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# Denture base Materials: Some Relevant Properties and their Determination

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## Abstract

The use of denture base resin has revolutionized the dental material sciences ever since their discovery. Many prostheses and implants made from polymers have been in use for the last three decades and there is a continuous search for more biocompatible and stronger polymer prosthetic materials. In this review, an attempt has been made to combine the material properties of the polymers used in denture dentistry, with emphasis on the most widely used poly methyl methacrylate resin (PMMA).This paper may be useful for material selection of polymers used for denture applications and may provide insight into the upcoming novel materials in denture dentistry. . PMMA resin continues to be the universal versatile polymer in denture dentistry.

## Introduction

Since first polymerized by Walter Bauer in 1936, acrylic resin denture base gradually took the place of traditional metal base and became most commonly used denture base material in clinical fabrication [1,2]. Poly (methylmethacrylate) is still the most predominantly used denture base material because of its excellent esthetics, ease of processing and repair and being economical. It is a combination of advantages rather than one excellent aspect that accounts for its wide usage [3], including its popularity in satisfying aesthetic demands and clearly defined processing method in dentistry application. However, this material is not ideal in every respect [4], especially when meeting with mechanical requirements of prosthesis. Fracture of acrylic resin denture base happens frequently because of the fatigue and chemical degradation of base material [3], which is reflected by a large number of denture repairs annually [5]. Thus, to overcome these drawbacks, there has been much new advancement in the field of acrylics. Resins have been reinforced using different materials to improve strength. The hypoallergenic resins overcome the problems of monomer allergy. Other physical properties have also been improved by using different additives in resins. Several modified poly (methyl methacrylate) materials have been used for denture base applications. These include the pour type of denture resins, rapid heat polymerized acrylics, light activated denture base materials and high impact resins [6]. This article reviews the various advancements in the field of acrylics.

## New Era in Denture Base Resins- A Review

Over the years, different approaches were considered to solve the problems associated with broken dentures, such as by using different denture repair material, modifying repair surface contours, reinforcing the fractured denture fragments and employing different processing methods. Nishi first reported curing denture resin with microwave energy in 1968. There are different types of modified acrylic resin used in dentistry.

1. Reinforced Resins
   a. Fibre-Reinforced  b. High Impact Resins
2. Hypoallergenic Resins
3. Resins with Modified Chemical Structure
4. Thermoplastic Resins
5. Enigma Gum Toning In Denture Bases

## Reinforced Resins

### Fiber reinforced resins

Primary problem with PMMA is low impact strength & low fatigue resistance. To improve the physical and mechanical properties of acrylic resin. Fiber reinforcement result in a 1000% strength increase over non-reinforced (if there is proper bonding). It was reinforced with embedded metal forms Fibres have been used in three forms, namely, continuous parallel, chopped and woven.

### High impact resins

Rubber reinforced (butadiene-styrene polymethyl methacrylate). Rubber particles grafted to MMA for better bond with PMMA. They are so-called because of greater impact strength and fatigue properties, hence indicated for patients who drop their dentures repeatedly e.g. Parkinsonism, senility. Available as powder-liquid system & processing is same as heat cure resins.

**Metal fiber reinforced:** Not widely used because unesthetic, expensive, poor adhesion between wire and acrylic resin and metal being prone to corrosion. Using full lengths of metal fibers offers the best reinforcement [7].

**Carbon / graphite fiber reinforced**: Carbon fibers (65-70 mm length, 5% by weight and treated with silane coupling agent) are placed during packing. Carbon Graphite fibres are available as-chopped, continuous, woven, braided and tubular but tubes of braided fibres provide a more even distribution of reinforcement, high filler loading and easy handling because fibre bundles at different angles are advantageous when multi-axial forces are present (e.g. in implant supported prosthesis) [8].

**Aramid fiber reinforced:** Aramid fiber reinforcement increases the strength but again they are unesthetic & difficult to polish so limited to locations where aesthetics is not important.

**Polyethylene fiber reinforced:** Multifibered polyethylene strands cut to 65 mm length and surface treated with epoxy-resin (to improve adhesion)

are placed in resin during packing. They develop anisotropic properties to the composite (i.e. increase strength and stiffness in one direction).

