Polymers in Dentistry (Polymerization and Crosslinking Reactions)

Basic

Polymerization

It is a process in which small molecules, called monomers, combine chemically to produce a very large molecule, called a polymer.

Types of polymerization reaction

1. Condensation polymerization.
2. Addition polymerization.

1. 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.

$$CH_3CO_2H + C_2H_5OH \rightarrow CH_3CO_2C_2H_5 + H_2O$$

2. Addition polymerization:

• involves the joining of monomer molecules to form polymers chain. In this type of reaction, no by-product is obtained. Most dental resins are polymerized by additional polymerization.

The additional reaction take place in 3 stages:

1. Induction stage
2. Propagation stage
3. Termination stage

$$R^* + M \rightarrow R - M^*$$
$$R - M^* + M \rightarrow R - M - M^*$$
$$R - M - M^* + M \rightarrow R - M - M - M^* \text{ etc.}$$

The initial reactive species is represented by R* and the monomer molecules by M. It can be seen how monomer molecules are added during each stage of the polymerization reaction and eventually a long-chain molecule is produced.

1. **Induction stage (initiation):** Induction or initiation period is the time during which the molecules of the initiator become activated and start to transfer the energy to the monomer.

• Any impurity present increases the length of this period.

• The higher the temperature, the shorter is the length of the induction period.

There are three induction systems for dental resins:

A. Heat activation
B. Chemical activation
C. Light activation

2. Propagation stage • the reactions continue with evolution of heat until all the monomer has been changed to polymer.

3. Termination stage: The growing chain is stopped. Termination occurs when monomer units are finished by reaction.

Inhibitor: it is chemical material added to prevent or delay polymerization during storage and to provide enough working time like hydroquinone.

The following factors inhibit the polymerization:

1. Any impurity in the monomer that can react with activated growing chain.
2. The addition of hydroquinone to the monomer.
3. Oxygen also inhibit the polymerization.

Plasticizer: these are substance added to the resins to:

1. Decrease the brittleness of the polymer.
2. Increase the solubility of the polymer.
3. It decreases strength, hardness and softening point so it is used to prepare flexible polymer.

Cross linking reaction

The formation of chemical bonds or bridges between the polymer chains is referred to as cross-linking.

• Cross-linking increases rigidity , Increase wear and solvent resistance, Increase thermal resistance, decreases solubility and water sorption