Ashur university college
Lect 7&8 polymers

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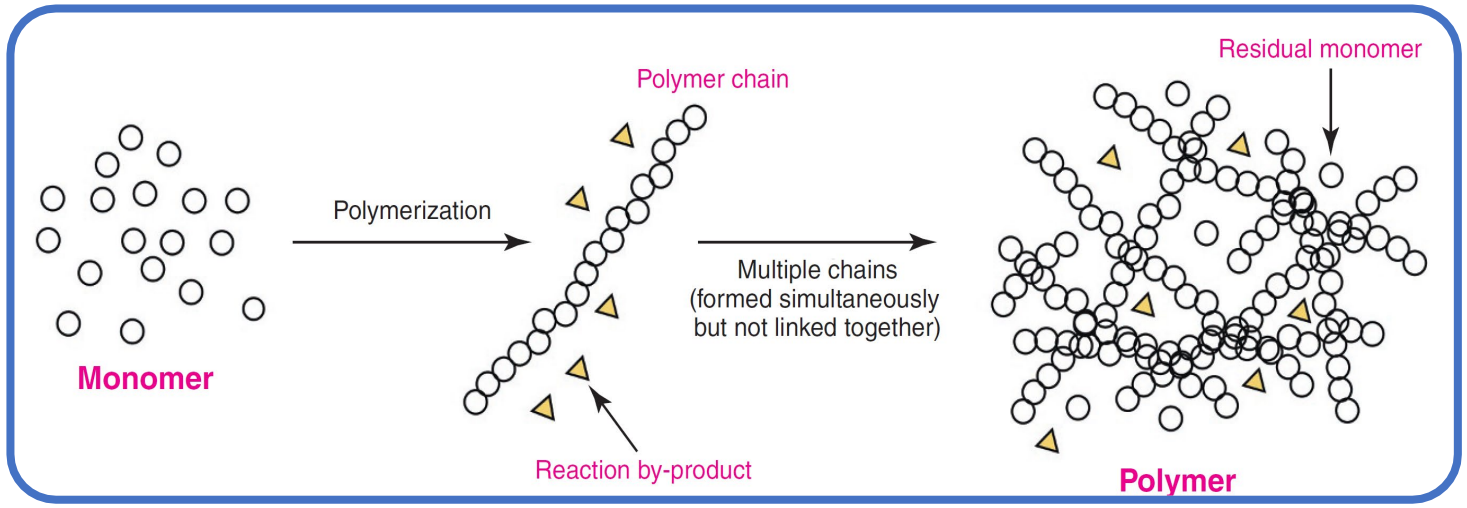
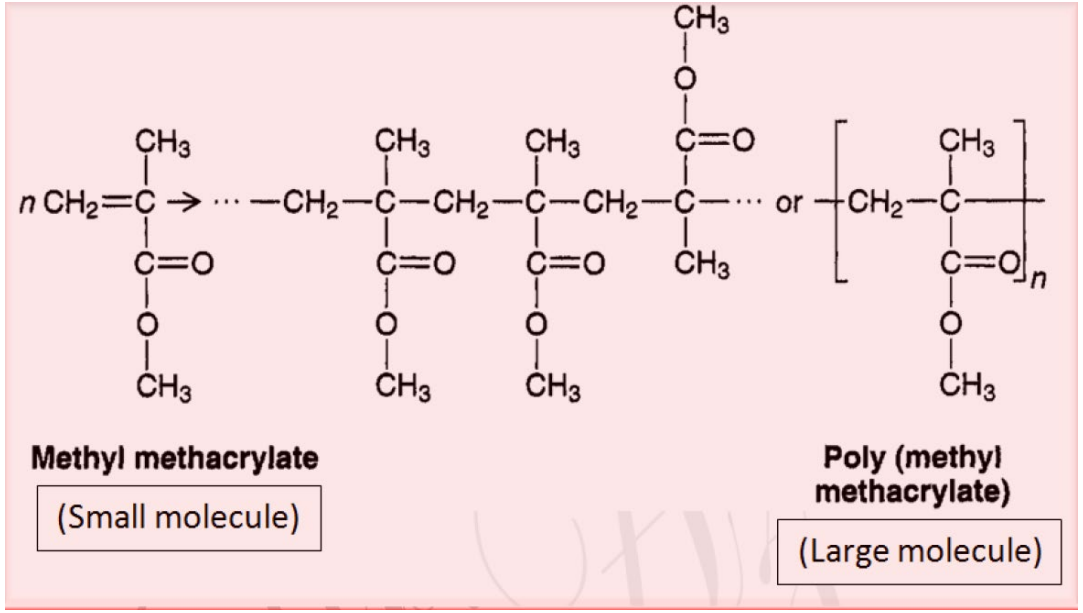
Polymer: a chemical compound consisting of a large organic molecule (macromolecule) formed by the union of many smaller repeating units (mers).

