
- Good stiffness.
- low water absorption
- easy of processing
- Good surface appearance
- Dimensionally stable at Room temperature.
- Good environmental stress, Crack Resistance

- Specific gravity - 1.18 - 1.70
- $T_g$  - 80 - 85°C

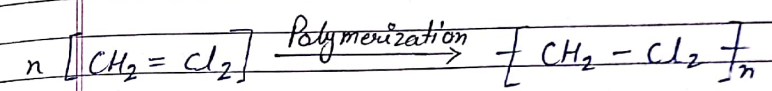
Processing Techniques :- Extrusion, Stretch Blow moulding, Rotational moulding, Coating, Injection moulding.

Applications :-

- House hold - Washing machine Part, Sport Shoes and Shoes, Stoles, Boxes for dry fruits, Bottle, Jethen Cloth, Vallet, Book and photo album.
- Automotive - Seat belt, arm rest, air filter, mud flap, By-cycle seat.

- Google Search application -

PVDC  
Poly Vinylidene Chloride



Vinylidene Chloride

Poly Vinylidene Chloride

Monomer Preparation :- VDC is prepared from trichloro ethane Pyrolysis at 400°C

Polymerization :- VDC can be polymerized by Bulk, emulsion and suspension Techniques. But suspension Techniques is very Common for PVDC manufacturing.

In suspension Process Glass lined Reactor with a water jacket for temperature Contrall is used in this process monomer water a methocel Cellulose and a free radical Initiator (Benzoyle Peroxide) are loaded and



Heated in a seed reactor

The polymer precipitates and crystalline giving a hard porous beads

Properties :- Presence of Chlorine atoms it is self extinguishing material.

Mechanical Properties of vinylidene Chloride Co-polymer depend of Co-monomer type, and degree of Crystallinity. Semi Crystalline Co-Polymer having high tensile modulus.

- Reinforced Polymer is having high impact resistance.
- It is clear and high Glass material.
- It is excellent resistance [Exp-Oxygen] material.

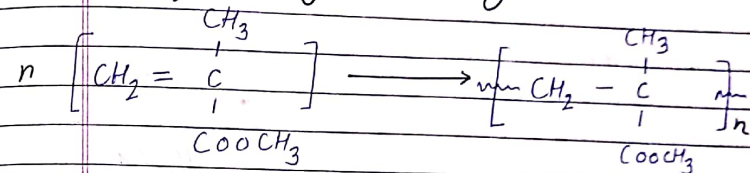
Applications :-

Decorative Radio grills, Filter Brush, Dolls hair, food Packaging, medical sector, Packaging film etc.

- Properties :-
- Superior chemical resistance
  - Extremely low moisture regain
  - Freedom from mould bacteria damage
  - High elastic recovery
  - Flame Resistance

PMMA

Poly methyl methacrylate

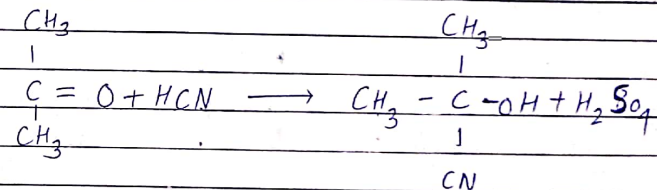


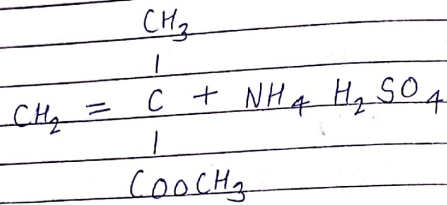
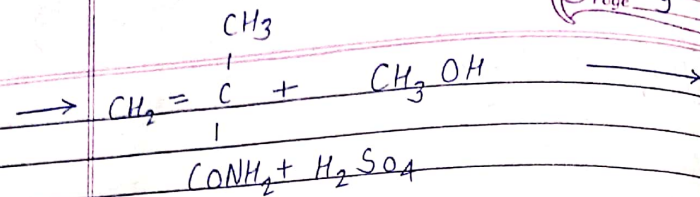
methyl methacrylate monomer

PMMA

PMMA is one of the most important Thermoplastic material. It is widely used for this property like - Transparency, Stiffness, Hardness, Excellent weather resistance property.

Monomer preparation :-





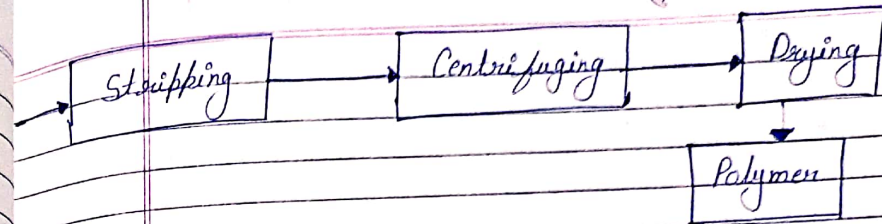
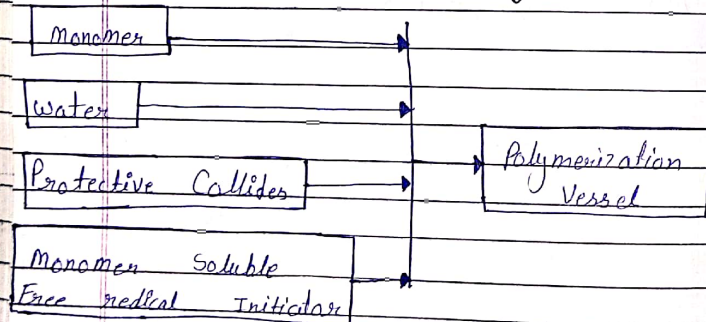
Acetone reacts with hydrogen cyanide [HCN].

