Polymer chemistry

Polymer :-

Those macro molecules which are formed by small simple molecules are known as polymers. These small simple molecules are called monomers. The combination of simple molecules repeatedly two or more times in the same regural manner to formed polymer is known as polymerization.

For eg :-

$$nM \xrightarrow{\text{Polymerization}} [M\text{-}M\text{-}M\text{-}M]_n$$

$$\underset{\text{ethene}}{CH_2=CH_2} + n\underset{\text{ethene}}{CH_2=CH_2} \xrightarrow[\text{Polymerization}]{\text{Polymer}} [-CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2]_n$$

Classification of polymer :-

There are diffrent basis to classify polymer are as follow :-

(A) On the basis of source of polymer, there are 2 types of polymer :

(i) Natural Polymer :-

The polymer which are obtained from nature i.e. plants and animals are called natural polymers.

For eg :

Starch, cellulose, natural rubber, proteins, paper etc.

(ii) Synthetic polymer:-

The polymers which are prepared by human beings in laboratories are called synthetic polymer.
Eg:- polyethene, bakelite, pvc, nylon etc.

(B) On the basis of combination of monomers units there are two types of polymers

(i) Homopolymer

The polymers which is formed by the combination on ~~type~~ type of monomers or same type is called Homopolymers. Eg: polythene, PVC etc.

(ii) Co-polymer:-

The pdymers which is formed by the combination of two or more types of monomers is called Co-polymer or Hetero-polymer

Eg: Bakelite [Formaldehyde + Phenol]
Nylon 6,6 [Adipic acid + Hexamethylene diamine]

(C) On the basis of combination of atoms, there are two types of polymers.

(i) Inorganic:

These polymers which are formed by the combination of atom other than carbon atoms are called inorganic polymers.

Eg:- silicon polymer, polyphosphazine, polynitrate etc.

Organic polymer:-

Those polymer which are formed by combination of carbon atoms are called organic polymers. Eg Backelite, Nylon 6,6 polyethene etc.

Types of organic polymer

IMP

(i) Addition polymer or chain polymers:-

Those polymers which are formed by addition of same monomers with intermolecular rearrangement is know as addition polymers they are also called chain polymer. The phenomenon known as additinal polymer occurs due to application of heat, light, catalysit for breaking down of covalent bond of monomers. For eg:- PVC or polyethene.

$$CH_2 = CH_2 + CH_2 = CH_2 \longrightarrow [-CH_2-CH_2-CH_2-CH_2-]$$

(ii) Condensation polymers

The polymers which are formed after condensation (elimination) of monomer are known as Condensation polymers and the phenomenon is called condensation polymersation. In this polymerisation the basis monomers combination of through condensation xn by elimation

simple molecules may be H_2O, NH_3, HCl etc

For eg:-

$NH_2 - CH_2 - COOH + NH_2 - CH_2 - COOH$

amino acid

↓ Polymerization

$-[NH - CH_2 - \overset{O}{\overset{\|}{C}} - N - CH_2 - \overset{O}{\overset{\|}{C}} -]_n$

polyamino acid

(iii) Plastic polymers :-

Those polymer which have higher molecular weight and can be moulded into any desired from when subjected to heat and pressure in the presence of catalyst are known as plastic polymers.

On the basis of moulded and non-remoulding there are categorized into 2 type

(a) Thermo plastic

Those polymers which are formed by only addition polymerization which can be reuse by heating and pressure or both is known as thermoplastic polymer.

Eg PVC, polyethene.

Properties of thermo plastic

(i) They are formed addition polymerization only.

(ii) They consist of long chain linear polymer with negligible crosslink.

(iii) They soften on heating readily because secondary forces between the individual chain bond can be broken easily by heat.
(iv) By reheating it can be reshaped and reuse
(v) They are usually soft, weak and less brittle.
(vi) They soluble in some organic solvents.

(b) Thermo setting plastic :-

Those polymer which are formed by only condensation polymerization which can not be reuse by heating or pressure or both is know as thermosetting polymers.

Properties of thermo-setting plastic :-

(i) They are formed by condensation polymerization
(ii) They are three dimensional network structure.
(iii) They cannot be reshaped and reused on heating.
(iv) Since thermo setting polymer are cross-link structure so, it is can not be break by heating.
(v) They are usually hard, strong and more brittle.
(vi) They are almost insoluble in all organic solvents.