Monomer: it is a single molecule from which the polymer is constructed. It is a chemical compound that is capable of reacting to form a polymer.

Mer: The term used to designate the repeating unit or units in a polymer chain; thus mers are the "links" in the chain.



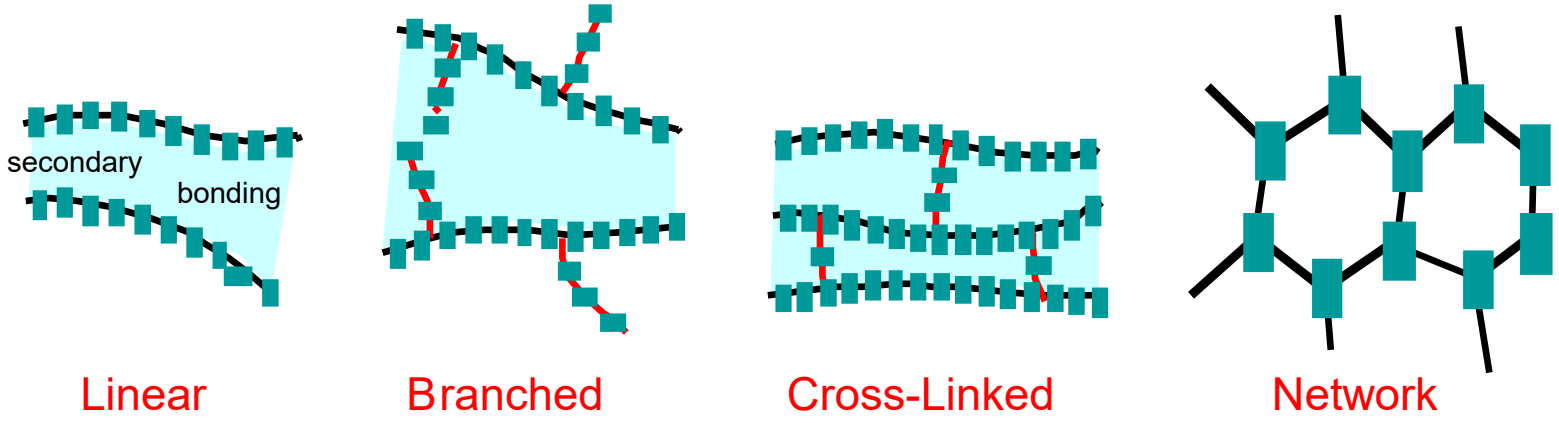
<u>Polymerization:</u> Chemical reaction in which monomers of a low molecular weight are converted into chains of polymers with a high molecular weight. The polymerization is exothermic reaction.