Aceto Cynodryrin then it react with 98%  $\text{H}_2\text{SO}_4$  to give methacrylate amide sulphate.

which react methanol to form acrylo monomer.

Polymerization  $\rightarrow$  In this process can use Suspension, Bulk and solution.

### Suspension Polymerization.



### Properties $\rightarrow$

- It is hard, rigid and Amorphous (Transparent) material.
- It is having good weathering resistance.
- Light transmission is 92%.
- The mechanical and electrical properties are depend on Temperature and humidity.
- Specific gravity - 1.17 - 1.19
- $T_g$  - 85 - 105  $^{\circ}\text{C}$
- It is soft
- at Room temperature PMMA is a hard and brittle Thermoplastic material.

Processing Techniques  $\rightarrow$  Injection moulding, Extrusion, Thermo-forming.

### Applications $\rightarrow$

- Auto - Production of mirror, wind shield, Reflector, Glass replacement, Rear lamp housing,



head light cover

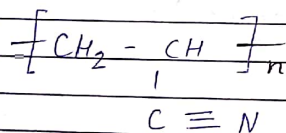
- Optical - optical lenses, Spectacle lenses, Video and TV Camera, watch etc.

- Aircraft - window glass, level indicator, meter cases, Food service tray, Bathroom accessories and Interior

- Medical - Disposable syringes, medical trays, Laboratory Fixture, Artificial body Parts, Baby incubator.

- From Google -

PAN  
Poly Acrylo Nitrile.



★ PAN is synthetic Semi-Crystalline resin.

Almost all Poly acrylo Nitril

resin are Co-Polymer made from mixture of Monomer with acrylo Nitrile.

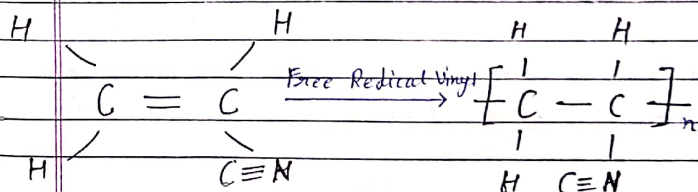
PAN fiber are the chemical component of high quality Carbone fiber.

It is chemically modified to make the Carbone fiber found in tennis racket and high Tech By-Cycle.

Monomer preparation  $\rightarrow$  Acrylonitrile  $[\text{CH}_2=\text{CN}]$   
a compound obtain by reacting propylene with ammonia  $[\text{NH}_3]$  and oxygen  $[\text{O}_2]$  in the presence of catalyst is polymerized to poly acrylo nitrile through suspension method using free radical Initiator.

Poly Acrylonitrile is a vinyl Polymer and a derivative of acrylate family of Polymer.

It is made from the monomer acrylonitrile by free radical vinyl Polymerization.



Properties  $\Rightarrow$  • It is mostly use in Clothing Purpose.

- It is a highly Crystalline material
- $T_g = 87^\circ\text{C}$
- Melting Point -  $319^\circ\text{C}$
- It is a flexible material
- It is high quality Carbon fiber
- It is fiber are resistance to breakage.
- Soft and Comfortable

This material are Thermalinsulating having a similar property to Natural wool.

In the form of fiber when heated it dose not melt maintain morphological structure.

It is use for the production of Carbon fiber. Insulating fiber.

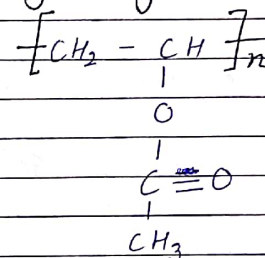
Applications  $\Rightarrow$  • It is use as fiber to make Knitted Item such as socks and Sweaters.

- It is used for Outdoor product like tent
- It is use as fiber in hot gas filtration system.

- Sails for yachts
- use in tennis racket and high tech Bicycle
- It is use in fire proof cloth
- Used in military purpose.
- Fishing rod, Carpet

PVA

Poly Vinyl Acetate



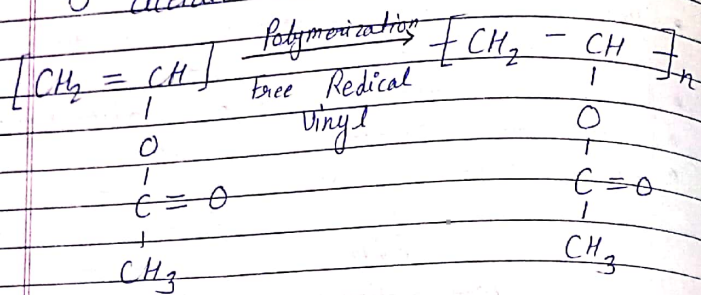
★ "Poly Vinyl Acetate was discovered in Germany in 1912 by Fritz Klatte."

it is an aliphatic Rubbery Synthetic Polymer with chemical formula  $[\text{C}_4\text{H}_6\text{O}_2]_n$  which belongs to the Poly vinyl ester family.

Preparation of PVA  $\Rightarrow$  Poly Vinyl Acetate is a Vinyl Polymer that is prepared by free radical vinyl



## Polymerization of the monomer Vinyl acetate.



Vinyl Acetate

PVA

Properties :- • PVA is an Amorphous Polymer.

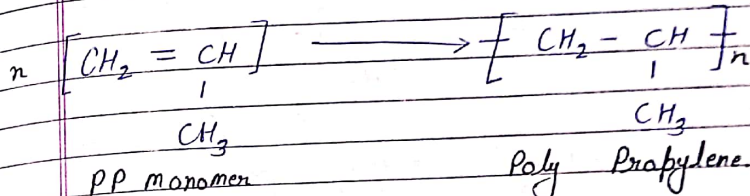
- The  $T_g$  between  $30^\circ C - 45^\circ C$ .
- PVA offer good adhesion most of the surfaces.
- Degree of Polymerization of PVA is 100 - 5000.
- PVC is does not cross link and it can be dissolve in many solvents other than water.

