Dental Materials

By

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Lecture No. (2)

Denture Base Materials

Polymers

Polymers are long chemical hydrocarbon compound consisting of a large organic molecule (macromolecule) are composed by the union of many smaller repeating units called (mers).

Monomer is unstable single molecular arrangement capable of reacting to form long polymer chains upon polymerization process.

Polymerization is the process involve chemical reaction in which monomers of a low molecular weight are converted into chains of polymers with a high molecular weight. Through polymerization, the primary structure of any polymeric material is created as a very long chain molecule which can be arranged as amorphous or crystalline phase. Most polymerization in denture base materials is exothermic reaction.

The intermolecular bonds are covalent, therefore; primary bond in each molecule is strong, but hydrogen bond and vanderwaals forces which are the weakest bands between molecule chains.

Degree of polymerization (D.P): is total number of repeated units in the polymer. When the higher degree of polymerization will be better physical and mechanical properties. The types of polymers are used as dental materials are thermoplastic polymer, thermosetting polymers and elastomers (rubbers).

Applications of Polymeric Materials in Dentistry Field

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

Prosthetic Dentistry

Prosthetic dentistry is the replacement of missing teeth, which may have been lost for a variety of reasons, with either fixed or removable dentures, partial and complete dentures.

A partial denture is made to replace one or more of lost teeth and they have the advantage that support and retention can be derived from adjacent retained natural teeth such as clasps. In general, partial dentures are ideally constructed with a metal (cobalt-chromium) base or from high quality, clinical and economical acrylic resin.

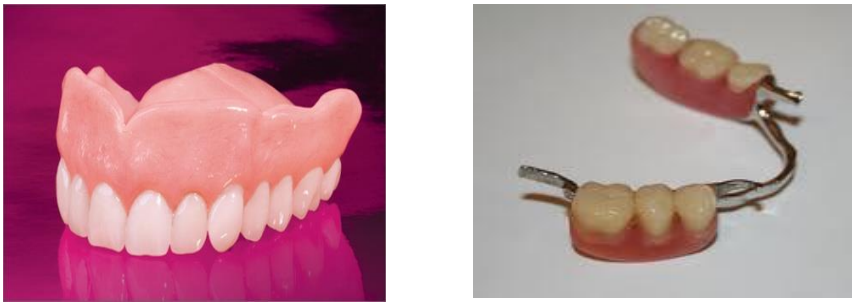
A complete denture replaces all the teeth in one dental arch. For people who are already edentulous (lacking teeth), the objectives of prosthetic treatment they would be have good speech, good appearance, effective chewing and biting, comfort and ability to done various social and interpersonal activities, and made from acrylic resin. Figure below shows images of complete and partial prosthetic denture.

Figure (1): Images of Prosthetic Denture.

Denture Base Materials

Denture base material represents one type of biomaterial that are used in the oral cavity and must be have good properties, compatibility, performance, color stability and dimensional stability, in addition to esthetical satisfactory.

Many polymer materials have been used to construct dentures, however they have suffering from a variety of problems. In particular, dentures base materials that made from PMMA acrylic resin.



Classification of Denture Base Materials

Denture base materials can be classified depending on type of material as metallic and non-metallic. The metallic type includes cobalt chromium, nickel chromium, gold, aluminum and titanium. The nonmetallic materials like porcelain

as ceramic materials, poly methyl methacrylate acrylic resin and other polymer materials (phenol formaldehyde, polycarbonate, nylon).

While according to the polymerization method in to addition polymers, e.g. poly (methyl methacrylate) and condensation polymers, e.g. nylon.

According to their thermal response into thermoplastic, e.g. (poly oxy methylene and polystyrene) and thermosetting, e.g. epoxy resins.

In addition, depending on their chemical composition and method of activation or processing technique, denture base materials are classified into various types as shown in table (1), where the different resin materials and the polymerization temperature. The two most commonly used types of denture base resins are heat-curing polymers and cold-curing polymers.

Table (1): Classification and Polymerization Temperature of Denture Base Materials.

Types	Characteristics
Type 1 - Heat-curing denture base resin.	Polymerization by heat in water bath at temperature > 65°C
Type 2 - Self-curing or cold- curing denture base resin.	Polymerization temperature < 65°C Curing mechanism done by catalyst depended on chemical reaction between components.
Type 3 - Thermoplastic (Flexible) denture base resin.	Polymers which are moldable when heated.
Type 4 - Visible Light-curing denture base resin.	Curing with UV radiation and/or visible light.
Type 5 - Denture base materials by microwave curing.	Heat-curing systems polymerized with microwaves.
Type 6 – Pour curing denture base resin..	Very fluid resin and poured into the model.

Ideal Requirements of Denture Base Materials

The requirements for materials that used as denture base material including:

1- High strength, proportional limit, hardness, toughness, stiffness and resistance to wear and abrasion, durability.

2- Good thermal conductivity.

3- The softening temperature should be higher than mouth temperature.

4- Dimensional stability when use by the patient, it should not expand, contract or warp during processing.

5- Insoluble and low sorption in saliva or other fluids taken in to the mouth.

6- Absence of taste and odor.

7- Tissue compatibility (non-toxic, none-allergic and none irritating the oral tissue).

8- Easy to clean and use.

9- Accurate production of surface detail.

10- Natural appearance and good esthetic.

11- Color stability.

12- Radio-Opaque (is meaning the relative inability of X-ray spectrum of electromagnetic radiation to pass through a dental material.