Monomer+ Monomer+ Monomer+ Monomer → polymerization → Mer—Mer—Mer—Mer—

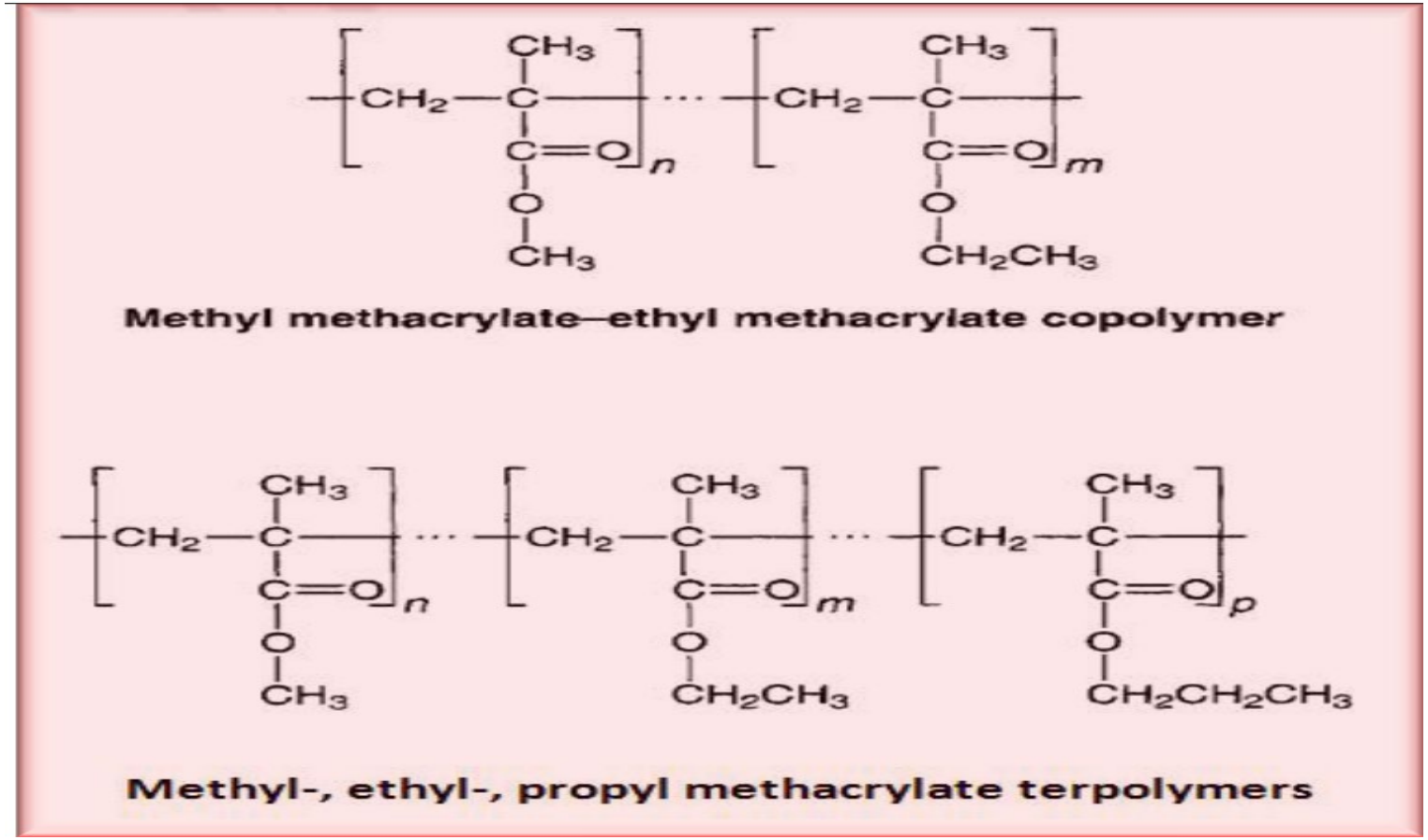
Copolymers: Polymer made of two or more monomer species and identical monomer units (mers) occurring in relatively long sequences along the main polymer chain. Copolymerization is used to improve the physical properties of the resulting resin.

