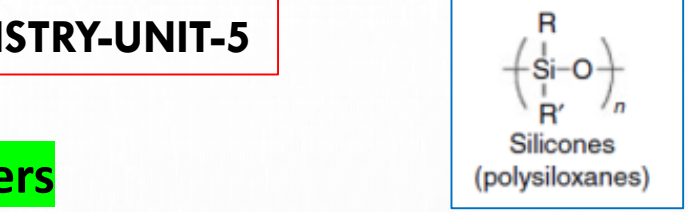
CHEM3020: POLYMER CHEMISTRY

Unit-5: Preparation, structure, properties and application of polymers

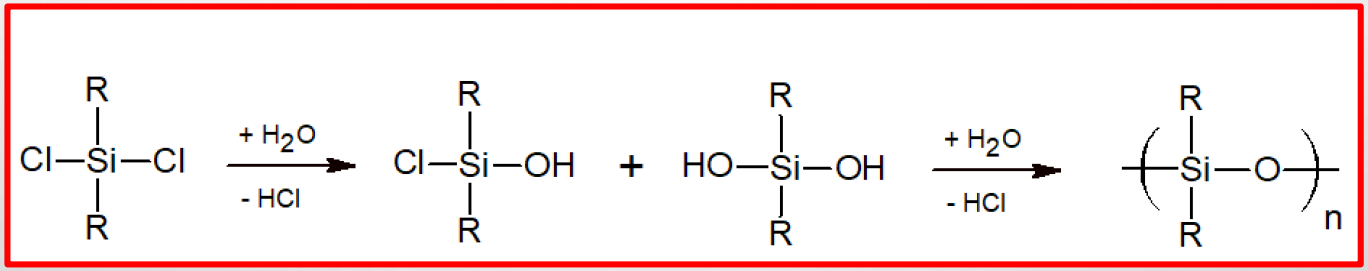
Silicone Polymer, Poly(vinyl acetate), Polycarbonate

Prof. Rafique Ul Islam
Department of Chemistry, MGCU, Motihari

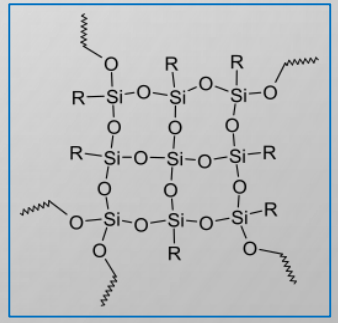


Silicone polymers

Silicone polymer (Polysiloxane): Silicone polymers are produced by the intermolecular condensation reaction of silanols which are prepared from halides of silicone by hydrolysis. It is made up of repeating units of siloxane (-Si-O-Si-O-Si-), a chain of alternating silicon atoms and oxygen atoms with different functionality and side groups attached to the silicon atoms.

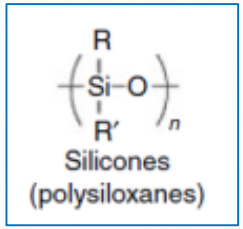


Depending upon the –Si–O– chain lengths, different side groups, and crosslinking pattern, silicones shows a wide variety of properties (from liquid to gel to rubber to hard plastic). The most common siloxane, silicone oil is linear polydimethylsiloxane (PDMS). The other important siloxane, silicone resins are formed by branched and cage-like oligosiloxanes.



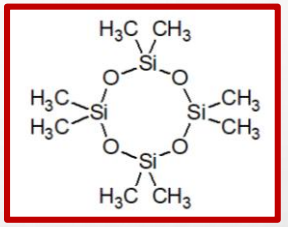
Silicone resin

Silicone polymers



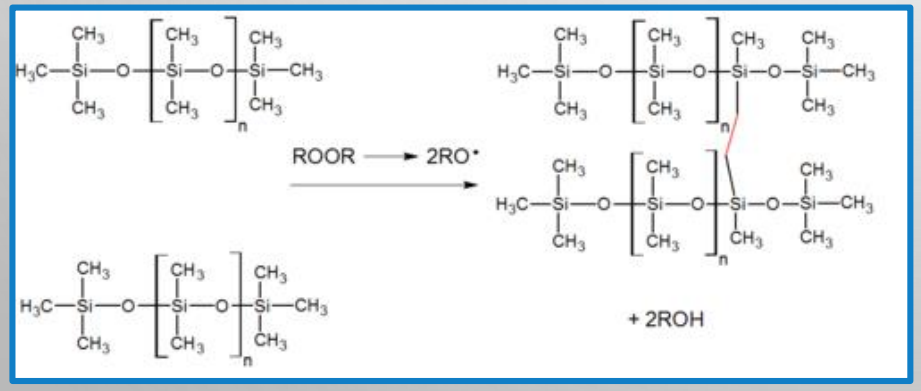
Types of silicone polymer (Polysiloxane): Depending on the crosslinking density, polysiloxanes can be categorized into three types: silicone fluids, elastomers and resins.