**Glass fibres (have best aesthetics):** Continuous parallel fibers provide high strength and stiffness in one direction (anisotropic) while randomly oriented fibers provide similar properties in all directions (isotropic properties). Continuous fibers provide superior reinforcement over chopped fibres but placing continuous fibers at weak parts of denture is difficult and there is formation of voids inside fiber polymer matrix system due to poor impregnation of fibers by resin and polymerization shrinkage, so chopped fibers mixed with denture base acrylic resin enhance isotropic mechanical properties. Six mm chopped glass fibers with 5% fiber in combination with injection moulding technique result in increase in transverse strength, elastic modulus& impact strength [6]. Glass fibers may be modified by plasma polymerization technique using HEMA, EDA, and TEGDME [6].

**E-glass fibers:** Each strand of this E-glass is computer impregnated with a PMMA (porous polymer) and silane coupler that allows dissoloution bonding to acrylic. (e.g. Preat Perma Fiber ).

## Hypoallergenic Resins

Diurethane dimethacrylate, Polyurethane, Polyethylenterephthalate and Polybutylenterephthalate, Hypoallergenic denture base materials exhibit significantly lower residual monomer content than PMMA [8], thus act as alternatives to Poly Methyl Methacrylate in allergic patients. Enter phthalate based (Promysan, thermoplastic) show low water solubility than PMMA [9]. Light activated indirect composite containing methane dimethacrylate (UDMA) is an alternative to PMMA for patients hypersensitive to PMMA [10]. But unfortunately these materials are not completely risk free. Dental polymer materials based on methacrylate, its polymer, and polyelectrolyte, seem to be a major cause of contact dermatitis in dental students. Dentistry uses a variety of different polymer materials. The setting of restorative materials and adhesives is initiated chemically by mixing two components or by visible light. In both cases, polymerization is incomplete and monomers, not reacted (also known as free monomers), are released. These free monomers may cause a wide range of adverse health effects such as irritation to skin, eyes or mucous membranes, allergic dermatitis, asthma and paraesthesiae in the fingers. Additionally, disturbances of the central nervous system such as headache, pain in the extremities, nausea, loss of appetite, fatigue, sleep disturbances, irritability, loss of memory, and changes in blood parameters may also be noted in dental students and dental personnel.

## Protection against Hypoallergenic Resins

Unfortunately, the gloves do not protect the hands against the free monomers, as they easily penetrate the gloves. Dental personnel may also inhale these free monomers, as facemasks do not provide enough protection, while eyes are exposed to the monomer vapor. Because permeability of the gloves to monomers, Andersson et al [9], tested the ability of six different types of gloves to prevent the penetration of 2-hydroxyethyl methacrylate (2-HEMA) and triethylene glycol dymethacrylate (TREGDMA) present in Scotchbond1 (a commonly used dental adhesive). The types of gloves were: 1 vinyl glove, 2 latex gloves, 2 nitrile gloves, and a 4H glove. Their results indicated that the 4H glove gave by far the best protection, followed by the 1 nitrile gloves. Latex gloves and the vinyl glove gave very poor protection against the adhesive. It is therefore suggested that when acrylate allergy is suspected, nitrile or 4H gloves should be used.

## Resins with Modified Chemical Structure

Addition of hydroxy-apatite fillers increases fracture toughness [10]. Addition of $Al_2O_3$ fillers increases the flexural strength and thermal diffusivity that could lead to more patient satisfaction [11]. The ratio of 2.2:1 by weight of powder to liquid was found to be the best ratio for mixing the material to give the best results in formulation [12]. 2% quaternary ammonium compound polymerised with a denture acrylic resin displays antiseptic properties and these dentures may be used for geriatric patients to improve their oral health [13]. Addition of ceramic or sapphire whiskers improves thermal diffusivity [14]. Addition of 11-14% of several compounds of either bismuth or uranium or 35% of an organo-zirconium compound impart radiopacity equivalent to that of aluminium [15]. Addition of Triphenyl Bismuth (Ph3Bi) is a promising new additive to provide radiopacity. Rawls HR et al found that cytotoxicity of PMMA was elevated slightly by inclusion of Ph3Bi, probably due to decreased monomer conversion. But when stored in water, cytotoxicity was reduced, so there is high level of safety for Ph3Bi wa a radiopaque additive for denture resins [16].