Applications :- • Emulsified PVA is used in water based adhesives like pastes and glues.

- PVA can be used as resinous component of latex paints, offering compatibility with a wide range of other paint chemicals.
- PVA is used as a primer for dry wall and other substrates.

## Assignment-2

Q1 Write down the P.P. manufacturing application and its properties.



Introduction of PP :- PP is Commodity Thermoplastic material Poly Propylene manufactured by various process.

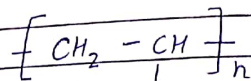
- Ziegler Process , • Batch Process
- Suspension Process

PP is prepared by using Ziegler type catalyst  $Ti$  tri chloride with aluminum tri ethyl, aluminum tri butyl in Naphtha under Nitrogen atmosphere to form slurry consisting of 10% catalyst and 90% Naphtha.

The Properties of Polymer are strongly dependent on the Catalyst Composition and its particle shape and size. The monomer weight can be controlled by using  $H_2$  as a chain

Transfor agent.

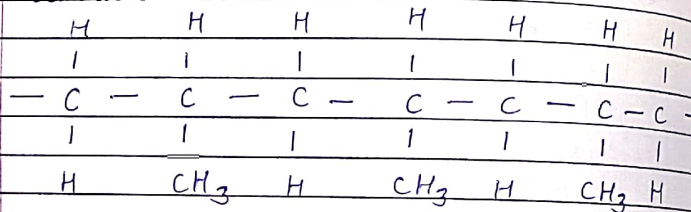
Structure Properties :->



- The  $\text{CH}_3$  group in the chain in Crystalline melting point.
- PP and PE having most of the similar properties.

Tacticity :-

1) Isotactic -

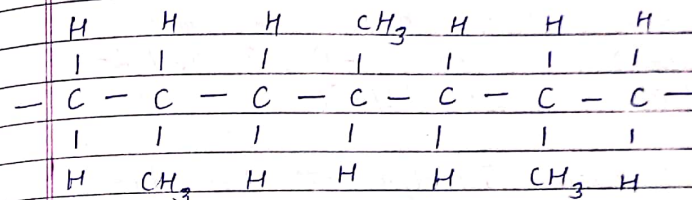


In isotactic all methyl group are on one side of the main chain of the Polymer.

2) Syndio tactic -

In Syndio tactic all the methyl group are arranged alternatively of the main chain.

3) Atactic -



In Atactic all methyl group are arranged randomly.

Properties :->

- Isotactic - It is highly Crystalline with a high melting point.
- Atactic - Material is a Amorphous and Rubbery material.
- General Property - PP Burns slowly and give smell of Crude oil.
- PP is tough and having good Impact strength.
- PP has high degree of



### Crystallinity

- Good Chemical resistance
- Excellent electrical Property
- High Optical Property
- Good surface hardness
- Good Puncture resistance
- Good glass and transparency
- Specific gravity -  $0.903 \text{ gm/cm}^3$
- Melting point -  $164^\circ\text{C}$

### Processing Techniques $\rightarrow$

- Injection moulding
- Blow moulding
- Pipe extrusion
- BOPP film

### Application $\rightarrow$

- Automotive - Door pocket, Radiator gasket, mud flap, seat Cover, Bumper
- Packaging - Film for Packaging of Tobacco, Candy, gum, Cosmetic, Contact lens Cases, Bottle, drum, Tool Box.
- Electrical/Electronics - Switch gear, Radio and T.V. housing, Control Knobs, Industrial light, Cable.
- House hold - Coffee maker, hair dryer, AC Part, Chair, table, mug, basket, bucket etc.

Q2. Write LDPE and HDPE manufacturing, application, properties, chemical Property

LDPE is prepared by the high pressure process.

HDPE is prepared by the Ziegler Process.

The Commercial high polymer are generally produce by under high pressure of  $1000-3000$  atmosphere temperature  $80-300^\circ\text{C}$

A free radical Initiator Benzoyl peroxide and oxygen is commonly used. The principal involve in high pressure of polymerization is free Radical of mechanism.

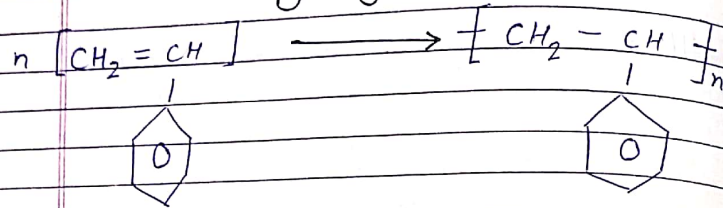
For the given system the higher temperature the faster the reaction and the lower the molecular weight.

Most high pressure polymer are the lower density range and usually low molecular weight range.

LDPE Contains 40-60% Linear Crystallinity. Density  $0.915$  to  $0.94 \text{ gram/cm}^3$ .

Q3. Write down the Poly Styrene manufacture Processes, application, Properties and write down the Co-Polymer of Poly Styrene.

Poly styrene [PS]

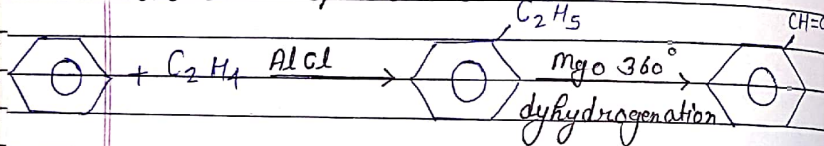


Styrene monomer

Poly Styrene

Introduction :- Poly Styrene is low cost material, it is a light weight material. The another name of Poly styrene is "Poly vinyl Benzene".