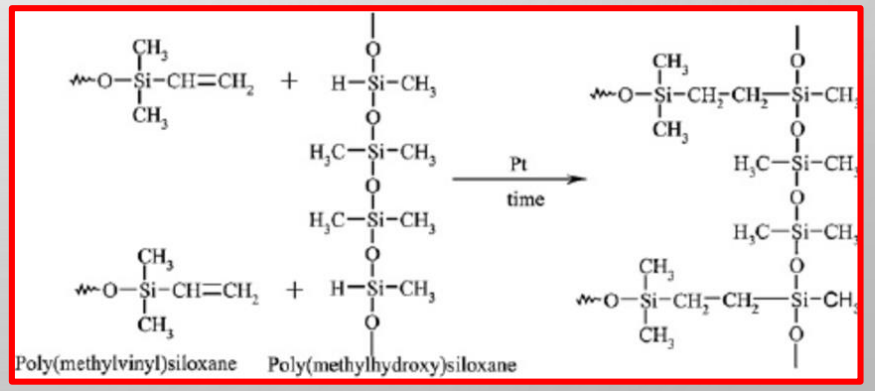
Silicone fluids: These are low molecular weight polymers produced by the hydrolysis of chlorosilanes with agitation. In may cases, the cyclic tetramer predominates in the resulting mixture.

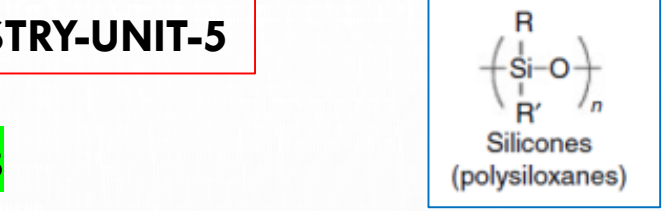


Silicone elastomers: Silicone elastomers are high molecular weight linear polymer usually polydimethylsiloxanes. This type of silicones can be prepared-

i. By free radical (benzoyl peroxide as initiators) crosslinking through the formation of ethylenic bridge between chains and
ii. By crosslinking of vinyl or allyl group attached to silicon through the reaction of silyl hydride groups.



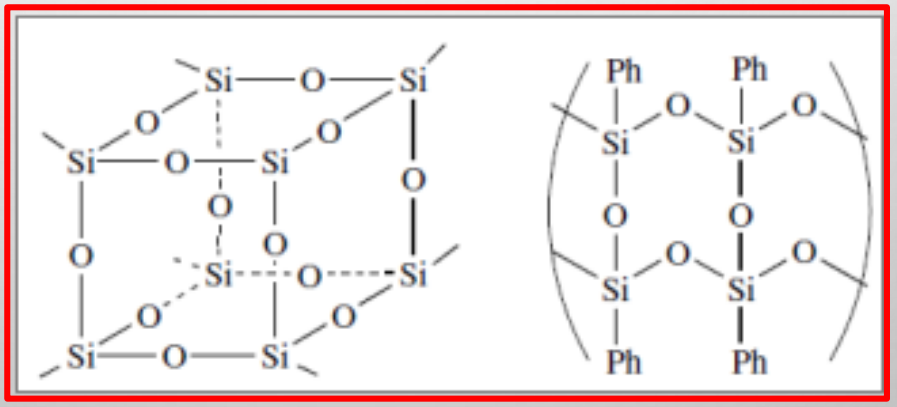




Silicone polymers

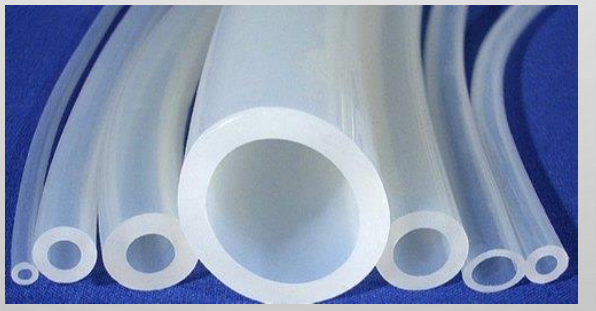
Silicone elastomers are outstanding materials in low temperature flexibility (upto -80^{0}C) and stability at high temperature (upto 200^{0}C). It has resistance to weathering and also to lubricating oils.