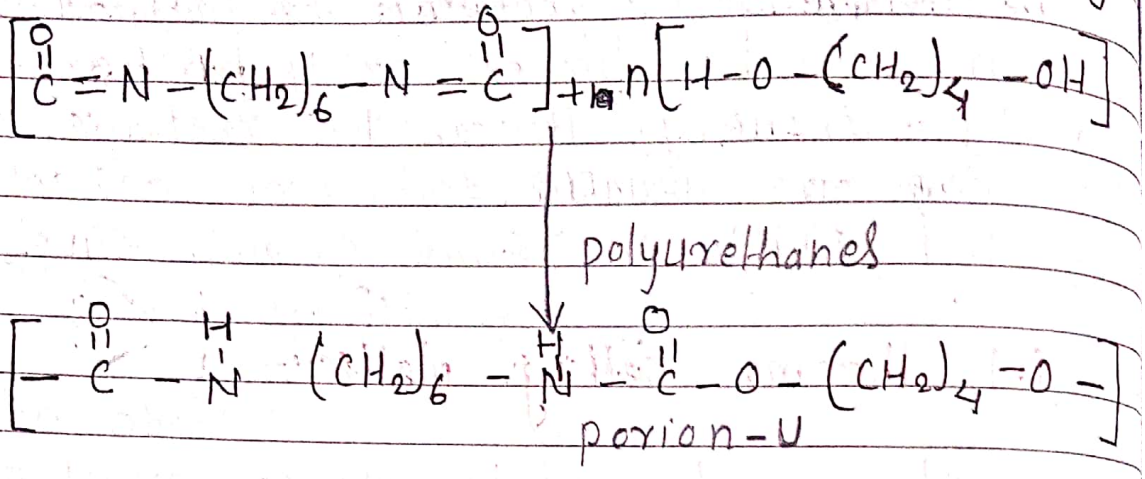
Preparation & application of organic polymer.

(1) Polyurethanes :

preparation :

It can be prepared by reacting of diisocyanate and diol. For example :- perion-4 is preparationed by the action of

1,4 → butane diol with 1,6- hexanediisocyna



Properties of urethane and polyurethane

(i) It is stable up to -40 degree Fahrenheit.
(ii) It is resistant to ozone, oxygen and water.
(iii) The compounds have low coefficient of friction when not lubricated.
(iv) Lower the number, the less, friction on the surface.

Uses :-

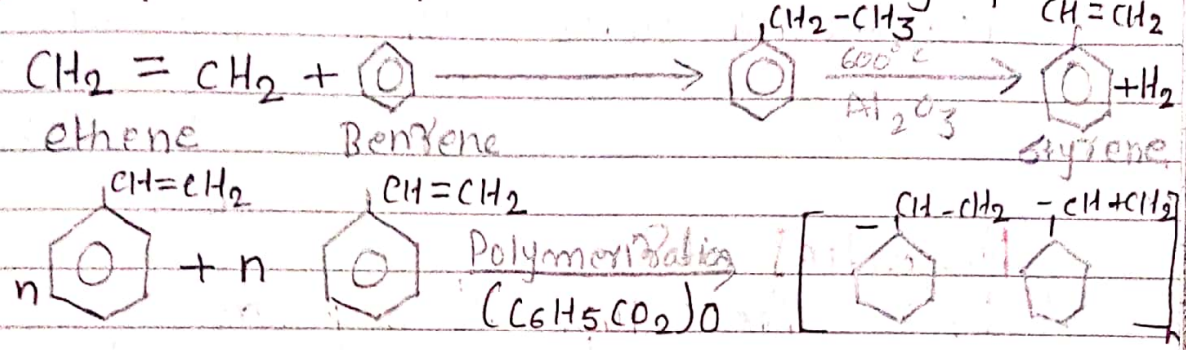
(i) They are used as a layer coating
(ii) Fibers of it is used in garment industry and swimsuit.
(iii) They are used as a synthetic leather
(iv) They are used to produce or manufacture different types of gasket and seals.

(2) Polystyrene (Polystyre)

Preparation :-

The monomer units are styrene molecules. It is additional polymer. It is

prepared by the free radical polymerisation of styrene in presence of benzoyl peroxide



Properties of polystyre:

(i) It is hard brittle; and have density of 1.050 g/cc and
(ii) It is highly flammable and burns with orangl yellow flame.
(iii) On oxidation it produced CO_2 and H_2O
(iv) It's melting point is 240°C
(v) It is chemically inactive due to being singe bond from double bond.
(vi) It is used to form container for food matteral and for chemical storages.
(vii) It is used to make hot dream cups. different types of toys, combs, household articles.
(viii) It is used to manufacture tiles for floors.