Monomer Preparation :-

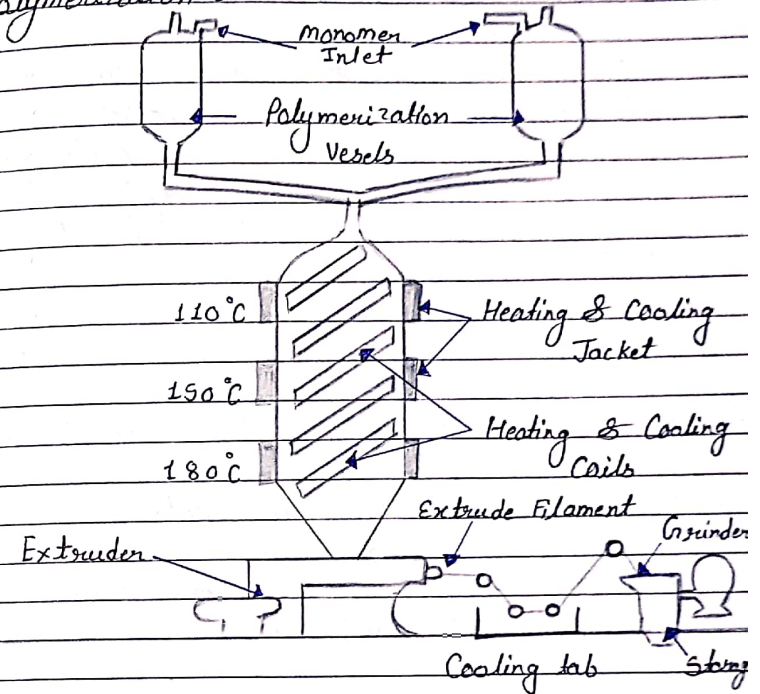


In this method benzene and ethylene to get "ethyl Benzene"

Ethyl Benzene prepared by reaction of ethylene and Benzene in the presence of catalyst as aluminum chloride.

Styrene is produced from ethyl Benzene by a process of dehydrogenation at  $630^\circ\text{C}$ .

Polymerization :-



This Process is known as "Tower Process" in this process styrene is polymerized by heating at  $80^\circ\text{C}$  for two days until 33% to 35% conversion to polymer is reached. The monomer polymer mixture is run into a tower about "25 feet" high.

The tower is fitted with heating and



Page 8  
Cooling jacket and melting and cooling coil. The top of the tower temperature is  $110^{\circ}\text{C}$  at center is  $150^{\circ}\text{C}$  at the bottom of the tower is  $180^{\circ}\text{C}$ .

The base of the tower an extruder from melt material passes from cooling channel the material cut by the griender after that store the material in to the packets.

Properties :-

- Specific Gravity of PS is 1.054
- PS is amorphous in nature
- PS is linear hydrocarbon polymer being thermoplastic in nature
- PS has extremely good electrical insulation properties
- PS has good dielectric and optical property.
- Available as low cost, excellent colour and transparency.
- Low water absorption

Date \_\_\_\_\_  
Page 9  
Processing Techniques :-

- Injection moulding
- Thermo forming

Applications :-

- Household - Boxes, gift article, Tray, Toys, Ball Pen, water jug.
- Automobile - Display si Reflector, Panel Cover.
- Electrical - Battery Cases, CD, Floppy storage Box.
- Medical - Disposable Syringe, Trip Controller
- Packaging - Bottle Cap, Bottle, Container, Flower Packing, Utility Box.

Co - Polymer of Poly styrene :-

ABS - Acrylo Nitrile Butadiene styrene  
HIPS - High Impact Poly styrene  
SAN - Styrene Acrylo Nitrile

## Cellulose

Cellulose is a Natural Polymer produced from wood pulps. The Cellulose contain various from plant to plant.

Woven grade Cotton contain about 90% Cellulose

CA - Cellulose Acetate

CAB - Cellulose Acetate butyrate

CAP - Cellulose Acetate Propionate

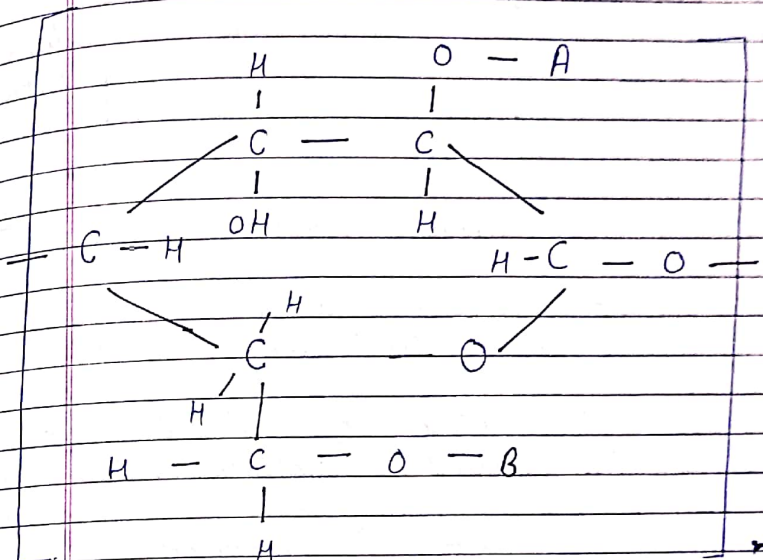
CAT - Cellulose Acetate Triacetate

Polymerization  $\rightarrow$  Cellulose Plastic are manufactured by chemical modification of Cellulose

The Cellulose ester are prepared by reacting Chemical Cellulose with organic acid and anhydrides using Sulphuric acid as a Catalyst.