Crosslinked: A difunctional or multifunctional monomer that forms a link between two polymer chains. Crosslinked polymers have many crosslinks between neighboring chains such that a three-dimensional interconnected polymer network result.



Copolymer: It is a polymer made by reaction of two different monomers.

Terpolymer: It is a polymer synthesized from three different monomers.



Degree of polymerization (D.P): is specified by the total number of repeated units in the chain of the polymer. The higher the degree of polymerization the better will be the physical properties.

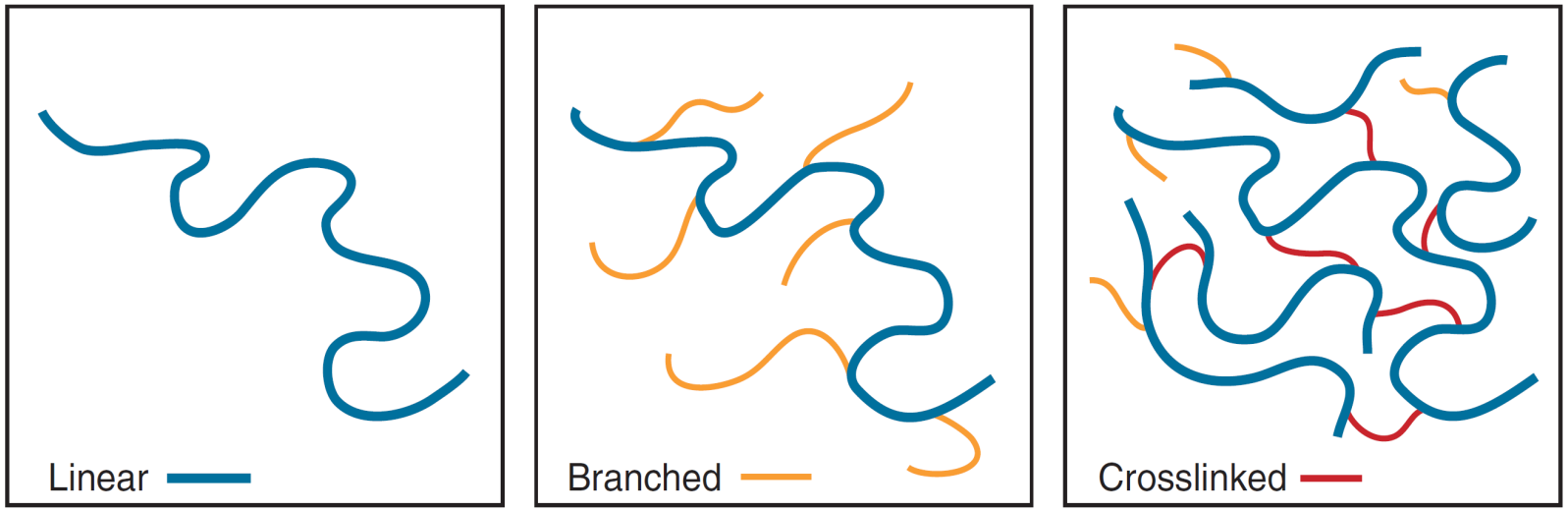
Glass transition temperature (Tg): It is the temperature when the polymers leave the rigid state and transfer into rubber like phase.

Factor control polymer properties:

1. Chemical composition of the polymer: This depends on types of monomers and its structure.

2. Topology of polymer chain:

- **Linear polymer. A-A-A-A**
- **Nonlinear (branched) polymer.**
- **Cross linked polymer (polymer network). The cross linking (permanent connection between the polymer chains) restricting the motion of the chains and improve rigidity of polymer.**

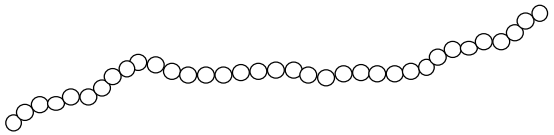


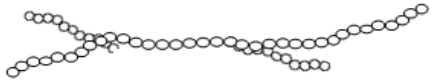
The advantages of cross-linking agents:

1. Improve hardness and stiffness.
2. Increase wear and solvent resistance.
3. Increase crazing resistance.
4. Increase brittleness.
5. Increase thermal resistance.
6. Decrease water sorption and solubility.