(3) PVC (Polyvinylchloride) ($CH_2 = CHCl$)

Preparation:-

It is monomer unit of vinyl-chloride. It is addition polymer. It is prepared by heating Vinylchloride in an inert solvent in the presence of peroxide like dibenzoyl peroxide.

$$CH \equiv CH + HCl \xrightarrow[60^\circ - 80^\circ C / HgCl_2]{1 \text{ to } 1.5 \text{ atm}} CH_2 = CHCl$$

i.e. Vinylchloride

$$n\,CH_2 = CHCl + n\,CH_2 = CHCl \xrightarrow[\text{dibenzoyl peroxide}]{\text{Peroxide}} \left[-CH_2-CH(Cl)-CH_2-CH(Cl)-\right]_n$$

PVC

(Free radical mech...)

Properties

(i) It is linear type of polymer.

(ii) It is hard and rigid, but it can be made soft by adding phosphate esters such as n-butylphosphate.

(iii) It has low permeability of gases.

(iv) It is not recommended to use at temp above 70°C because it may crack and destroyed above 70°C.

Uses:

They are used in two ways:

(i) As unplasticized PVC:

Unplasticized PVC are used for manufacturing of tanks, helmets, refrigerator, windows and door for house used. They are also used for manufacturing of ~~vechical~~ vehicle type.

(ii) As plasticized PVC:

plasticized PVC are used for manufacturing of raincoat, hard bags, cloths, toys, table cloths, belts etc. They are also used to prepared insulating materials for wires and other electric goods. Also used in artificial flooring.

(5) Polyethene :-

Preparation:

It is prepared by polymerization of ethene under appropriate condition of temp^{r} and pressure.

$$n\,CH_2=CH_2 \xrightarrow[\Delta]{\text{Pressure}} \left[-CH_2-CH_2-CH_2-CH_2\right]_n$$

polyethene

In conamercial scale, it is prepared by passing ethene through hydrocarbon solvent containing catalyst, mixture of triethyl aluminium $(CH_3CH_2)_3Al$ and titanium tetrachloride $(TiCl_4)$ called Ziegler Natta catalyst at 70°C.

$$n\,CH_2=CH_2 \xrightarrow[\text{hydrocarbon solvent}]{\text{Pressure, 70°C, } CH_3CH_2Al + TiCl_4} \left[CH_2-CH_2-CH_2-CH_2\right]_n$$

polyethene

Properties and Uses:

polyethene is insoluble in acids, alkalis and organic solvents and highly flaminable towards heater fire. It is used to make plastic bags, bottles, containers, electric insulator, etc.

(6) Polytetrafluoro ethylene (TEFLON or PTFE):-

Preparation:-

It is an addition polymer of tetrafluoro ethylene

It is obtained by polymerization of water

emulsion of tetrafluoro ethylene under pressure in presence of benzoyl peroxide as a catalyst.

$$n\,CF_2=CF_2 + n\,CF_2=CF_2 \xrightarrow[\text{Benzoyl peroxide}]{\text{polymerisation}} \left[CF_2-CF_2-CF_2-\right]_n$$

Teflon

Properties:

(i) It is very tough material and its resistance towards heat, action of chemicals like acids, base and all known solvents.
(ii) It is only attack/reacted by alkalimetals and by fluorine at high temp.
(iii) It is heat resistance upto 260°C and bad conductor of electricity.
(iv) It has coefficient of friction extremely low so, it is non-sticky.

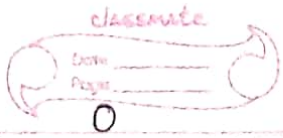
Uses:

(i) It is used in manufacturing insulating material for motor transformers, cables wire e
(ii) It is also used for making gasket and seal
(iii) It is also used in transportation of chemicals
(iv) It is used for coating, cookware to make them non-sticky.