In the standard synthesis of CA the reaction acetic acid and acetic anhydrides to the Triester stage. CA is then

prepared by hydrating the triester to remove its acetyl group plastic grade CA contain 38-40%



| where                                                                                                  | where                                                                                                  | Plastic |
|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|---------|
| $\begin{array}{c} \text{A} \\ \text{H} \\   \\ - \text{C} - \text{CH}_3 \\    \\ \text{O} \end{array}$ | $\begin{array}{c} \text{B} \\ \text{H} \\   \\ - \text{C} - \text{CH}_3 \\    \\ \text{O} \end{array}$ | CA      |
| $\begin{array}{c} - \text{C} - \text{CH}_3 \\    \\ \text{O} \end{array}$                              | $\begin{array}{c} - \text{C} - \text{CH}_2 - \text{CH}_3 \\    \\ \text{O} \end{array}$                | CAP     |



|                                                   |                                                             |                   |
|---------------------------------------------------|-------------------------------------------------------------|-------------------|
| $\begin{array}{c} -C-CH_3 \\    \\ O \end{array}$ | $\begin{array}{c} -C-CH_2-CH_2-CH_3 \\    \\ O \end{array}$ | CAB               |
| $-NO_2$                                           | $-NO_2$                                                     | Cellulose Nitrate |

### Cellulose Acetate

Cellulose acetate is a forming substance for acetate fiber.

Acetate is obtained by dissolving wood pulp into purified Cellulose.

- Cellulose acetate is produced by reacting the purified Cellulose with acetic acid and acetic anhydride, using sulfuric acid as a catalyst.

#### Properties -

- High water absorption
- Poor electrical insulating properties
- Limited heat resistance
- Good strength
- Good Impact Resistance

### Applications

Photographic purpose  
tooth brushes.

Combs  
spectacle frames  
greeting cards

### [CAB] Cellulose Acetate Butyrate

CAB is an amorphous, transparent Cellulosic thermoplastic. It is similar to Cellulose acetate but more resistant to weathering and has low moisture absorption.

#### Properties -

Good toughness  
Excellent appearance  
Giving good coating  
Low water absorption  
Better flow properties  
Lower Density

#### Application -

- Tonys
- Tools handles
- telephone housing
- outdoor display
- goggles
- Bathroom fitting
- drawing stencils



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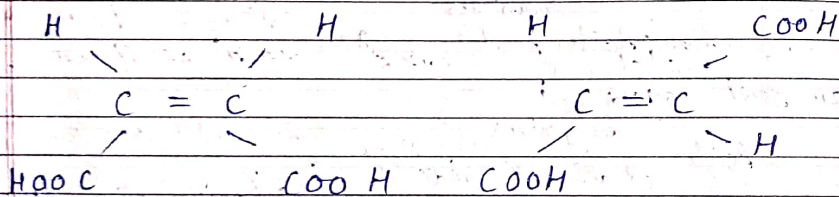
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## Topic Unsaturated Polyester Resins -

Unsaturated polyester (UP) are linear poly condensation products based on unsaturated and saturated acids/anhydride and diols or oxides.

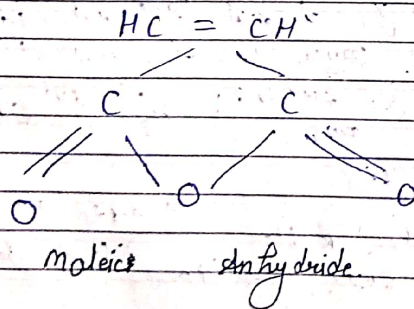
Usual reinforcement is glass fibers as a perform, cloth, mat or roving, but sisal or more conventional fabrics may be used.

Unsaturated and saturated Acids/Anhydrides.



Maleic Acid

Fumaric Acid



Maleic anhydride is prepared by passing a mixture of benzene vapour and air over a catalyst [Vanadium derivative] at elevated temperature [450°C]. It is a crystalline solid melting at 52.6°C.

Fumaric acid is prepared by heating maleic acid with or without catalysts.

The acid is a solid melting at 294°C.

Phthalic anhydride is most commonly used for this purpose because it provides an inflexible link and maintains the rigidity in the cured resins.

It is usually produced by the catalytic oxidation of o-xylene.

It is a crystalline solid melting at 131°C.

Manufacture: →

Polyester laminating resins are produced by heating the component acid and glycols at 150-200°C for 12 hours.



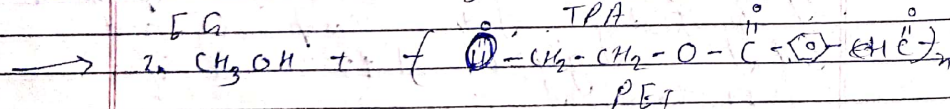
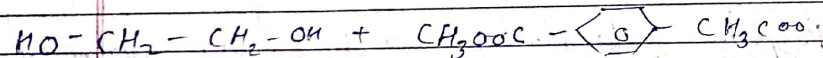
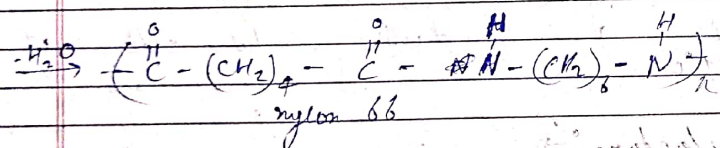
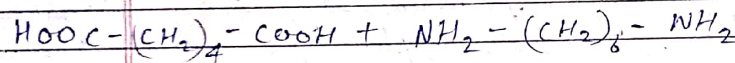
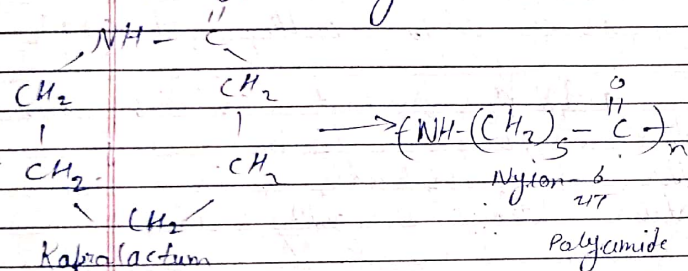
- Under an inert blanket of carbon dioxide or nitrogen

A typical charge for general-purpose resin would be.

