



Dental Materials

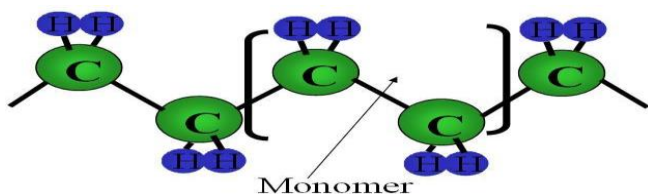
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Polymers are widely used in dentistry like: impression materials (silicone & polysulfide impression materials), acrylic resin that is used in denture base material or denture teeth or fabrication of special trays, composite filling materials.

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 that unite to form a polymer.



Degree of polymerization: Total number of mers in a polymer molecule.

Polymers could be:

1. **Homopolymers** : polymer molecules which prepared from one type of monomer.

A-A-A-A-A-A-A-A

2. **Co-polymer**: polymer molecules which prepared from the mixture of different type of monomer. To have better the physical properties of resins. It could be:

- a. Random copolymer: A-B-A-B-B-A-A-A-B-A-A-B

- b. Alternating copolymer: A-B-A-B-A-B-A-B-A-B

- c. Block copolymer: A-A-A-A-A-B-B-B-B-B

cross-linking of polymer improves hardness and stiffness, increases crazing resistance, increase wear and solvent resistance and increase thermal resistance (which means that such final denture could be finished and polished easily)



Polymerization: the process by which monomer are converted into polymer.

Types of polymerization reactions

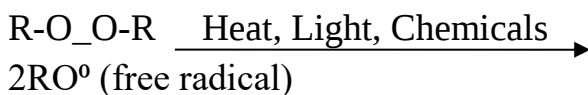
Condensation reaction: Polymerization reaction in which the polymer chains all grow simultaneously and by-product is formed (water, hydrogen or alcohol could be by products). Condensation silicone & polysulfide impression materials are examples

Addition reaction: Polymerization reaction in which each polymer chain grows to maximum length in sequence and there is no by-product. Addition silicone impression material is an example of such reaction.

The ADDITION polymerization reaction takes place in three stages:

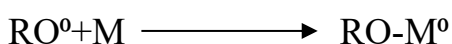
1. Initiation stage

Initiators are molecules which contain one relatively weak bond which is able to undergo decomposition to form two reactive species (**free radical**) each carrying an unpaired electron. The decomposition of initiators need source of energy like heat, light or chemical activation.



R=represent any organic peroxide (like benzoyl peroxide) as initiator that will form the free radical which reacts with a monomer and initiate the polymerization process

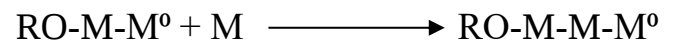
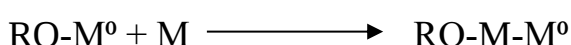
Benzoyl peroxide is the most popular initiator in dentistry & it needs to be activated by heat, light or chemical to decompose and produce free radicals. The free radicals will react with the monomer to form free radical activated monomer.



Free radical + monomer = free radical activated monomer

2. Propagation stage:

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



Polymer-free radical + monomer $\longrightarrow$ growing chain

3. Termination:

(the growing chain is stopped).

Termination occurs when monomer units or free radical are **used up**, the polymer chain can be terminated either by reactions of two growing chain to form one dead chain or by reaction of growing chains with molecules of initiator or impurity.

Polymer-free radical + free radical $\longrightarrow$ polymer chain

Denture base material

Ideal requirements for denture base materials:

- 1- Adequate strength and durability
- 2- Satisfactory thermal properties
- 3- Processing accuracy and dimensional stability
- 4- Good chemical stability
- 5- Insolubility in and low sorption of oral fluid
- 6- Tasteless & odorless
- 7- Biocompatible
- 8- Natural appearance
- 9- Color stability
- 10- Adhesion to plastic, metal and porcelain

11- Easy to fabricate and repair

12- Moderate cost.

Denture base materials could be:

1. Metallic denture base:
 - a. Cobalt chromium
 - b. Gold alloys
 - c. Aluminum
 - d. Stainless steel
2. Non-metallic denture base: acrylic resin (poly methyl methacrylate (PMMA))

Acrylic resin Denture base material

The material of choice to use as denture base material is acrylic resin (Polymethyl methacrylate) PMMA which was introduced to dentistry in 1937 & still very popular due to: esthetically pleasing, easy to process and cheap.

Types of poly methyl methacrylate resins

According to initiation reaction (activation)

1. Heat cured acrylic: sets by heat
2. Cold cure acrylic: it doesn't need heat only chemical amine cause them to become hard
3. Light cured: harden as subjected to light at certain wavelength
4. Pour and cure resins: very fluid and poured in to the model.

Heat cured resin

It's the most popular acrylic resin used in fabrication the denture base. External heat is needed to activation.

Composition of heat cured acrylic:

❖ powder

- Granules of PMMA (poly methyl methacrylate)
- Initiator benzoyl peroxide 0.5% (produces free radical)
- Pigments

❖ Liquid

- Methyl methacrylate monomer
- Cross linking agents: to improves mechanical properties (add strength)
- Hydroquinone: inhibitor – prevent fast setting.