(6) Nylon 6,6

Preparation:

The monomer units of nylon 6,6 are hexamethylene ~~and hexamethylene~~ diamine & adipic acid.



$$NH_2-(CH_2)_6-NH_2 + HO-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-OH$$

adipic acid

↓ Polymerized

$$\left[-NH-(CH_2)_6-\overset{H}{\overset{|}{N}}-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-\right]_n + n H_2O$$

Properties

(i) They have high melting point.
(ii) They are white in colour
(iii) They are strong and elastic in nature
(iv) They insoluble in organic solvent but soluble in phenol and formic acid

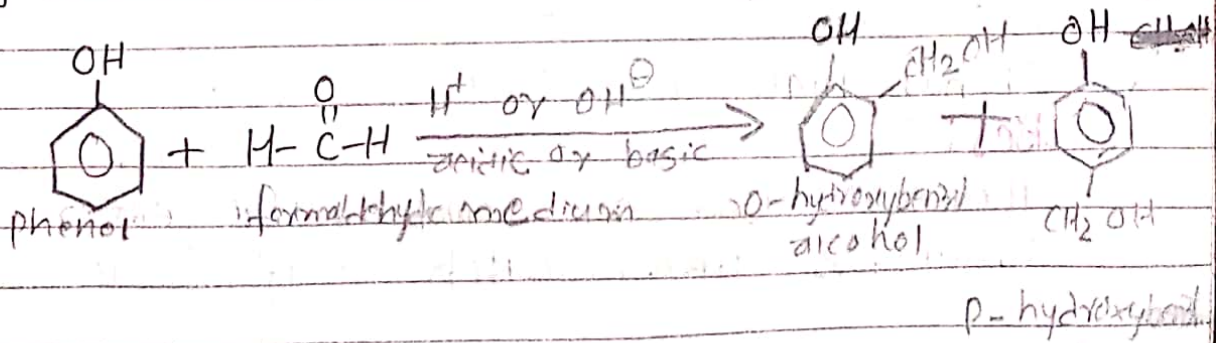
Uses :-

(i) They are used in preparation in brushes.
(ii) They are used making textiles.
(iii) They are used in making ropes.
(iv) They are used making automobiles tubes.

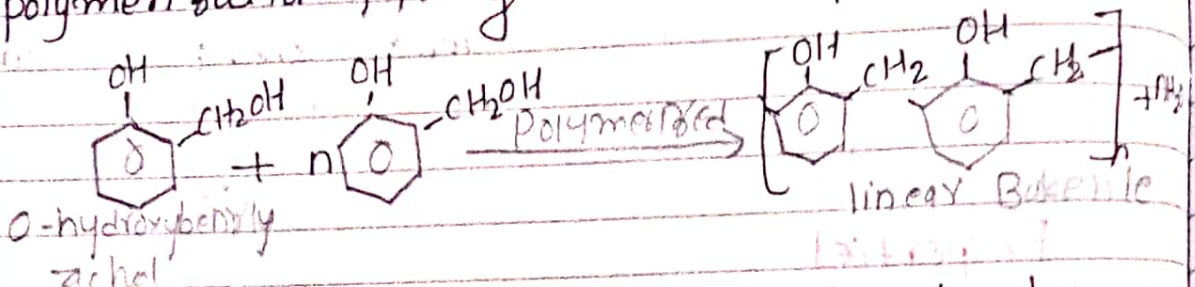
(7) Phenol formaldehyde resin (Bakelite)

Preparation :-

It is condensation polymer and is obtained from phenol formaldehyde in presence of acidic / base as as catalyst.