Propylene glycol 146 Parts

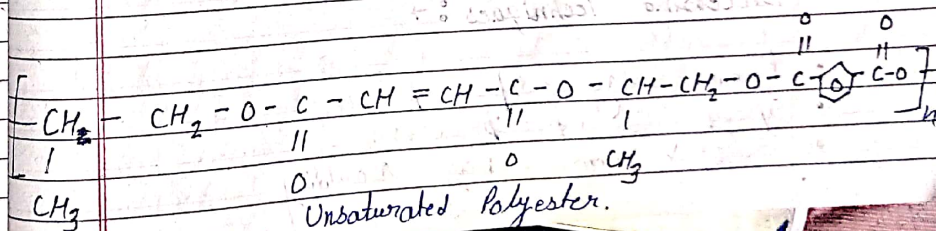
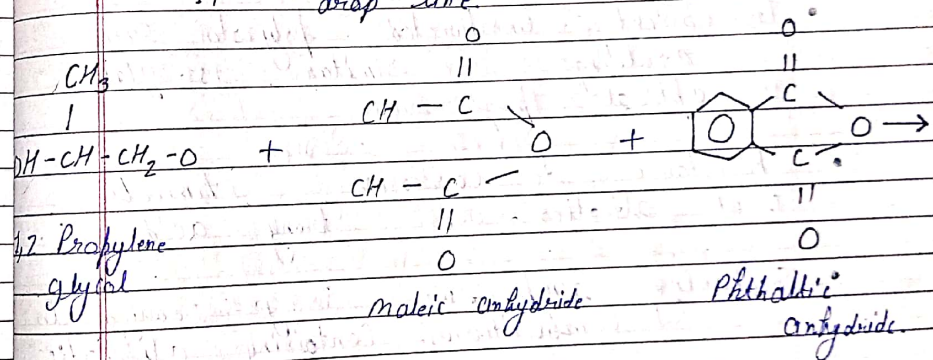
maleic anhydride 114 Parts

Phthalic anhydride 86 Parts



where -

- 1- Pressure rated reactor ( $22\text{m}^3$ )
- 2- agitator blade
- 3- internal and heating and cooling coils.
- 4- Fractionating column
- 5- Condenser
- 6- distillates receiver
- 7- glycol tank
- 8- acid tank
- 9- inert gas unit
- 10- drop valve
- 11- blend tank ( $35\text{m}^3$ )
- 12- internal cooling coils
- 13- Agitator blades
- 14- drop line



## Properties :-

### Tensile

- Good weather Resistance

Fiber reinforcement improve both the tensile and flexural strength Characteristics.

- Deformation at higher temperature is greatly reduced by inorganic fillers.

- Transparent unsaturated polyester resin mouldings are similar to glass in optical performance.

- Resistance to corrosive chemicals, weak alkalis and strong acids.

- Softening temperature is reduced in compositions containing aliphatic.

### Processing Techniques :-

- Hand lay-up process
- Spray up process
- Vacuum Bag moulding

## • Autoclave moulding

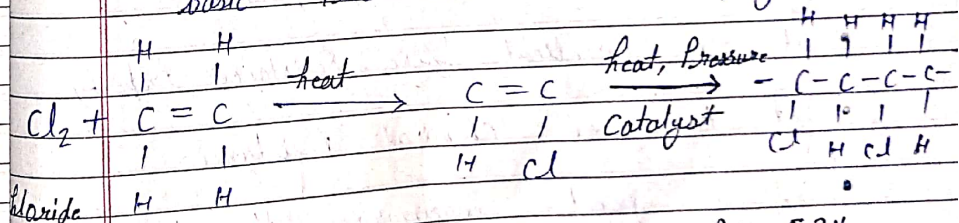
### Applications ->

- Multi-purpose FRP Building.
- FRP-door
- Land transport and air craft
- for Dash Board and engine hood in automobile
- Floor Hockey stick
- Tennis racket.
- Elbow
- Chemical storage Tanks
- Pipe line for chemical transport.
- Electrical Junction Box.

## Topic - CPVC [Chlorinated Poly vinyl chloride]

CPVC is a PVC Homopolymer that has been subjected to a chlorination reaction.

Chlorine and PVC react according to the basic Free radical polymerization

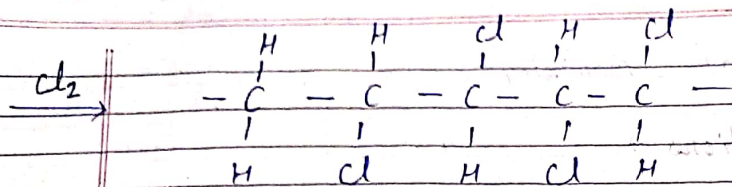


chloride

ethylene

PVC-57%  
Chloride





CPVC - 67% Chloride

The Reaction is Typically Initiated by application of thermal or UV energy.

Properties: → • CPVC has most of the properties of PVC.

- It is also workable, machining, welding, forming because of its excellent corrosion resistance at elevated temperatures.
- It has excellent fire resistance property.
- It has good chemical resistance.
- It is popular engineering thermoplastic material due to its low cost.