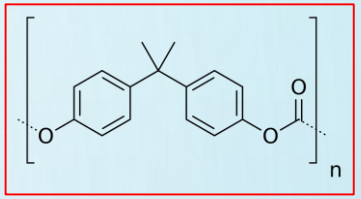
Silicone resins: Silicone resins contains Si-atoms with no or only one organic substituents, hence it crosslinked to a harder and stiffer compounds than the elastomers. It is prepared form the desired chlorosilane blend in the presence of solvent (mineral spirit, butyl acetate, toluene or xylene). These materials are usually treated with metal soaps or amines.



Application of Silicone polymers

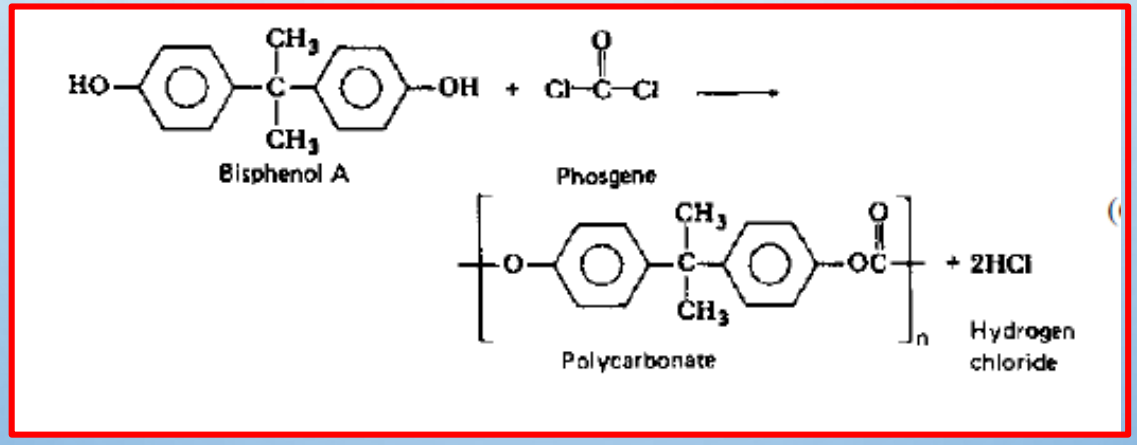
Silicone fluid is used as cooling and dielectric fluids, in polishes, waxes and also as antifoam agents. Silicone elastomers are used as Gaskets and seals, wire and cable insulation, and hot and liquid outlets. Silicone resins are used as insulating varnishes, impregnating and encapsulating agents and in industrial paints. A part to be coated is dipped into the resin solution and drain the free excess resin and allowed to evaporate the solvent. Silicones are also used molds for chocolate, ice, cookies, muffins and various other foods, kitchen utensils.



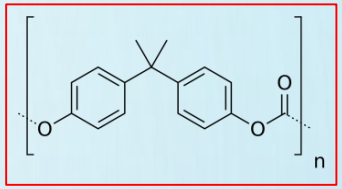


Polycarbonates

Polycarbonates: Polycarbonate is a high-performance tough, amorphous and transparent thermoplastic polymer with organic functional groups linked together by carbonate groups (–O–(C=O)–O–). The main polycarbonate material is prepared either by the reaction of bisphenol A (BPA)(4,4'-dihydroxy-2,2'-propane) and phosgene $COCl_2$ or by the ester exchange between Bisphenol A and diphenyl carbonate. Recently tetramethylcyclobutanediol has been developed as a replacement for BPA.



PC is popularly used as an engineering plastic owing to its unique features that includes-High impact strength, High dimensional stability and Good electrical properties amongst others.



