Filling material

Filling material: the material that is used to replace a missing part of the tooth which may result from dental caries, trauma or abrasion. It can be divided in to:

1. **Direct filling materials:** it placed directly into a cavity on a tooth, and shaped to fit it.
2. **Indirect filling materials** the dental impression is taken after tooth preparation and sent to a dental technician who fabricates the restoration that place in the prepared tooth.

- **Requirement of an ideal Filling material:-**
  1. Working time should be sufficiently long, to enable manipulation and placement of material before setting.
  2. Setting time should ideally be short for comfort and convince of both the patient and clinician.
  3. The material must withstand large variation in PH and a variety of solvents which may be taken into mouth.
  4. Filling should be good thermal insulator, protecting the dental pulp from the harmful effect of the hot and cold stimuli (low thermal diffusivity).
  5. Materials should have values of coefficient of thermal expansion similar to those of enamel and dentine.
  6. Metallic material should not undergo excessive corrosion, or be involve in the development of electrical currents which may cause " **Galvanic pain** " .
  7. Should have satisfactory mechanical properties to withstand the force applied, abrasion resistance, compression and tensile strength, modulus of elasticity.
  8. It should adhere well to the tooth walls and seal the margins to prevent ingress of fluid and bacteria.
  9. It should be harmless to the operator and to the patient and should not be irritant to dental pulp and soft tissue.
  10. It should be radiopaque.
  11. It should bacteriostatic and anticariogenic.
  12. It should be easily polished.

  No single restorative material is suitable for all cases. For some situations, the strength and abrasion resistance of material may be the prime consideration. In other situation, appearance and adhesive properties may become more important.

Classification of filling materials:

1. **Metallic**
   a. Amalgam.
   b. Direct Gold filling.
   c. Indirect cast restorations.

2. **Non metallic which include**
   a. Polymeric
      - **Unfilled resin (acrylic)(** not used now)
      - **Filled resin (composite, compomers)**
   b. Non polymeric
      - **Silicate cement(**not used now**)**
      - **Glass ionomers cement**

Other classifications:

1. **Anterior filling material (tooth colored filling).**
2. **Posterior filling material.**

Composite materials

The term composite may be defined as a compound of **two or more** distinctly different materials with properties that are superior or intermediate to those of the individual constituents.

Composite is polymeric filling material reinforced with filler particles used as restorative materials. The proper term is polymer matrix composite or resin composite. It has higher mechanical properties than of acrylic filling and of silicate cement.

Modern composite materials have excellent esthetics that mimics the natural teeth and excellent durability, wear-resistance, high mechanical properties for stress bearing areas (used as anterior and posterior filling materials).

• Composition:

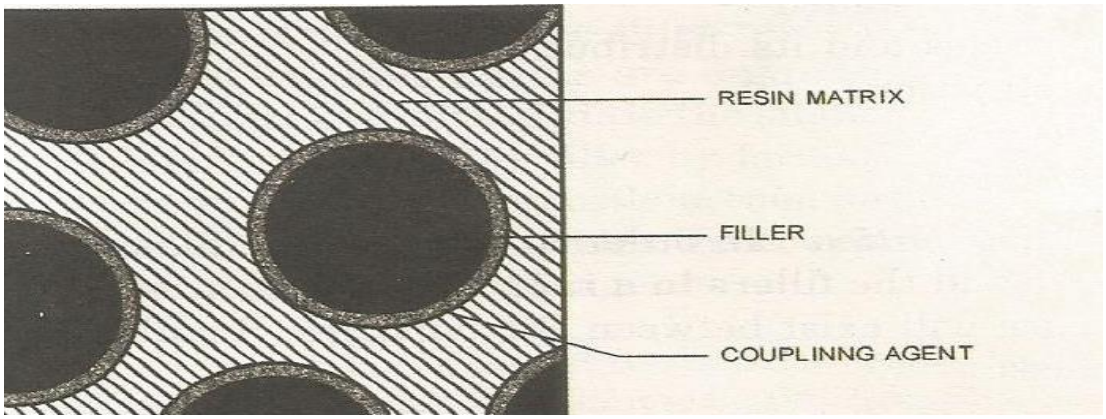
A resin composite is composed of four major components:

1. **Organic resin matrix**. (Bis- GMA or urethane dimethacrylate).
2. **Inorganic filler particles** (Quartz, colloidal silica glasses or ceramic containing heavy metals).
3. **Coupling agent** (organo silanes).
4. **The initiator-accelerator system**.