Manipulation:

Polymer/monomer ratio is either: 3:1 by volume or 2.5:1 by weight. The liquid is placed in clean dry mixing jar followed by slow addition of powder allowing each powder particle to become wetted by monomer & wait till the mixture reaches a consistency suitable for packing. During the waiting period, the mixing jar should be covered to prevent evaporation of monomer the resultant mixing will pass into 5 stages:

- 1- Sandy stage :- this when monomer wets the outer surface of polymers particle

- 2- Sticky stage:- the monomer attaches the surface of polymer beads & some polymer chains are dispersed in the liquid monomer. The viscosity of mix is increased in this stage & it is characterized by stickiness when the material is touched
- 3- Dough stage :- when the monomer diffuses further into the polymer particles and the mass becomes saturated, the mass does not adhere to the walls of mixing jar
- 4- Rubber stage :- in this stage monomer is dissipated by evaporation and by further penetration into remaining polymer beads the mass is no longer plastic, it is rubber like
- 5- Stiff stage on standing for a period the mixture becomes stiff, this may be attributed to the evaporation of free monomer clinically the mixture appears very dry

Dough – forming time :- the time from beginning of mixing the polymer with monomer until reach a dough stage in less than 10 minutes

Working time: - the time that a denture base material remains dough like stage

Important notes:

- In heat activated acrylic the transition from sandy to sticky to dough and eventually rubber and hard stages are due to physical changes occur within the mixture. NO substantial polymerization occurs until the denture flask is heated to polymerization.

- The average time need to reach dough stage is only 5 minutes for chemically accelerate type (cold cure acrylic) compared with 15 minutes for heat polymerization acrylic

Polymerization cycle: - the heating process used to control polymerization is termed Polymerization cycle or curing cycle process should be well controlled to avoid the effects of uncontrolled temperature rise such as boiling of monomer and denture base porosity

➤ We have two recommended curing cycles:-

- 1- long cycle processing procedure is to cure the plastic in a constant temperature water bath at 74c for 8 hours or longer (10hs)
- 2- 74c for 2 hours and then increase temperature to 100c for 1 hours (short cycle)

Notes:

- The denture flask should be cooled slowly to room temperature because rapid cooling may result in warpage of denture base because of different in thermal contraction of resin and investing stone
- In addition to water bath curing methods, curing may be done in microwave where the flask used should be non-metallic advantage of this

technique faster polymerization may be accomplished

Properties of heat processed acrylic

1. Completely polymerized acrylic resin is tasteless and odorless
2. It is a clear transparent resin which be colored easily to look like the oral tissue
3. Low strength
4. Acrylic has low hardness can be easily scratched and abraded
5. A well proceed acrylic resin dentures has good dimensional stability & the processing shrinkage is balanced by the expansion due to water sorption
6. Acrylic resin shrinks during processing due to
 - a. Thermal contraction on cooling
 - b. Polymerization shrinkage
7. Water sorption: Acrylic resin absorb water and expand & this partially compensate for it is processing shrinkage
8. Solubility: Acrylic is soluble in water, oral fluid, ketones and esters.
9. Thermal conductivity: Poor conductors
10. color stability: Heat cured acrylic has good color stability while cold cured is slightly lower

11. Biocompatibility: Completely polymerized acrylic is biocompatible

12. Adhesion : The adhesion of acrylic to metal and porcelain is poor and mechanical retention is required adhesion to plastic denture teeth is good (chemical adhesion)

Note: Instances of toxicity or allergic reaction have been related to excessive residual monomer that result from improper processing

Chemically activated resins

Also known as cold cure (self-cure) acrylic. It is Identical in Composition to heat cure resin. The only exception is that the liquid contains tertiary aromatic amine 1% which activate benzyl peroxide to produce free radicals and polymerization is initiated in manner similar to that describe for heat activated systems

➤ Chemically activated resins Compared to heat activated resin :-

- 1- Lower molecular weight (degree of polymerization is not as complete as that achieved using heat activated
- 2- Higher amount of free monomer 3.5wt% while heat activated up to 1%
- 3- Less colour stability due to oxidation of aromatic amine accelerators

- 4- Working time is shorter
- 5- Less shrinkage than heat activated because less complete polymerization
- 6- Lower strength
- 7- Lower hardness

Light activated resin

Composition (usually one component)

- 1- Dimethacrylate resin
- 2- Light initiating system
- 3- Inhibitors
- 4- Filler particle

it supply in premixed sheets having a clay like consistency & polymerized in a light chamber (curing unit) with blue light of 400-500 nm (the light is activator)

Processing errors

❖ Porosity :-

When porosity is present on the surface of the denture, the denture becomes rough & porosity will cause:

- a. Poor esthetic of the denture
- b. Proper cleaning of denture is not possible causing bad oral hygiene.
- c. It weakens the denture base

Types of porosity

- 1- Internal porosity
- 2- External porosity

➤ Internal porosity:

They are bubbles within the mass of polymerized acrylic (not present on the surface of the denture). This type of porosity develops in thicker portion of denture base. Internal porosity is **due to** the vaporization of monomer when the temperature of resin increases above the boiling point of monomer (100.3c)

- ✓ Avoided by : denture with excessive thickness should be cured using long low temperature curing cycle

➤ External porosity

It can occur due to two reasons

- 1- Lack of homogeneity if the dough is not homogenous at the time of polymerization the portions containing more monomer will shrink more than the adjacent area
- ✓ Avoided by :- using powder – liquid ratio and mixing it well, the mix is more homogenous in the dough stage so packing should be done in the dough stage
- 2- Lack of adequate pressure :-

Lack of pressure during polymerization or inadequate amount of dough in the mold during final closure causes bubbles which are not spherical the resin is lighter in color

- ✓ Avoided by: - using the required amount of dough check for excess or flash during trail closure flash indicates adequate material.

❖ Crazing:

Formation of surface cracks on the denture base resin. Crazing has a weakening effect on the resin and reduces the esthetic qualities the cracks formed can cause fracture.

❖ Denture warpage :-

Is the **deformity or change of shape of the denture** which can affect the fit of the denture warpage can occur during processing as well as at other