Properties of polycarbonate

Polycarbonate has high strength making it resistant to impact and fracture, and further providing safety and comfort in applications that demand high reliability and performance.

PC is an extremely clear plastic that can transmit over 90% of light as good as glass.

Polycarbonates can be designed to block ultraviolet radiation and provide 100% protection from harmful UV rays.

Polycarbonate exhibits good chemical resistance against diluted acids, aliphatic hydrocarbons and alcohols; moderate chemical resistance against oils and greases. PC is readily attacked by diluted alkalis, aromatic and halogenated hydrocarbons.

Offering good heat resistance, Polycarbonates are thermally stable up to 135°C. Further heat resistance can be improved by adding flame retardants without impacting material properties.

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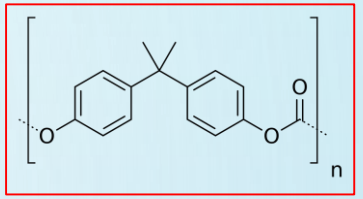
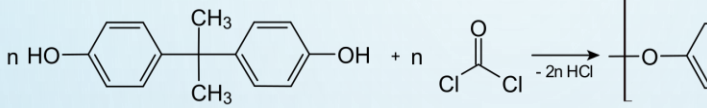
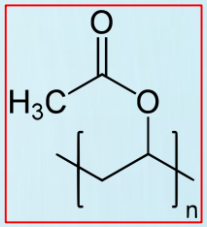
Application of polycarbonate



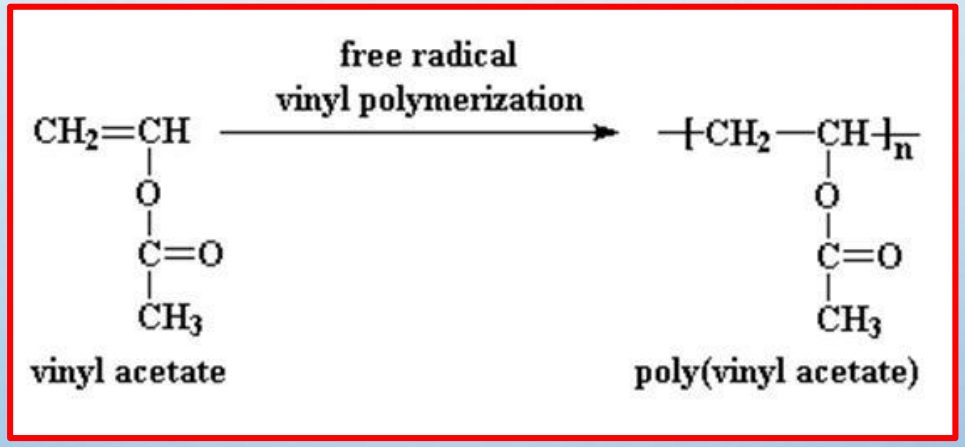


The most common applications of polycarbonates are compact disc, safety helmets, bullet-proof glass, car headlamp lenses, baby feeding bottles, roofing and glazing etc.

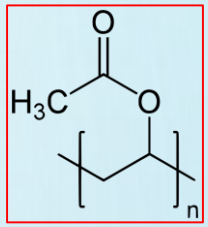
Polyvinyl acetate



Polyvinyl acetate: Polyvinyl acetate, a vinyl polymer, is prepared by the emulsion polymerization of vinyl acetate monomer via free radical vinyl polymerization. Bulk polymerization of vinyl acetate is difficult to control at high conversion because of chain branching.



Polyvinyl acetate is atactic and therefore it is amorphous. This polymer is tough and stable at room temperature, becomes sticky at elevated temperature. It is sensitive to water in certain physical properties, i.e. strength and adhesion but do not hydrolyze in neutral system.



Applications of Poly(vinyl acetate)

Applications: It is also used as a primer for drywall and other substrates. As an emulsion in water, Polyvinyl acetate emulsions are used as adhesives for porous materials, particularly for wood, paper, book binding and cloth.

The major use of Polyvinyl acetate is the production of polyvinyl alcohol and this alcohol is used in the water based emulsion paint.

References and suggestions for further reading:

1. Textbook of Polymer Science by Fred W. Billmeyer, Wiley

2. Polymer Chemistry by Charles E Carraher, Jr., Marcel Dekker, Inc.

3. Principle of Polymerization by George Odian, Wiley

THANK YOU