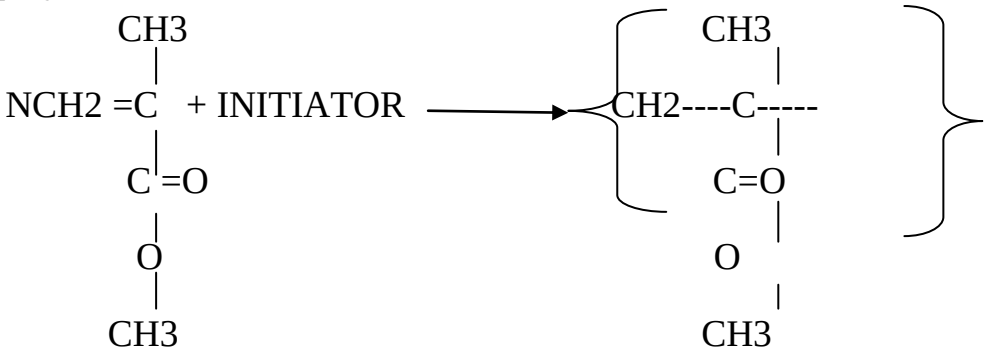
Polymer and Polymerization

The term (polymer) is a chemical compound consisting of a giant molecule that is made up of many (poly) parts (mer). A polymer is a macromolecule formed by linkage of many similar simple structural molecules, a polymer consist of a large organic molecules built up by repetition of smaller, simpler chemical units called monomers. In some cases the repetition is linear, in other cases the chains are branched or inter connected to form three dimensional networks, the repeat units of polymer is called monomers, which is the starting material from which polymer is formed .



Methyl methacrylate (monomer)

Polymethyl methacrylate (polymer)

Terminology:

Polymer: chemical compound consisting of giant molecules (macromolecules) formed by union of many (poly) small repeating units (mers).

A mer: is the simplest repeating chemical unit of which the polymer is composed.

Monomers: (mono = single) are the molecules with a double or triple bond that unit to form a polymer.

Oligomer: is a short polymer composed of two, three or four mer units.

Co-polymer: polymer molecules which prepared from the mixture of different types of monomer. It is used to better the physical properties of resins.

Molecular weight: Summation of the molecular weights of the mers of which it is made.

Cross-link polymer: is a high molecular weight network polymer. Results in the formation of a network structure of covalently bonded atoms. Cross-linking provides a sufficient number of bridges between the linear molecules to form a three dimensional network that alters the strength, solubility and water sorption of the resin.

Polymerization: the process by which monomer are converted into polymer. The polymerization is exothermic reaction, dental resins solidify when they polymerize.

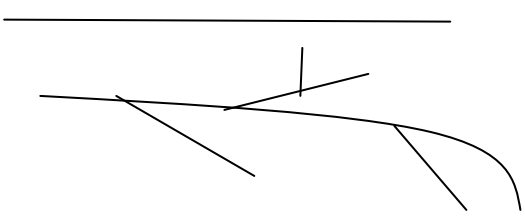
Glass transition temperature (Tg) (softening temperature): Temperature at which rigidity of polymer decreases.

Factors control polymer properties:

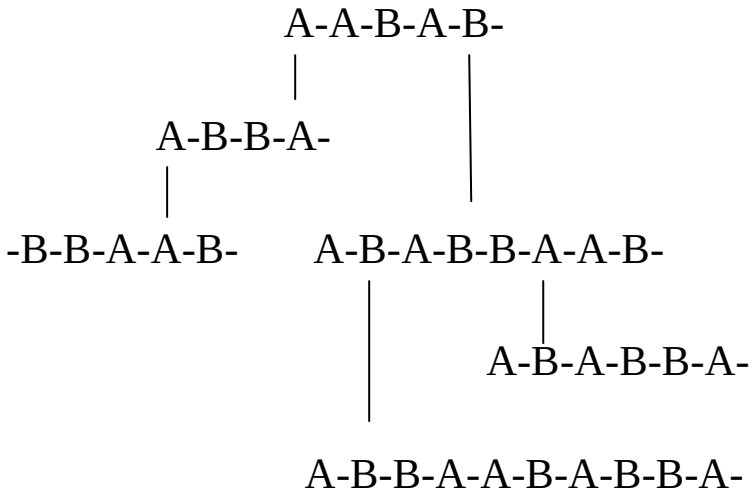
1. Chemical composition of polymers (type of monomer, its structure):

* Polyethylene; hydrophobic, semi crystalline polymer.
* Poly vinyl alcohol; hydrophilic, water soluble polymer.

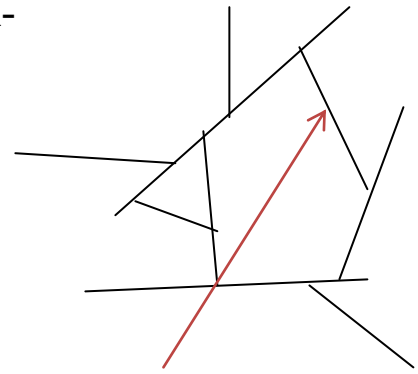
2. Topology of polymer chains:



* Linear polymer A-A-A-A-A-
* Nonlinear (branched) polymer
* Cross-linked (network) polymer



- Improve hardness and stiffness.
- Increase crazing resistance.
- Increase wear and solvent resistance.
- Increase brittleness.
- Increase thermal resistance.



Cross link (permanent connection) between chains restricting motions of chains → regidity

3. Monomer distribution in polymer chains:

* Homopolymer (one type of monomer –A)

  A-A-A-A- (linear/branched)

* Copolymer (2-3 types of monomers –A-B)
  - A-B-A-B-B-B-A- statistical , random
  - A-A-B-B-B-B-A-A- block
  - A-B-A-B-A-B-A alternating
  - A-A-A-A-A

    B-B-B-B-B graft, branched

4. Polymer molecular weight: it plays an important role in determining the physical properties of the polymer.

Molecular weight of polymer molecules =
molecular weight of various mers × number of mers

Most polymers have a wide range of molecular weight, so vary widely in their properties.

Example:

- ☒ The higher the molecular weight, the higher the softening and melting point and the stiffer the plastic.
- ☒ The higher the molecular weight of polymer made from a single monomer, the higher the degree of polymerization; as a result the strength of the resin increased.

5. Supra molecular structure (molecular organization):

- ❖ Amorphous polymers – coiled irregular (random) shape of polymer chains.
- ❖ Semi crystalline polymers – domains with regular (crystalline) structures acting as special type of cross-links.

Polymers used in dentistry:

- ➢ Natural polymer (natural rubber).
- ➢ Synthetic polymers (prepared via polymerization reaction).

Synthetic polymers used in dentistry:

1. Dentures (bases, artificial teeth, relining materials).
2. Filling materials (composite, cements, adhesives).
3. Impression materials.
4. Equipment (spatula, measures, etc.).