

Biomedical polymers

(II) Dental polymers - Polymers are formed through chemical reactions that convert large numbers of low-molecular-weight molecules, known as monomers into large, very high-molecule weight long-chain macromolecules. Resins are compositions of either monomers or macromolecules blended with other components to provide a material with a useful set of properties. The particular form and morphology of the macromolecule determine whether it is a fiber, a rigid solid, or an elastomer (rubberlike) material. Monomer resins are useful in dentistry because they can be shaped and molded and then transformed to a solid to take on a permanent shape when they polymerize. Synthetic polymer resins are often called plastics, which are substances that, although dimensionally stable in normal use, can be permanently reshaped by irreversible deformation. The utility of plastics is derived from their ability to be permanently formed and molded into complex shapes, either by the application of heat and pressure or by a chemical reaction. Based on their thermal behavior, they can be divided either into thermoplastic ~~plgm~~ polymers if they undergo a reversible change or thermosetting polymers if they undergo an irreversible change when heated. Elastomers readily undergo extensive reversible deformation under small applied stresses; that is they exhibit elastic behavior.

• Dental uses of polymeric materials and Resins

Polymeric materials are used in a variety of dental applications. Hardly a single clinical procedure is accomplished without the use of one or more of these products, typical applications of which include the following:

- Prosthodontics: denture bases and teeth, soft liners, custom trays, impression materials, core buildup materials, temporary restoratives, cementing/luting materials and maxillofacial prostheses.

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- Operative Dentistry: dentin bonding agents, cavity fillings, resin and glass-ionomer cements, pit and fissure sealants, splinting materials, and veneers.
- Orthodontics: brackets, bracket bonding resins and cements and spaces.
- Endodontics: gutta-percha points, root canal sealants and rubber dams.
- Equipments: mixing bowls and spatulas, mouth guards (Sports equipment) and protective eye wear.

Polymeric resins are increasing in use for restoring and replacing tooth structure and missing teeth.

These resins can be bonded with other resins, directly to tooth structure or to other restorative materials such as amalgam. If all teeth are missing, a denture base with attached denture teeth can be made to restore chewing ability. Most of these restorative and prosthetic applications are based on methacrylate resins. More recently, epoxy resins and related silorane materials, based on ring-opening polymerization mechanisms, have been introduced. ~~These resins are discussed in a later section.~~