13- Low density.

14- Easy to fabricate and repair.

15- Reasonable adhesion (good retention).

16- Retain high polish and should not be porous.

17- Good chemical stability (not deteriorate during use in the oral environment).

18- Inexpensive with good shelf life.

19- Could be disinfected and not provide culture for growth of bacteria and fungus.

Acrylic Resin Denture Base Materials

Acrylic resins are the most widely used and accepted in dentistry applications, majority of denture bases used consist of poly methyl methacrylate (PMMA) which is transparent and rigid thermoplastic polymer and it was estimated that they represent (95%) of the polymeric materials using in prosthodontics applications.

The poly methyl methacrylate resin (PMMA) is now the material of choice to use as denture base material because it distinguishing by many properties, such as availability, dimensional stability, handling characteristics, biological properties color stability and compatibility with oral tissues, also PMMA polymers are capable of providing an excellent balance of performance and characteristics needed for use in the oral cavity. Some of important features of PMMA material are it's distinguishing by the follows:

1. Satisfactory mechanical properties, except the impact and fatigue strength.
2. Dimensional stability is chiefly affected by the water sorption property.
3. Excess levels of residual monomer content have been found to cause mucosal irritation.
4. Have high glass transition temperature (Tg) is usually between (89.9-109.9 ˚C) but can be affected by the composition of the material.
5. Various Co-polymer of acrylic are now available with improved impact strength.
6. Excellent esthetically pleasing, inexpensive techniques, ease of manipulation, ease of processes and using.

Glass Transitional Temperature (Softening Temperature):

Glass transition temperature (Tg): is the temperature at which motion begins to force the polymer chains apart. So, at which rigidity and hardness of polymeric materials decrease and polymer soften increase when heated above this temperature. (i. e. it is the temperature was the polymers leave the rigid state and transfer into rubber state).

PMMA can be fabrication and processed by casting (Hand lay-Up), also PMMA can be extrusion, injection and thermoforming. Some of the common applications of acrylic PMMA are:

- Denture base materials.
- Artificial teeth.
- Rebasing and relining materials.
- Impression materials.

- Permanent soft lining materials.
- Repair materials.

Composition of Acrylic Resin Denture Base Materials

Acrylic denture base material is usually early supplied as Gel (Plastic Cake) form which is rarely used. But the continuous further development then ultimately led to today's PMMA denture base materials consisting of polymer powder of pre-polymerized of (poly methyl methacrylate PMMA) and monomer liquid (methyl methacrylate, MMA), most acrylic resins denture base used today are based on this PMMA / MMA system. **The polymer powder consists of the following:**

1- Acrylic polymer: contains poly (methyl methacrylate) as beads or granules.

2- Initiator: benzoyl peroxide or di-isobutylazonitrile is usually added partly as (0.5% to 1.5) %, to produce free radicals and act in the polymerization of the residual monomer, as a catalyst.

2- Plasticizer: di-butyl phthalate these are substance added to the resins to assist dough formation, decrease the brittleness of the polymer, increase the flexibility and solubility of the polymer in the monomer and decreases strength, hardness and softening point it is used to prepare flexible polymer.

3- Inorganic matters: which are added with use of coupling agent like glass fibers, alumina whiskers, polyethylene woven and aramid fibers to increase the stiffness, decrease the coefficient of thermal expansion and increase thermal diffusivity.

4- Opacifiers: zinc oxide or titanium oxide are being added to polymer, the later one is more effective and increase the opacity of the denture base material. The radio-opacity of denture plastics helps in locating fractured fragments in denture.

5- 6- Dye and Pigments: organic dyes are added at concentration of (10 to 15 %), to make the denture radiopaque like barium, glass fillers, bismuth, While the

organic pigments are used for color, like mercuric sulphide, cadmium sulphide, and ferric oxide are being added during polymerization or after to obtain tissue like appearance i.e. (to match the shade of the oral tissue). The use of cadmium salts is restricted due to its toxicity.

While the liquid monomer consists of the following:

1- Monomer: methyl methacrylate which is a liquid at room temperature. Figure below shows the chemical formula of MMA monomer.

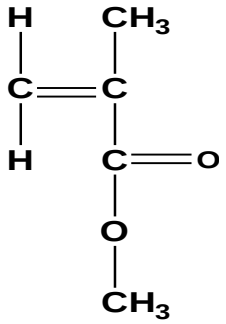


Figure (2): Chemical formula of (MMA) Monomer.

2- Inhibitor: it is chemical materials was added at concentration (0.003% to 0.7%) like hydroquinone ($C_6H_6O_2$) is an aromatic organic compound, impurity and oxygen to prevent the monomers from polymerizing and setting during storage, to give clinician adequate working time and decrease sensitivity to ambient light.

3- Accelerator: the accelerator is used to speed up the decomposition of benzoyl peroxide to perform polymerization at room temperature like tertiary aromatic amine or amine sulfonic acids as (catalyst) at concentration of (1-2%) to liquid.

4- Cross-linking agent: The most common cross-linking agent are dimethacrylate, either (glycol dimetharylate) or (butlane glycol dimethacrylate) which are added with ratio (2 to 4%) to link long polymer molecules together to form bridges between the linear macromolecules chains as three dimension network that provides greater resistance to surface cracking, resistance of denture to organic solvent, improves the mechanical properties (strength, fatigue properties in termed crazing) and decrease solubility and water sorption of the resin.