- High  $T_g$  about 100°C
- High Impact strength
- good Tensile strength
- Non-Toxic
- more ductile material
- CPVC and PVC Resistance to fire

- It is typically very difficult to ignite
- Self-extinguishing material when not a direct flame applied.

Application -

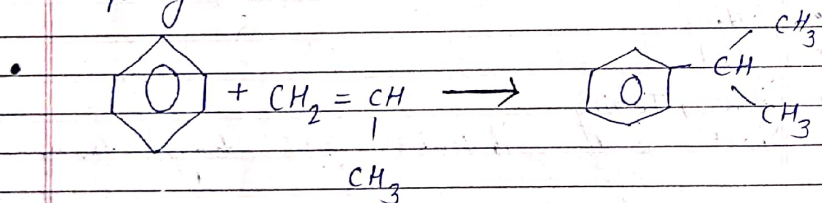
- Pipe and fitting for water supply
- large diameter duct
- Pump
- Ball
- ~~Strainers~~ Strainers
- Filters
- Sheet
- Rod, Tubing
- Sheet for fabrication of storage tanks

## Phenol formaldehyds

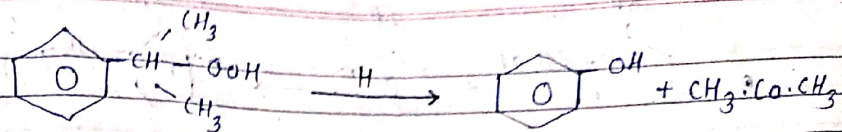
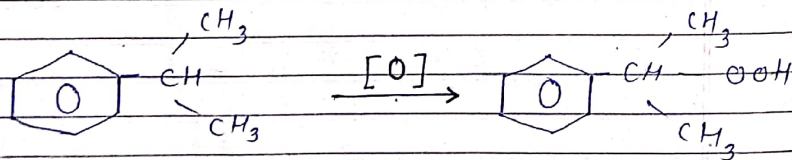
- Phenol formaldehyde resin are used as moulding powders, laminating resins, adhesive binders, surface coatings.
- P.F. Considered to be the first polymeric product produced commercially.
- First Commercial phenolic plant started on 1910 by "Rutgerswerke A.G."

### Preparation of Phenols -

Cumene process is the most important process, more than 95% of phenol capacity.



then,



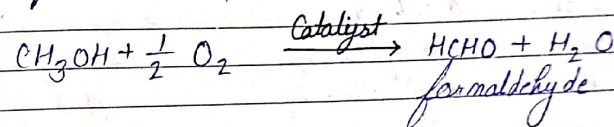
Phenol

In this process liquid propylene containing some propane mixed with Benzene.

### Preparation of formaldehyde

Pure phenol is "Colorless".

### Preparation -

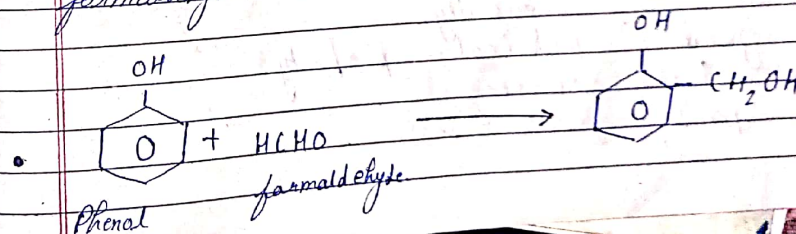


### Types of phenol Formaldehyde

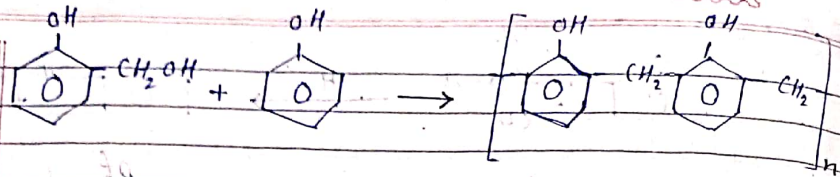
i) Novolak Resins.

### Preparation -

Prepare by reaction of phenol and formaldehyde







Novolac P.F.

## ii) Resol Resins -

### Preparation -

Prepared by reacting phenol with formaldehyde in molar ratio 1:1.5 - 2

### Processing Techniques -

Compression moulding  
Transfer moulding  
Injection moulding

### Properties -

- High Surface Hardness
- High Toughness
- High Heat-Distortion Temperature.
- Low water absorption.
- Low flammability.
- good Electrical property.
- High stiffness
- Specific gravity - 1.38

### Application -

Handle Knobs, All kind of Handle used in intensil, Insulating material, fibrous and Granulated wood,

Textiles, papers, Desk lamp, Laboratory for Countertops, Circuit, switch etc.

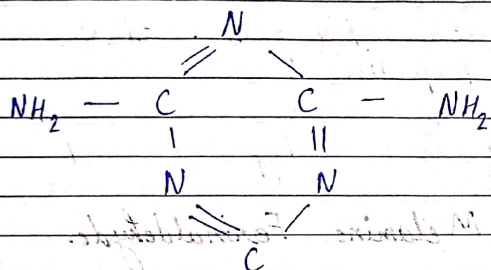
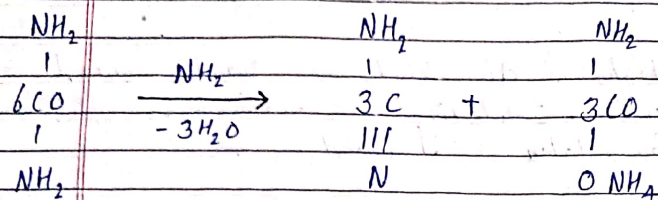
- Phenolic resin have good adhesive and bonding properties.