Also they contain

1. **Hydroquinone** - inhibitor to prevent premature polymerization
2. **UV absorber** - to improve color stability
3. **Opacifiers** - e.g. titanium dioxide and aluminum oxide.
4. **Color pigments** - to match tooth color

- **Organic resin matrix (binder):-** The nature of it may alter slightly from one product to another; essentially The monomers used for the resin matrix are **dimethacrylate** compounds. Its properties were superior to those of acrylic resins. The two monomers that have been commonly used are (**Bis-GMA**) and **urethane dimethacrylate (UDMA**). Both contain reactive carbon double bonds at each end that can undergo **addition** polymerization initiated by free-radical initiators. Both of Bis-GMA and UDMA are viscous and sticky so, **TEGDMA** 'triethylene glycol dimethacrylate' with low molecular weight added as a dilute monomer to control the consistency of composite paste.



- **Inorganic Filler particles:** Composite resins use 3 types of fillers:

1. **Ground quartz filler**: They are obtained by grinding or milling the quartz. They are mainly used in conventional composites. They are chemically inert and very hard. This make restoration more difficult to polish and can cause abrasion of opposing teeth and restoration. The quartz filler is harder than the glass filler.
2. **Colloidal silica:** Referred to as **microfillers**, they are added in small amount (**5 wt %**) to modify the paste viscosity. Colloidal silica particles have large surface area thus even small amount of micro fillers thicken the resin. It used in microfilled composites.
3. **Glasses / ceramics containing heavy metal**: There filler provide radiopacity to resin restoration. ex. Barium ;Zirconium. The most commonly used is barium glass. It is not as inert as quartz some barium may leach out.

- **The function of the addition of filler particles into resin matrix are**

1. Reinforcement (Improves mechanical properties). Increased filler loading generally increases physical and mechanical properties such as compressive strength, tensile strength, modulus of elasticity.
2. Reduction of polymerization shrinkage/contraction. (less resin is present so the curing resin is reduced).

3. Reduction in coefficient of thermal expansion and contraction. (Fillers thermally expand and contract less than the polymers).
4. Decreased water sorption. Increased filler loading decreases water sorption. Absorbed water softens the resin and makes it more prone to abrasive wear and staining.
5. The radiopacity are improved
6. Control of workability/viscosity. The more filler, the thicker is the paste

Factor with regard to filler that determine the properties and clinical application of composite

a- ***Amount of filler added.***

b- ***Size of particles and its distribution:*** In order to increase the amount of filler in the resin, it is necessary to add the filler in a range of particles size. If a single particle size is used, a space will exist between particles, smaller particles can then fill up these spaces.

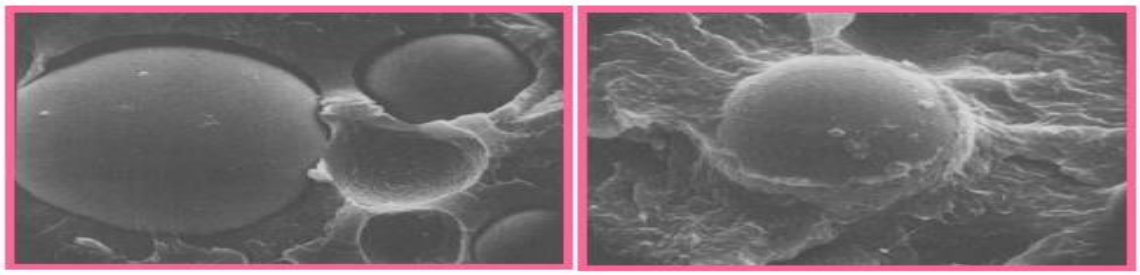
c- ***Index of refraction*****:** For esthetic, the filler should have a translucency similar to tooth structure. To achieve this, the refractive index of filler should closely match that of the resin. Most glass and quartz filler have a refractive index 1.5, which much than that of bis-GMA.

d- ***Its hardness***

e- ***Radiopacity***

- **The Coupling agents:** the composite to have successful properties, a good bond must form between the inorganic filler and the organic resin, The most commonly used coupling agents are organosilanes (often referred to as silane). It is applied to the inorganic filler particles to surface-treat the fillers before being mixed with the monomer. They called coupling agents, because they bond the filler particles to the resin matrix. This allows the more plastic resin matrix to transfer stress to stiffer filler particles. Function of coupling agents.

