Denture base resin material
Heat cure denture base resin

Compositions: The heat cure acrylic resin supplied as powder and liquid.

Powder:
1. Poly methyl methacrylate beads or granules so they are already polymerized not monomer (Main ingredient which will polymerize).
2. Benzoyl peroxide (initiator to produce free radicals).
3. Dibutyl phthalate (Plasticizer to make it softer and added flexibility).
4. Zinc or titanium oxide (opacifier to make it radio-opaque).
5. Pigments.
6. Synthetic fibers (nylon acrylic to look like blood vessels and to give the gingival tissues natural appearance).

Liquid:
1. Methyl methacrylate monomer.
2. Cross linking agent that improves the mechanical properties (add strength)
3. Hydroquinone Inhibitor prevent setting while storage.
Properties of Methyl methacrylate monomer

- It is a clear transparent liquid (colorless), liquid at room temperature. It has typical smell of its own.
- Can get evaporated (Volatile).
- Inflammable.
- Should store in dark colored bottle.
- It is a known allergen.
- Boiling point 100.8 °C, Melting point 48 °C.
- Light weight.
- Volumetric shrinkage during polymerization of 21%.

Manipulation of heat cure acrylic resin (Polymer-monomer interaction):

The liquid is placed in clean and dry mixing jar then powder is added slowly and mixed in proper proportion (Powder /liquid ratio is 3:1 by volume or 2.5:1 by weight) and allow each powder particles to become wetted by monomer and workable mass is formed and left until it reaches a consistency suitable for packing. During this period, a cover should be placed above the mixing jar to avoid monomer evaporation. The type of the reaction is addition polymerization reaction (it is extremely exothermic reaction).

The resultant mixture will pass into 5 stages:

1- **Sandy stage**: the monomer wets the outside of the polymer’s particles.

2- **Sticky stage**: the monomer attaches the surface of the polymer beads, some polymer chains are dispersed in the liquid monomer, the viscosity of the mixture was increased, this stage is characterized by stickiness when the materials is touched.

3- **Dough like stage**: when the monomer diffuses further into the polymer particles and the mass become saturated. The mass does not adhere to the walls of the mixing jar; clinically the mass behaves like as pliable dough.
4- **Rubber or elastic stage:** in this stage monomer is dissipated by evaporation and by further penetration into the remaining polymer beads. The mass is no longer plastic, its rubber like.

5- **Stiff stage:** on standing for 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 of polymer with monomer until reaching the dough like consistency less than 10 min.

**Working time:** The time that the mixture remains in dough like stage. The dough remains moldable for at least 5mins. the working time is affected by temperature. In warm weather when the working time is insufficient can be extended by refrigeration (the resin store in refrigerator in air tight container to avoid moisture contamination). The complete Polymerization not occurs until the denture flask is heated to **above 70°C**. (In heat activated acrylic resin), The chemically activated materials start to polymerization soon after the powder and liquid are mixed and proceed more rapidly through the various consistency stages than the heat accelerated types.

**Technical consideration:** Heat activated denture resin are shaped by:

1. **Injection molding technique:** This technique required a special thermoplastic resin and special equipment. The fluid resin is contained in the injector and is forced into the mold space as needed. It is kept under pressure until it has hardened.
2. **Compression mold technique:** This is the most commonly used technique in the fabrication of acrylic resin denture. The steps of this technique are:

- Preparation of the waxed denture pattern.
- Preparation of the mold. (Flasking, De waxing).
- Application of separating medium.
- Mixing of powder and liquid (Placing acrylic dough in the mold).
- Packing, closing the flask together and removing the excess.
- Curing (Heat curing under pressure, the denture flask under pressure is placed in heated water bath or microwave oven).
- Cooling. Deflasking, finishing and polishing.

**Packing:** The placement and adaptation of denture base resin within the mold cavity are termed packing. This process represents one of the most critical steps in denture base fabrication.

**Cooling:** The flask should be cooled slowly i.e. bench cooled. Fast cooling can result in warpage of the denture due to different in thermal contraction of the resin and the gypsum product mold. Cooling overnight is ideal.

**Deflasking:** the cured acrylic denture is removed from the flask. Deflasking should be done with care to avoid breaking of the acrylic denture.
**Polymerization cycle or curing cycle:** The curing cycle or polymerization cycle is the technical name for the heating process used to control the initial propagation of polymerization in the denture mold. This process should be well controlled to avoid the effect of uncontrolled temperature rise such as boiling of monomer and denture base porosity. Curing may be done either:

1. In **water bath** to raise the temperature.
2. In **microwave** oven (where the flask used should be non-metallic type).