- Also used for coating of wood

### Melamine Formaldehyde

Methods of producing melamine formaldehyde

- Heating dicyanodiamide, either with ammonia or on its own under pressure.
- Fusion of dicyanodiamide with a guanidine salt.
- form urea



### Manufacture of melamine formaldehyde.

In a typical process a jacketed still fitted with a stirrer and reflux condenser is charged with 140 part 37% w/w formalin and PH adjusted 8.0 to 8.5 using  $\text{Na}_2\text{CO}_3$  126 part of melamine [to given melamine formaldehyde ratio 1:3]

melamine goes into solution and forms methylol derivatives.

### Properties-

High surface hardness.  
Scratch resistance  
Resistance to moisture  
Heat Resistance  
Resistance to chemicals  
low water absorption  
Transparent  
Abrasion Resistance  
M.F. more expensive than UF and P.F

### Applications-

Plywood, Particle board adhesive, Countertops and Tabletops, Automotive surface coating, Textile furnishing etc

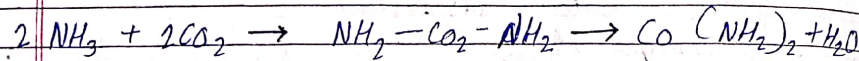
Kitchens - spoon, plates, Trays

Melamine moulding compounds are available as powder, fibers, Granules.



## UREA Formaldehyde Resin

Urea is prepared by the reaction of liquid Carbon dioxide and ammonia in silver-lined autoclaves at temperature  $135 - 195^{\circ}\text{C}$  and Pressure  $70 - 230$  Atm.



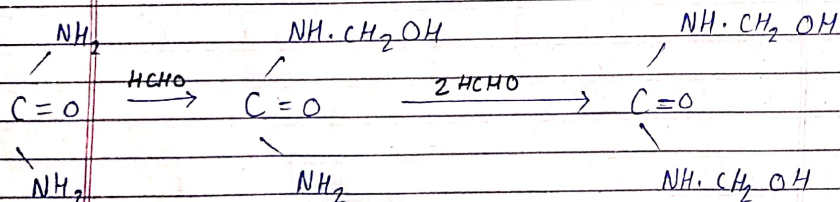
### Preparation of Formaldehyde

In the case of phenolic resin, Formalin with both high and low methanol content is used to prepare formaldehyde.

### Manufacturing -

Urea formaldehyde resin are manufacture by two-stage reaction.

U.F. ratio range  $1:1.3$  to  $1:1.5$



Solution, at the end of first stage process contain urea formaldehyde and mono and dimethyl urea.

### Properties -

- Wide colour range.
- High tensile strength.
- High heat distortion temperature.
- Low water absorption.
- mould shrinkage.
- High surface hardness.
- Volume Resistance.
- Heat Resistance.
- Hardest plastic material.

### Application -

- Laminates, Textiles, products cosmetic, wrinkle resistant fabrics.
- Foam, Artificial Snow, Plugs, sockets, switches, switch box, lamp holder, table mats, telephone sets, office accessories and used in moulding areas.



## EPS

### Expanded Poly Styrene -

Expanded Polystyrene is a lightweight and rigid Foam material.

Expanded Polystyrene is a lightweight, rigid and insulating material commonly used in packaging, construction and various other application.

### Manufacturing →

- Polystyrene beads are loaded into a pre-expander machine where they are exposed to steam. ~~not visible~~
- Raw Polystyrene beads are pre expanded using steam. This step increase their size and reduces density.
- The Pre-expanded beads are left to cool and age for a specific period to allow them stabilize.
- The aged beads are then moulded into the desired shape using steam and pressure.

### Properties →

- EPS is light weight material.
- Excellent thermal insulating properties.
- Excellent impact strength.
- fire Resistance.
- EPS is 100% Recyclable.
- Good die-electric properties.
- Excellent chemical Property.
- Weathering Resistance

### Applications →

Building and Construction - Road, bridges, Railway lines, Public building, Roof and flooring.

Packaging → fruit tray, drink cups, ice food packing, industrial packing boxes.

Others → Sport helmet, seating in sports car, Chair, Insulated panels.



## Thermoplastic Elastomer

### TPE

A Thermoplastic elastomer is flexible and rubber like material that process like plastic.

A TPE is a true thermoplastic which does not require vulcanization.

#### Properties-

- TPE is a flexible material
- Ease of Processing
- Chemical Resistance
- Temperature Resistance
- Light weight
- Abrasion Resistance
- Good recyclable
- Good Adhesion

#### Applications-

- Automotive - Seals, gaskets, Interior components like dashboard trim and armrests.
- Footwear - shoe soles, sportswear and athletic shoe, scuba slippers.

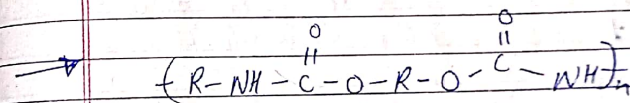
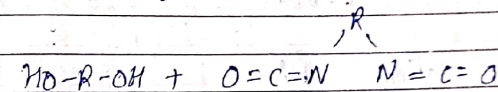
Medical - Breathing tubes, Syringe seals, Ventilation mask

Construction - Seals for door and windows, glazing seals, Pipe seals.

### TPU

Thermoplastic Poly urethane

Thermoplastic Poly urethane [TPU] is a type of thermoplastic elastomer known for its versatility and excellent physical properties.



#### Properties ->

- High Impact Resistance
- Abrasion Resistance
- High tensile strength
- Excellent Heat Resistance
- melting Point - 240°C
- good bio Compatibility
- weather Resistance

Application - conveyor belts, Inflatable items, sports equipments, footwear, adhesives, floor mats, Paints, mobile phone casings.