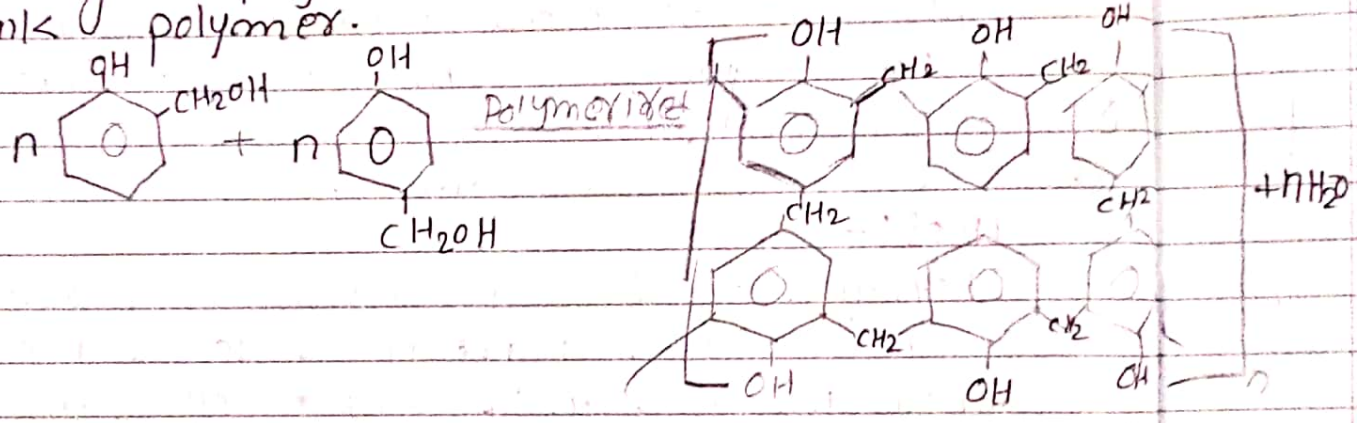


Here, ortho and para hydroxybenzl alcohol is produce. The same molecules when undergoes polymerization, it gives linear product.



o-hydroxybenzyl alcohol

Thus, ortho and para substitude phenols can undergoes polymerization of produce a cross link polymer.



Properties:

It is thersetting polymer.
It is to rigid and very hard
It has high restance towards heat and water
It is insoluble solid.
It is unreactive towards many chemicals like acid, base etc.
It has high insulating properties.

Uses:

They are used in manufacturing electric insulators like, switch, plugs, heater handle etc

They are used to make body parts of telephone, radio etc.
They are used in paints and vernish
They are used to make handle of cookwares which are used for heating pre-purpose.

Inorganic Polymer

Silicones or silicons polymer:

~~Preparation~~

Silicon polymer contains silicon oxygen alternate structure chain which has organic radicals or groups attached as side chain to the silicon atom.

Preparation :-

Silicon polymer is prepared by reacting siliconhalide with alkylahalide or silicon halide with Grignard reagent to give alkyl silicon halide which uncontrolled hydrolysis gives silicon polymer.

$Si + 3CH_3Cl \longrightarrow CH_3SiCl_3 , (CH_3)_2SiCl_2$

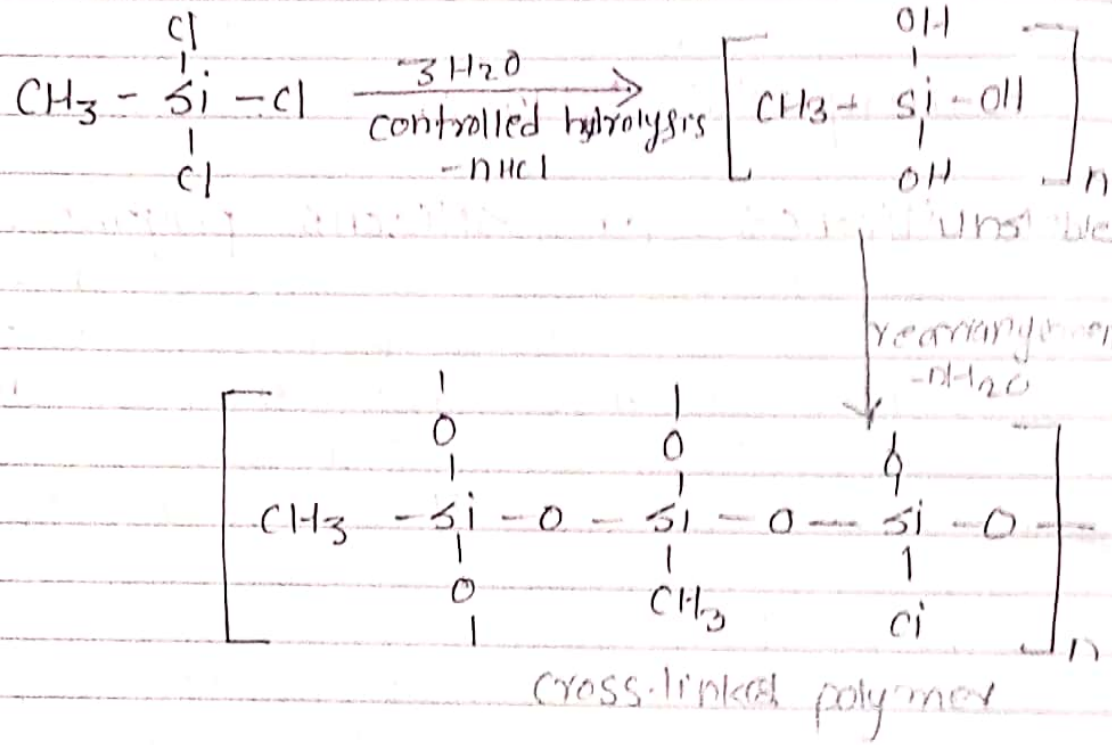
$SiCl_4 + 7CH_3MgCl \longrightarrow (CH_3)SiCl , (CH_3)_4Si + 7MgCl_2$