3. Monomer distribution in the polymer chain:

A. <u>Homo polymers</u> (one type of monomer) (linear or branched).

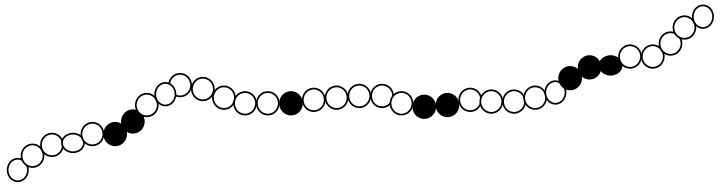




B. <u>Co polymers</u> (2 or 3 types of monomers) it is ether:

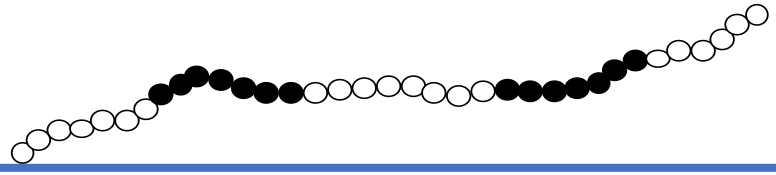
- ***Random copolymer:*** **No sequential order exists among the two or more mer units along the polymer chain.**

...ABBABABAAABAAAABABBBBABAAAABABABB...

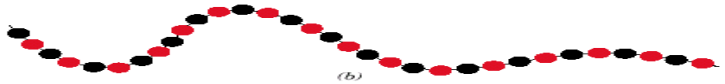


- ***Block copolymer***: **Identical monomer units occur in relatively long sequences (blocks) along the main polymer chain**

…AAAAABBBBBBBAAAABBBBBBBAAABBBAAAA…



- **Alternating …..ABABABABAB….**



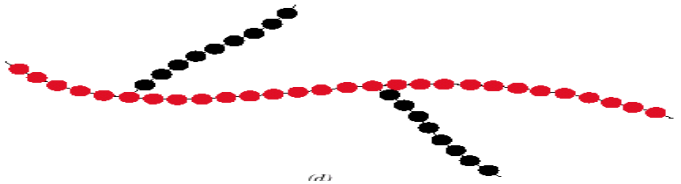
- ***Graft or branched copolymer***: **Sequences of one type of mer unit (B) are "grafted" onto a backbone chain of a second (A) type of mer unit to form a branched configuration.**

…….AAAAAAAAAAAAA …

| |

B B

B B



4. Polymer molecular weight (Mw).

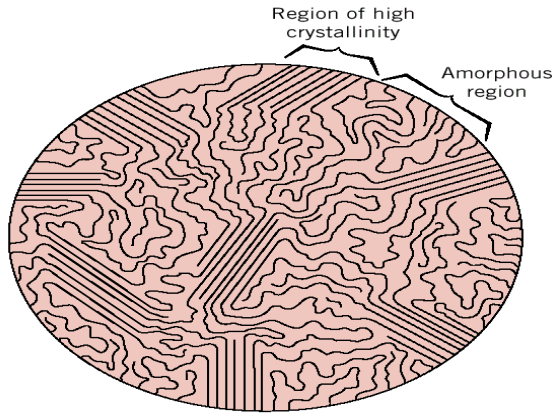
Mw of polymer molecules= the Mw of the mers x number of mers

Mw may range from thousand to millions of molecular weight units depending on preparation conditions.The strength of the resin increases with the increasing of the degree of polymerization until a certain Mw is reached. Above this there is no change.