## Thermoplastic Resins

This new procedure, during which a fully polymerized basic material is softened by heat (without chemical changes) and injected afterwards, has opened up a new chapter in making dentures [16].

## Advantages of Thermoplastic Materials

Thermoplastic resins have many advantages over the conventional powder-liquid systems. They provide excellent esthetics with tooth or tissue colored materials and are very comfortable for the patient. These are very stable, resist thermal polymer unzipping, have high fatigue endurance, high creep resistance, excellent wear characteristics and solvent resistance. They are non-porous so no growth of bacteria, and even if it is non-porous, it still retains a slight amount of moisture to keep it comfortable against gums. They may also be relined and repaired by repressing the restoration. These include thermoplastic Nylon (polyamide), thermoplastic acetal, thermoplastic acrylic and thermoplastic polycarbonate [16].

### Thermoplastic nylon

The Basic material of thermoplastic nylon is polyamide (derived from diamine and dibasic acid monomers). Thermoplastic nylon was introduced to dentistry in 1950's. It uses Rapid Injection System (currently known as The Flexite Company - USA) originated in 1962 which introduced the first flexite thermoplastic (a fluoropolymer - a Teflon type plastic). Thermoplastic nylon is injected at temperatures from 274 to 293 degrees Celsius. The application of nylon-like materials to the fabrication of dental appliances has been seen as an advance in dental materials. This material generally replaces the metal, and the pink acrylic denture material used to build the framework for standard removable partial dentures [17]. Valplast and flexiplast are polyamides (nylon plastics), since then there is a continued interest in thermoplastic dental materials [18]. In 1992, The Flexite Company, developed and patented the first pre-formed tooth colored clasps known as Clasp-Eze, made of nylon material and is available in pink and clear shades.

### Thermoplastic acetal

Acetal was first proposed as an unbreakable thermoplastic resin removable partial denture material in 1971. Rapid injection system developed the first tooth coloured clasps with thermoplastic fluoropolymer [19]. In 1986, Dental 'D' reintroduced tooth colored clasps using Acetal resin. Acetal as a homo-polymer has good short-term mechanical properties, but as a co-polymer has better long-term stability.

### Thermoplastic acrylic

Heat-cure polymethyl methacrylate demonstrates high porosity, high water absorption, volumetric changes and residual monomer [20]. Thermoplastic acrylic has poor impact resistance, but has adequate tensile

and flexural strength. Thermoplastic acrylic is available in both tooth and gingival colors, and has both translucency and vitality, providing excellent esthetics. However, acrylic does not wear as well as acetal during occlusal forces and consequently will not maintain vertical dimension over long periods of time. The material is easy to adjust, handle and polish. It is relineable and repairable at the chair-side Flexite M.P.-a thermoplastic acrylic, is a special blend of polymers and has the highest impact rating of any acrylic and does not crack even if falls on floor, thus very popular for bruxism appliances as well as dentures.

### Thermoplastic polycarbonate

Polycarbonate is a polymer chain of bisphenol-A carbonate. Similarly to Acetal resin, polycarbonate resin is also very strong, resists fracturing, and is quite flexible. However, polycarbonate does not wear as well as Acetal during occlusal force and consequently will not maintain vertical dimension as long. Polycarbonate is not suitable for full or partial dentures but ideal for provisional crown and bridges. The material has a natural translucency and finishes very well, yielding excellent esthetics. Temporary and provisional restorations with thermoplastic polycarbonate provide patients with excellent short or mid-term function and esthetics [19,20].

## Applications of Thermoplastic Resins

Current dental applications of thermoplastic materials include: preformed partial denture clasp, flexible tooth born partial denture framework, single cast partial dentures, temporary crowns and bridges, provisional crowns and bridges, occlusal appliances, implant abutments, orthodontic and sleep apnea appliances.

## Enigma Gum Toning

1) Custom shade matching of natural gingival tissue using 'Enigma' colour tones. 2) Gives extra confidence to patient in appearance of their dentures. 3) Available in Ivory, Light Pink, Natural Pink, Dark Pink and Light Brown. Different colors are mixed to get the desired gum tone.

## Conclusion

The various advancements in denture base resins have provided promising results. Today many limitations of poly-methyl methacrylate denture base resins have been overcome. And it's certain to have additional new applications in the future, to provide a better treatment and care to the patients.

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