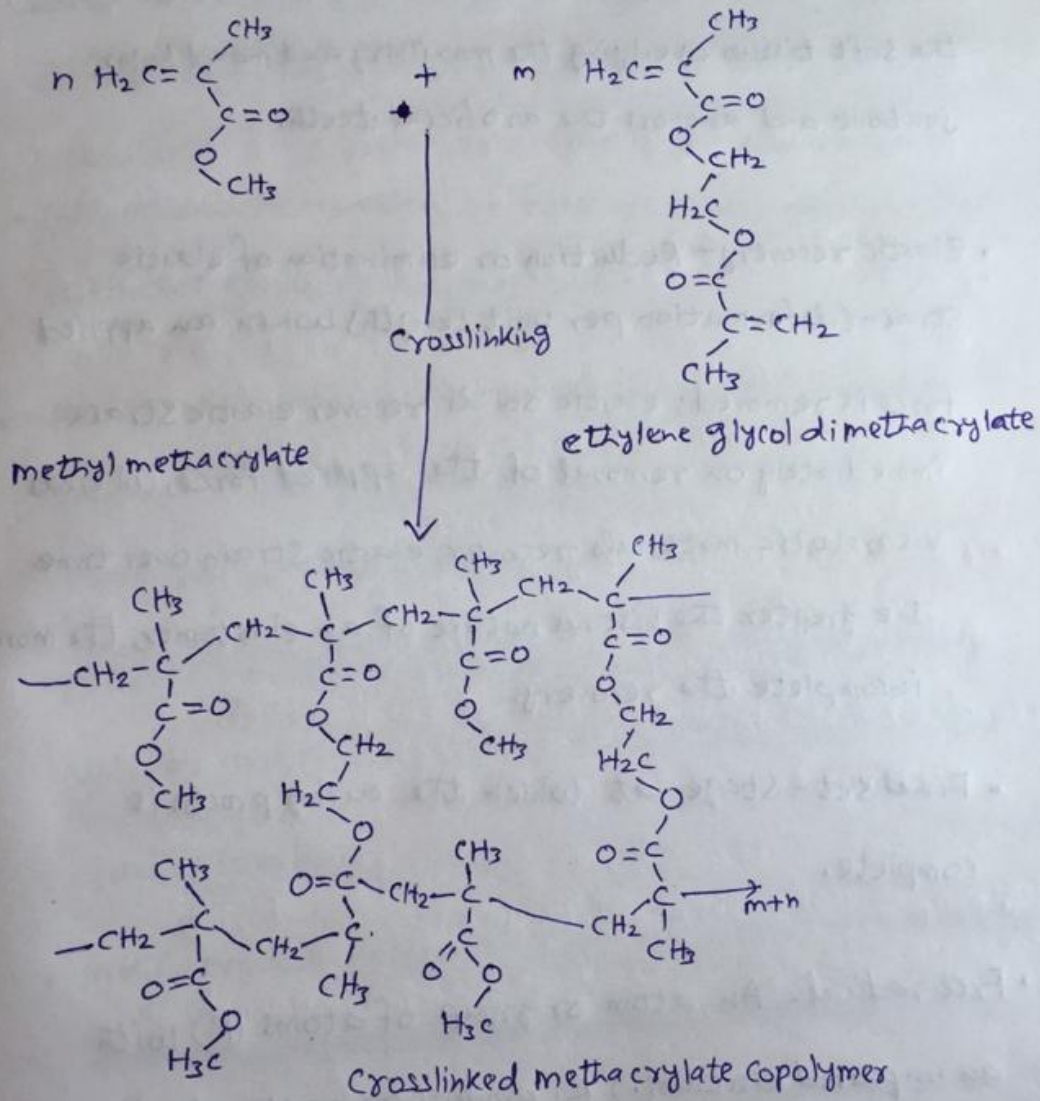
• Key terms

- Backbone - The main chain of polymer
- Block copolymer - Polymer made of two or more monomer species and identical monomer units ("mers") occurring in relatively long sequences along the main polymer chain.

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- Chain transfer - stage of polymerization in which the free radical on the growing end of one polymer chain is transferred to either a monomer or a second polymer chain. This terminates chain growth in the first chain and initiates chain growth in the monomer or second polymer chain.
- Curing - chemical reaction in which low-molecular-weight monomers (or small polymers) are converted into higher molecular weight materials to attain desired properties.
- Crosslink - A difunctional or multifunctional monomer that forms a link between two polymer chains. Crosslinked polymers have many such crosslinks between neighboring chains such that a three dimensional interconnected polymer network

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A cross linked structure is formed by copolymerization, where at least one comonomer is multifunctional. Here methylmethacrylate is copolymerized with ethylene glycol dimethacrylate.

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- Denture base - The part of the denture that rests on the soft tissues overlying the maxillary and mandibular jawbone and anchors the artificial teeth.
- Elastic recovery - Reduction or elimination of elastic strain (deformation per unit length) when an applied force is removed; elastic solids recover elastic strain immediately on removal of the applied force, whereas viscoelastic materials recover elastic strain over time. The greater the viscous nature of an elastomer, the more incomplete the recovery.
- Final set - Stage at which the curing process is complete.
- Free radical - An atom or group of atoms (R) with an unpaired electron (\cdot) R, producing reactions that initiate and propagate polymerization and eventually lead to a final set.
- Graft or branched copolymer - Polymer in which a sequence of one type of mer unit is attached as a graft (branched) onto the backbone of a second type of mer unit.

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- Initial set (of a polymer) - The stage of polymerization during which the polymer retains its shape.
- Induction - Activation of free radicals, which in turn initiates growing polymer chains.
- macromolecule - A large high-molecular-weight compound usually consisting of repeating units in a chainlike configuration.
- mer - The term used to designate the repeating unit or units in a polymer chain; thus, mers are the "links" in the chain.
- methacrylate polymers - Type of macromolecule derived from monomers with the chemical structure.
- monomer - Chemical compound that is capable of reacting to form a polymer.
- plastic flow (of a polymer) - Irreversible deformation that occurs when polymer chains slide over one another and become relocated within the material.

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- Polymer - Chemical compound consisting of a large organic molecule ("macromolecule") formed by the union of many smaller repeating units (mers)
- Polymerization - Chemical reaction in which monomers of a low molecular weight are converted into chains of polymers with a high molecular weight.
- PMMA and MMA - Poly(methyl methacrylate), a commonly used acrylic thermoplastic dental material derived by polymerization of the monomer, methylmethacrylate (MMA).
- Propagation - Stage of polymerization during which polymer chains continue to grow to high molecular weights.
- Random copolymer - Polymer made of two or more monomer species but with no sequential order between the mer units along the polymer chain.

- Resin or synthetic resin - Blend of monomers and/or macromolecules with other components, which form a material with a set of useful properties.
- Resin-based composite - A highly cross linked resin reinforced by a dispersion of amorphous silica, glass, crystalline, or organic resin filler particles and/or fibres bonded to the polymer matrix by a coupling agent.
- Setting (of a polymer) - Extent to which polymerization has progressed.
- Thermoplastic polymer - macromolecule material made of linear and/or branched chains that softens when heated above the glass-transition temperature (T_g), at which molecular motion begins to force the chains apart and soften the polymer. Thermoplastics can be heated above the T_g , molded to a new shape, and then ~~cooled~~ cooled below the T_g to retain the new configuration.

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- Thermosetting polymer - Polymeric material that becomes permanently hard when heated above the temperature at which polymerization occurs and that does not soften again on reheating to the same temperature.
- Termination - Stage of polymerization during which polymer chains no longer grow.
- Viscoelastic - Term describing a polymer that combines the spring-like behavior of an elastic solid (such as rubber band) with that of the puttylike behavior of a viscous, flowable fluid (such as honey).