5. Supra molecular structure (molecular organization).

A. Amorphous polymers (coiled irregular) random Shape of polymer chains.

B. Semi crystalline polymer: domains with regular (crystalline) structure acting as special type of cross - links.



Polymers used in dentistry:

- **Natural polymers. e.g. gutta percha.**
- **Synthetic polymers (prepared by polymerization reaction).**

<u>Application of polymers in dentistry:</u>

1. **Prosthodontics: denture bases, denture teeth, soft liners, custom trays, impression materials, cementing materials, maxillofacial prostheses …….**
2. **Operative Dentistry: dentin bonding agents, cavity fillings, resin and glass-ionomer cements, veneers…..**
3. **Orthodontics: brackets, bracket bonding resins and cements, and spacers.**
4. **Endodontics: gutta-percha points, root canal sealants, and rubber dams.**
5. **Equipment: mixing bowls, mouth guards , protective eyewear….**

The types of polymerization reaction:

1. Condensation polymerization.
2. Addition polymerization.

Condensation polymerization: usually more than one type of monomer is used; The condensation reaction progress by the same mechanism as chemical reaction between two or more simple molecules. The reaction produces by products such as water, halogen acids and ammonia or alcohol.

Addition polymerization: *most dental resins* are polymerized by additional polymerization which simple involves the joining together of monomer molecules to form polymers chain. In this type of reaction, no by product is obtained.

The additional reaction take place in 3 stages as follow:

1. Induction stage(Initiation)
2. Propagation stage
3. Termination stage

1. Activation and initiation stage

To start the addition polymerization process a free radicals must be present. (Free radicals are very reactive chemical species that have an unpaired electron).

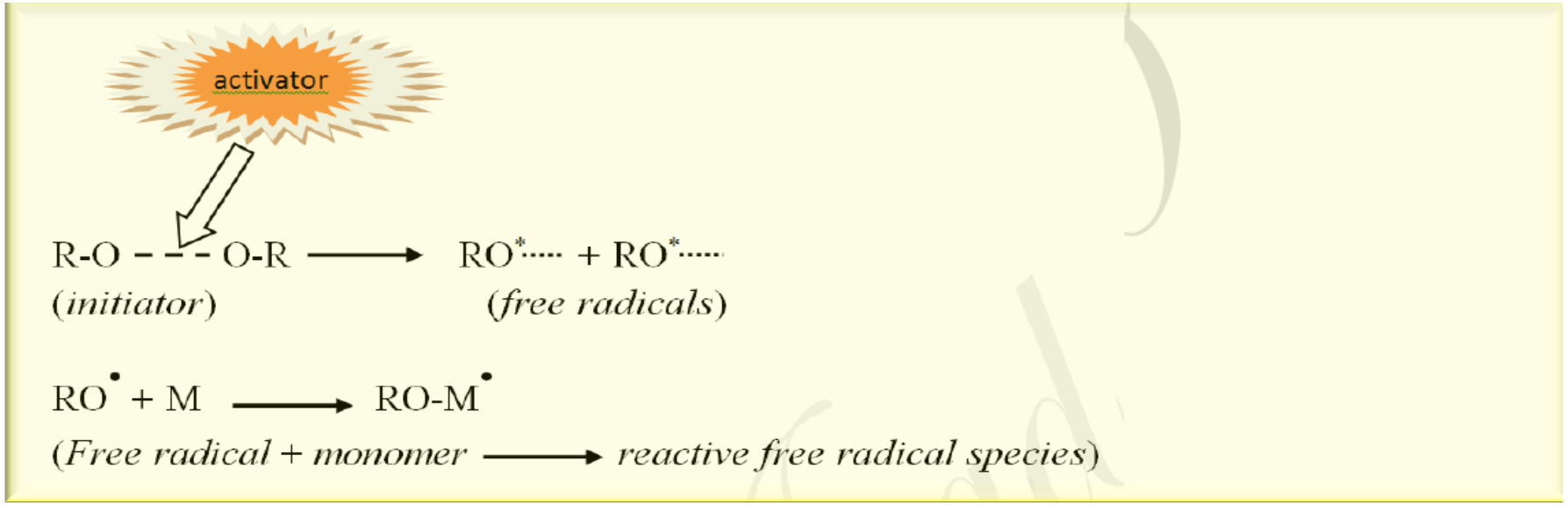
The free radicals are produced by reactive agents called initiators.