1. They improve the physical and mechanical properties of resin.
2. They prevent water from penetrating the filler - resin interface. (Micro leakage of fluids into filler resin interface led to surface staining).
3. Prevent the filler from being dislodged from the resin matrix.



- **The initiator-accelerator system:** is to polymerize and cross-link the system into a hardened mass. The polymerization reaction can be activated by
  1. light-activation
  2. self-curing (chemical activation)
  3. dual curing (chemical and light-curing).

Properties of the composite

1. Low polymerization shrinkage
2. Low water sorption
3. Coefficient of thermal expansion similar to tooth structure
4. High fracture resistance
5. High wear resistance
6. High radiopacity
7. Good bond strength to enamel and dentin (by using bonding)
8. Good color match to tooth structure
9. Easy to manipulation
10. Easy of finishing and polishing

Types of composite

Classification of composite based on curing mechanism

1. Chemically activated composite or self cured composite.
2. Light activated composite.
3. Dual cured composite

Classification of composite based on size of filler particles:

1. Conventional or traditional composite.
2. Small particles composite.
3. Micro filled composite.
4. Hybrid composite.
5. Nanocomposites.

Chemically activated composite resins (self cured composite):

This is two paste system (base and catalyst) two tubes.

- **Base paste**: contains benzoyl peroxide initiator.
- **Catalyst paste**: tertiary amine activator.

Setting: When the two pastes are mixed the tertiary amine reacts with the benzyl peroxide to form free radical which stats the polymerization. The correct proportions of the base and catalyst pastes are dispensed onto a mixing pad and combined by rapid spatulation with a plastic instrument for **30 seconds**. (Metal instrument should be avoided as it may discolor the composite) it can be inserted in the cavity with a plastic instrument or syringe. The cavity is slightly overfilled; a matrix strip is used to apply pressure and to avoid inhibition of air.

The properties of self cures composite are:

1. Activated by peroxide-amine system.
2. Chemical activation is accomplished at room temperature
3. Cures throughout its bulk.
4. Working time is limited.
5. Supplied as two component system.
6. Air may get incorporated during mixing resulting in reduction of properties.

Light activated composite resins:

- **UV activated systems:** The earliest system used Ultra Violet light. Not used now a day because of the

1. Limited penetration of the light into the resin,

2. Lack of penetration through tooth structure
3. it Irritant to the soft tissue.

- **Visible Light activated resins:** They are widely used than the chemically activated resins. These are single paste system containing Photo initiator (**camphoroquinone**) and **Amine accelerator**.

Under normal light they don't interact.but when exposed to light of the correct wave length the photo initiator is activated and reacts with amine to form free radical. Camphoroquinone has an absorption range between ***400-800 nm***. This is in the blue region of visible light spectrum. In some cases inhibitors are added to enhance its stability to room light or dental operatory light.

The properties of light cures composite are:

1. Supplied as single component (light tight syringes) or unit-dose capsules.
2. Working time under control of Operator.
3. More Homogenous mix
4. Required light of correct wave Length for its activation.
5. Cure only where sufficient Intensity of light is received.
6. Less chance of air entrapment during manipulation

Light activated	Chemically activated
1. Required light of correct wave length for its activation. 2. Cure only where sufficient intensity of light is received. 3. Working time under control of operator. 4. Supplied as single component in light tight syringe. 5. Less chance of air entrapment during manipulation, more homogenous mix. 6. More Homogenous mix	1. Activated by peroxide-amine system. 2. Cures throughout its bulk. 3. Working time is limited. 4. Supplied as two component system. 5. Air may get incorporated during mixing resulting in reduction of properties. 6. Less homogenous mix

Dual cured composite: This formulation contained an initiator and accelerator that allow light activation follow by self curing. It consists of two light-curable pastes, one containing **benzoyl peroxide** and the other containing an **aromatic tertiary amine accelerator**. The major advantage of this system is assurance of completion of cure. The major disadvantage is porosity caused by the required mixing. But this has been greatly alleviated by the use of mixing syringes. There is also less color stability than with the light cure resins due to the accelerators, but this is still better than for self-cure systems.