There are two recommended curing cycles:

1. **Long curing cycle:** Curing in a constant temperature water bath (8hr-10hr at 74 °C). (The satisfactory processing).
2. **Short curing cycles:** curing for 2hr at 74 °C then 1hr at 100 °C.

**Properties of heat cured acrylic resin:**

1. **Taste and odor:** completely polymerized acrylic resin is tasteless and odorless.
2. **Esthetic:** it is clear transparent resin which can be pigmented (colored) easily to duplicate the oral tissue. It is compatible with dyed synthetic fillers so esthetic is accepted.
3. **Density:** the polymer has a density about 1.2 gm/Cm³.
4. **Strength:** these materials are typically low in strength. Compression strength=**75 Mpa**, while the tensile strength= **52 Mpa**. The cold cured resin has lower strength value than the heat cure acrylic.
5. **Impact strength:** it has lower impact strength, the ideal denture resin should have high impact strength to prevent breakage when it is accidently dropped, Addition of plasticizers increases the impact strength. Self-cured acrylic has lower impact strength.
6. **Hardness:** acrylic has lower hardness, can be easily scratches. Self-cured acrylic has lower hardness value than Heat cured acrylic. Brienell hardness number heat cure acrylic: **22** while for cold cure resin= **16-18**.
7. **Modulus of elasticity:** they are sufficient stiff for use in complete and partial dentures. When compared with metal denture bases it has very
low stiffness (more flexible than metal). The cold cured resin has slightly low modulus of elasticity than the heat cure acrylic.

8. **Dimensional stability**: well processed acrylic resin denture base has **good** dimensional stability. The processing shrinkage is balanced by expansion due to water sorption.

9. **Shrinkage**: acrylic resin shrinkage during processing due to: 1. Thermal shrinkage on cooling and 2. Polymerization shrinkage.

10. Polymerization shrinkage of heat cure acrylic (volume shrinkage 8%, linear shrinkage 0.53 %) while the linear shrinkage of cold cure resin about 0.25%

11. **Water sorption**: acrylic resins absorb water and expand (0.6mg/cm²). This partially compensates for its processing shrinkage. This shrinkage is reversible. Thus, on drying they lose water and shrink. However repeated wetting and drying should be avoided as it may cause warpage of the denture.

12. **Solubility**: acrylic resin is insoluble in water and oral fluids. They are soluble in Ketons and esters.

13. **Thermal conductivity**: they are **poor** conductors of heat. This is undesirable because the patient wearing acrylic dentures often complain that they cannot feel the temperature of food or liquids they ingest.

14. **Coefficient of Thermal Expansion**: Acrylic has **High** Coefficient of Thermal Expansion about $76 \times 10^{-6} \text{ Cm/Cm. } ^\circ\text{C}$. Addition of fillers reduces the coefficient of expansion.

15. **Color stability**: Heat cured acrylic have **good** color stability. Cold cured is slightly lower (yellows very slightly).

16. **Biocompatibility**: Completely polymerized acrylics are biocompatible due to low percentage of residual monomer, so allergic reactions to acrylic resin may be seen in the oral cavity.

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

18. **Residual monomer**: Instances of toxicity or allergic reaction have been related to excessive residual monomer that results from improper processing. The highest Residual monomer level is observed with cold
cure acrylic. During the polymerization process of the hot cured acrylic the amount of Residual monomer decrease firstly rapidly and then later more slowly. It should be processed for a long time to reduce the Residual monomer.

**Microwave polymerized polymer**

Resins are the same as used with conventional heat cured material or using specially microwave acrylic resin and are processed in a microwave by using **non-metallic flask**. The properties and the accuracy of these materials have been shown to be as good as or better than those of the conventional heat cured material. The advantages of microwave curing are cleaner and faster than the water bath polymerization. Processing time is much shorter (4-5 min).

**Light activated denture base resins**

This material is a composite having a matrix of urethane dimethacrylate with an acrylic copolymer, microfine silica fillers, inhibitors and light initiator for polymerization (comphorquinone amine).

It is supplied in premixed sheets (Single component) and rope form in light proof pouches having clay like consistency. It is polymerized in a
Chemically activated resin (auto polymerized or cold cure or self-cure polymethyl methacrylate):
Composition same as the heat cure version with following differences

1) The powder contains small particles size beads of polymer of poly methyl methacrylate that have a lower molecular wt. and contain benzyl peroxide (initiator).
2) The liquid contains a chemical activator ((1-2%) tertiary aromatic amine) which activated the benzyl peroxide (initiator) to produce free radicals so that polymerization is initiated in manner similar to that describe for heat cure acrylic. (Upon mixing tertiary amine causes activation of benzyl peroxide).