(Initiators are molecules which contain one relatively weak bond which is able to undergo decomposition to form two reactive species (free radical), the decomposition of bond of initiator need source of energy (activator) such as heat, chemical compound, light, electromagnetic radiation).

Initiator is used extensively in dental polymers is (Benzoyl peroxide).

Addition polymerization reaction is initiated when the free radical reacts with monomer molecules producing another active free radical species which is capable of further reaction.

Activation and initiation



R——/——**R** **+ external energy** → **2 R•** (R= represent any organic molecular)

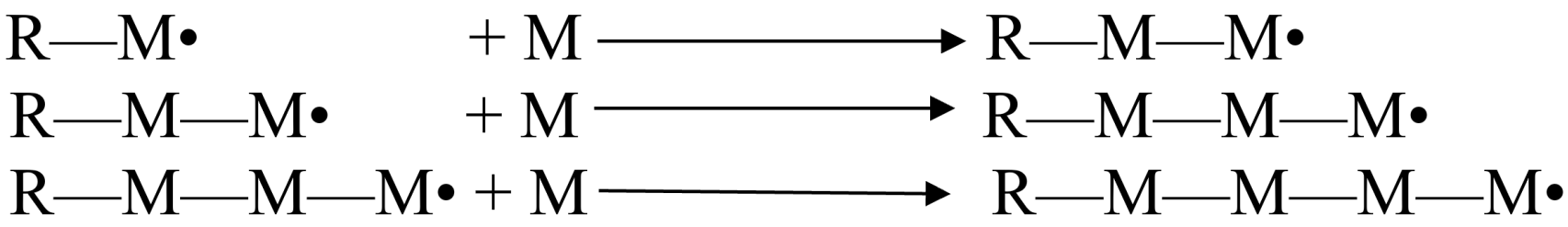
Initiator free radicals

R• + **M** → **R-M•**

Free radicals monomer reactive free radical species

2. Propagation stage:

The initiation stage is followed by the rapid addition of other monomer molecules to the free radical and shifting of free electron to the end of growing chain, this called propagation stage.

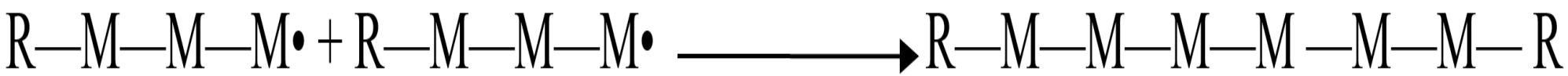


3. Termination stage

The propagation reaction continues until the growing free radical is terminated either by:

a- Reaction of two growing chains to form one dead chain.

b- Reaction of growing chains with materials as (hydroquinone, eugenol, impurities, or large amounts of oxygen).



Classification of polymer according to thermal response:

1. Thermoset polymer.
2. Thermoplastic polymer.

<u>Thermosetting polymer or resins:</u> **Thermosetting polymers undergo a chemical change during the setting reaction and become permanently hard when heated above the temperature at which they begin to polymerize; they do not soften again on reheating to the same temperature.**



Classification of polymer according to thermal response:

<u>Thermoplastic polymer or resins:</u> They soften when heated above the glass transition (The resin can be shaped and molded) and upon cooling it will harden; this cycle can be repeated almost indefinitely. e.g. flexible denture.



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