These polymer can be separated by fractional distillation

Types of silicon polymer

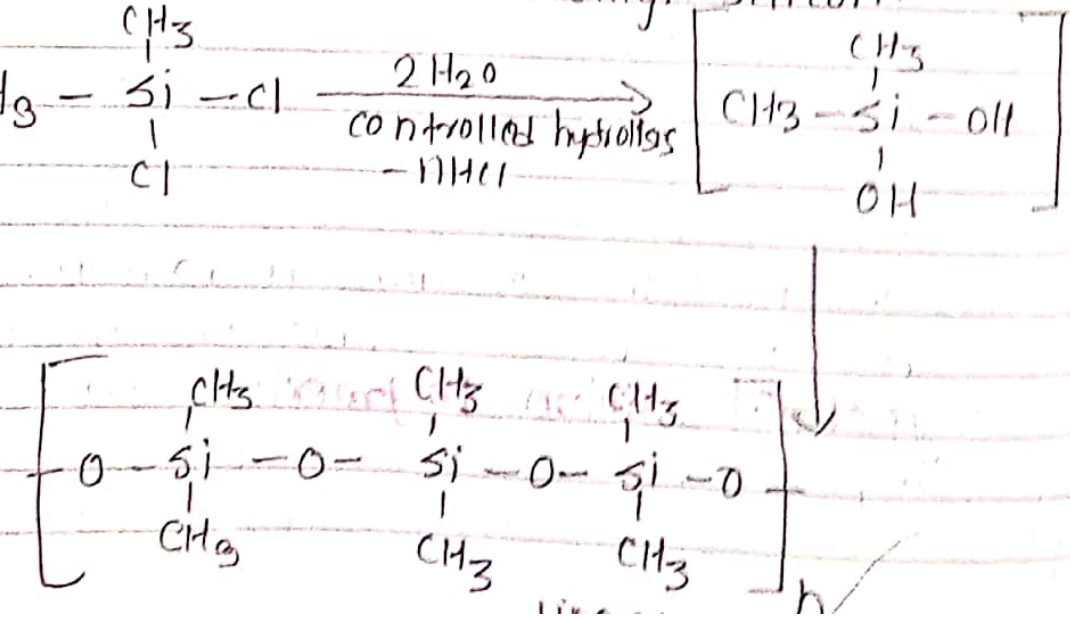
(i) Monomethyl silicon trichloride (CH_3SiCl_3)

It is trifunctional unit particle and give cross link to the final polymer.



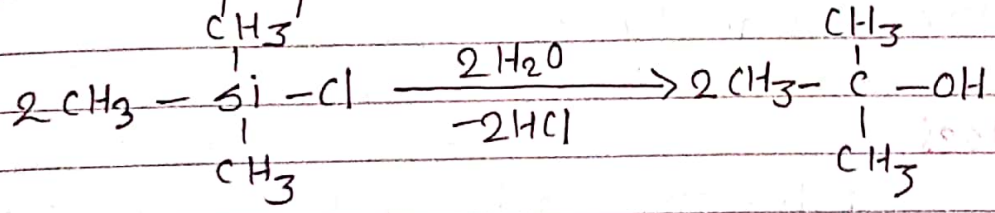
(ii) Dimethyl silicon dichloride $(CH_3)_2SiCl_2$

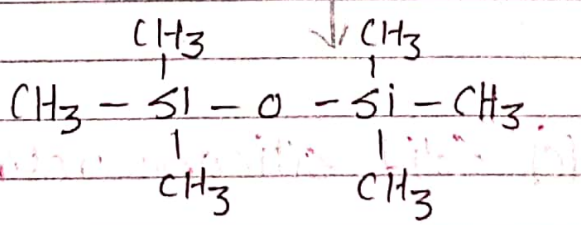
It is bifunctional unit particle after polymerisation it gives the liner chain polymer or silicon rubber or dimethyl silicon.