Compared to heat cure acrylic:
1. Low molecular weight (degree of polymerization not completed compared to that achieved using heat activated). Dentures processed have more residual monomer (3-5%). While heat cured resin is reach up to 1%.
2. Color stability inferior (tertiary aromatic amine susceptible to oxidation), stabilizing agents should be added.
3. Working time is shorter than heat cure acrylic. The chemically accelerated materials start to polymerize soon after the powder and liquid are mixed and proceed more rapidly through the various consistency stage than the heat accelerated type.

4. Less shrinkage than heat cures resin (Lower dimensional change).

5. Decreased transverse strength (residual monomer act as plasticizer).


**Thermoplastic polymer (flexible dentures)**

Thermoplastic resins are used for the fabrication of flexible denture. A thermoplastic is a plastic which becomes pliable or moldable above a specific temperature and returns to a solid state upon cooling. There are different kinds of thermoplastic resin like:

1. Thermoplastic acetal.
2. Thermoplastic acrylic.
3. Thermoplastic polycarbonate.
4. Thermoplastic nylon.

The Thermoplastic nylon is used as a denture base in every case specially used in partial and complete denture when we have undercut (because of the flexibility of the material) also used in tilted teeth, patient allergy to acrylic monomer, (there is no free monomer in this material), patient allergic to nickel, if there is reduced mouth opening and when we need high esthetic demand.

Chemically nylons are **condensation copolymers** formed by reacting equal parts of diamide and dicarboxylic acid. Water result as reaction by product. Usually, the Thermoplastic nylon is supply as beads and prepared by injection molding technique, the injection temperature ranges from (274-293) °C.
Properties of the Thermoplastic nylon (Flexible dentures):

1. High strength.
2. Excellent flexibility and ductility.
3. It is semi translucent and provides excellent esthetic. No metal clasp appearance on the tooth surface.
4. Bio compatible (frees of monomer and metal which are the principle cause of allergic reaction).
5. High fracture resistance and impact properties, unbreakable martial (not fracture even if thrown from height).
6. Difficult to adjust, polish and repair.
7. Lower water sorption than PMMA resin.
8. Good resistance to most chemical but they can affect by strong acids and alcohols.
9. Light weight.
10. Nylon is aprone to creep.
11. Minimal bonding strength to artificial teeth and to relining material.
12. After short period of time the flexible dentures deteriorate, stain and develop a rough surface.

**Processing Errors:**

1. **Porosity:** Presence of voids or bubbles within structure of resin. When the porosity present in the surface it:

   - Makes the appearance of the denture base unsightly.
   - Proper cleaning of the denture is not possible, so denture hygiene and oral hygiene is suffered.
   - It weakens the denture base.

Porosity can be of two types: **internal porosity and external porosity.**
Internal denture porosity: it is in form of voids and bubbles within the mass of polymerized acrylic. Not present on the surface of the denture. It is developed in thick portion of the denture base. **Causes:**

1. Vaporization of the monomer when the temperature of the resin increases above the boiling point of the monomer (100.8 °C).
2. Very low molecular weight polymer exothermic heat of the surface resin dissipates easily into the investing plaster.
3. The center of the thick portion, the heat cannot be conducted away therefore the temperature in the thick portion may rise above the boiling point of monomer causing porosity.

**Minimized by:** Denture with excessive thickness should be cured using long and low temperature curing cycle.

External denture porosity: it can occur due to two reasons

1-Lack of homogeneity: **Causes:** if the dough is not homogenous at the time of polymerization the portions containing more monomer will shrink more than the adjacent area. This localized shrinkage results in voids, the resin appears white. **Minimized to by** Using proper powder liquid ratio and mix it well. The mixture is more homogenous in the dough stage (so packing should be done in dough stage).

2-Lack of adequate pressure: **Causes:** lack of pressure during polymerization or inadequate amount of dough in the mould during final closure cause bubbled which are not spherical and the resin color is lighter. **Minimized by** using the required amount of dough in flask and check for excess of flash during closure (flash indicated adequate material).
2. **Crazing**: Crazing is formation of surface cracks on denture base resin and has a weakening effect on the resin and reduces the esthetic qualities. The cracks formed can cause fracture. **Causes**:

- Mechanical stresses (tensile stress).
- Attack by solvent (alcohol)
- Incorporation of water during processing.

3. **Denture warpage**: It is change in shape or deformation of denture which can affect the fit of the denture. Warpage can occur during processing as well as at other times. **Cause by**

- Release of stresses incorporation in denture during processing. Causes of stress are (curing shrinkage or rapid cooling or packing of the acrylic in rubber stage or improper deflasking).
- Rise in temperature while polishing.
- Immersion of processed denture in hot water.
- Re-curing of the denture after addition of relining material.
- Repeated wetting and drying cause warpage of the denture.