(iii) Trimethyl silicon chloride $(CH_3)_3SiCl$

It is monofunctional and it is also known as chain stopper unit particles. Therefore, used in proportions to limit the chain length





Different types of silicon polymer and their uses

(a) Liquid silicon or silicone oils:

They are generally dimethyl silicon having relatively low molecular weight silicones. They posses low surface tension very small changes in viscosity with temperature and great wetting power for materials.

Uses:

(i) They are used as high temperature lubricants.
(ii) They are used as an anti forming agent, water repellent finishes for leather and textiles.
(iii) They are used in cosmetics and polishes.
(iv) They are also used in heat transfer media as damping and hydraulic fluids

(b) Silicon greases:

They are modified form of silicon oils. They are prepared by mixing of dimethyl silicon with filler like silica, carbon black lithium soap, wood flour, marble floor, china clay etc.

Uses

The are particularly used in the form of lubricant in situation where very high and very low temperature are encountered.

(c) Solid silicon resins:

They are highly cross-linked silicone obtained by condensing bi-functional silicon halide and tri-functional silicon halides like $(CH_3)_2SiCl_2$ and CH_3SiCl_3.

Uses:

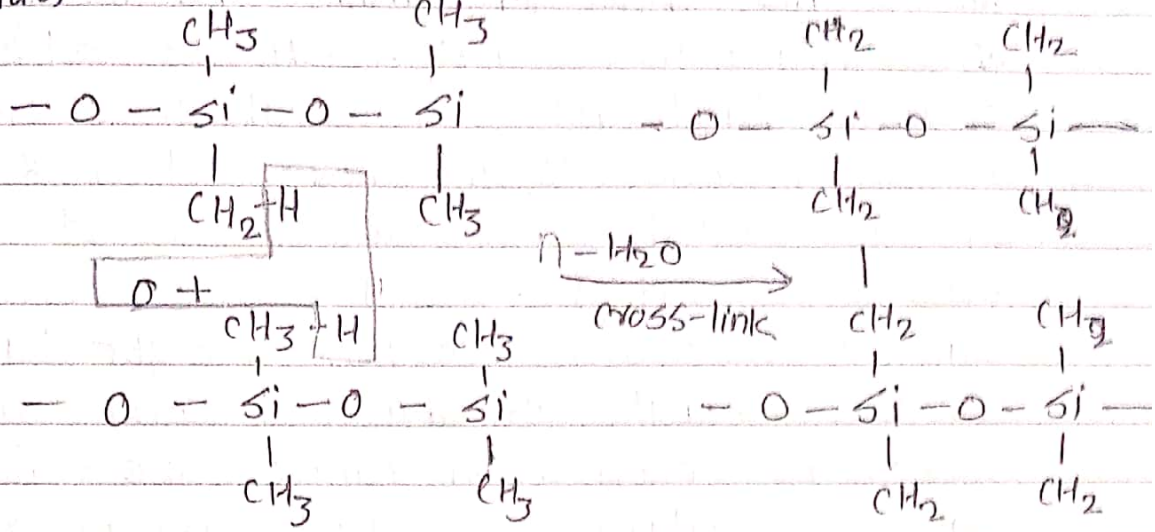
They are used for making high temperature insulating foams for making high voltage insulators.

(d) Silicone rubbers: (Boots of Neil Armstrong)

They are obtained by mixing high molecular weight of linear dimethyl silicon, polymers with fillers like silica, carbon black etc (and perioxide containing curing agents) Oxygen of perioxide causes the formation of dimethyl

bridge (cross-link) between methyl groups of adjacent chains.

Thus,



Properties of silicones:

- Good electrical insulation. Because silicon can be formulated to electrically insulation or conductive, it is suitable for a wide range electrical applications.
- Does not stick
- Thermal stability (constancy of properties over a wide operating range of -100 to 250°C)
- low chemical reactivity.

Uses:

(i) They are used as a sealing material in search lights and in aircrafts engines.
(ii) For manufacture of tyres for fighter aircrafts.
(iii) For insulating the electrical wiring in ships.
(iv) As adhesive in electronic industry
(v) For making insulating for washing machines and electronic blankets for iron board covers.