Silicate Filling Material

Composition
Powder: Sodium alumino-silicate glass with 20% calcium fluoride.
Liquid: 50% phosphoric acid, H2O, Buffering agent

Advantages
1- Easy manipulated.
2- Anticariogenic: fluoride release lead to less chance for caries development.
3- Good insulator.

Disadvantages
1- Pulpal irritation due to low pH (5-3.5).
2- Brittle and has weak mechanical properties.
3- Shrinkage on setting.
4- Discoloration.
5- High solubility and disintegration.

Acrylic Resin

Composition
1- Powder: polymers (polymethyl methacrylate beeds).
   Initiator (benzoyl peroxide)
   Pigments (salt of calcium or iron or organic dyes)
2- Liquid: Monomers (methyl methacrylate)
   Gross linking agent (ethylene glycol dimethaerylatc)
   Inhibitor (hydroquinohe)
   Activator (tertiary amine)

Advantages:
1- Less soluble than silicate over a wide range of pH.
2- Less irritant to the dental pulp than silicate but it has residual methyl methacrylate which is irritant to the pulp.
3- Less brittle than silicate.
4- Has the ability to match the color of the tooth.
5- Some products which contain fluoride (anticariogenic)

Disadvantages
1- Temperature rise during setting caused by highly exothermic polymerization reaction necessitate the use of protective cavity base material which is calcium hydroxide.
   Products containing Eugenol should be avoided.
2- Undergo a considerable setting contraction (high coefficient of thermal expansion 92 x 10^-6 / °C). This could produce a significant marginal gap in to which the fluids can penetrate.
To overcome this problem:

A) Fill the cavity with small increments and allow contraction occur towards the walls before next increment is added,
B) Over fill the cavity and put the setting material under strong finger pressure with a matrix strip.
C) Water absorption (1-1.5%) leads to expansion which may improve the marginal seal.
3- Low compressive strength and hardness value (low wear resistance).
4- Porosity: air trapped during mixing or during evaporation of monomer leads to poor strength and color changes.

1. Poor activator system.
2. High polymerization shrinkage.
3. High coefficient of thermal expansion (CTE).
4. Lack of abrasions or wear resistance.
5. Poor marginal seal leading to microleakage.
6. Irritation and injury to pulp.
7. Color changes.
8. Poor strength and hardness.
9. Dimensional instability
10. No bonding to tooth structure.

Composite Resin
- In search of ideal tooth-colored restorative material, attempts were being made to improve the properties of unfilled acrylic resins. This search resulted in the development of composites or resin-based composites by R Bowen in 1964. Composites

Composition
1- Resin Matrix
   The nature of resin may alter slightly from one product to another, essentially, they all contain dimethacrylate monomer, like Bis- GMA (Bis phenol-A & glycidyl methacrylate) or UDMA (Urethane dimethacrylate), Bis - GMA and UDMA are viscous and sticky so, TEGMA (Triethylene glycol dimethacrylate) a low molecular weight monomer added as a dilute to control the consistency of composite paste.

Fillers
- They are silicate particles in two forms crystalline forms (quartz) and non-crystalline form (glass like aluminosilicates and borosilicates), the type of
filler, particle size, and distribution in resin matrix are the major factors controlling properties.
Zinc, Barium, Zirconium ions may be added to produce radiopacity in the filler particles.
- The quartz filler is harder than glass fillers but difficult to polish to the smooth surface.

**Advantages of adding fillers**
1- Polymerization shrinkage is reduced, as compared with unfilled due to less resin is present in a composite. Although shrinkage is varies from one product to another.
2- Water sorption and CTE are significantly reduced.
3- Mechanical properties such as compressive strength, tensile strength, abrasive resistance and modulus of elasticity are improved.
4- Optical properties (color match and radiopacity) are improved.

**3- Coupling agent**
Interfacial bonding between the matrix phase and the filler phase is provided by coating the filler particles with silane coupling agents. This bonding increases the strength of the composite and reduces its solubility. Such coupling agents work best with silica particles. Therefore, all composites have been based on silica containing fillers.
Organosilanes are added to bond the filler particles to the resin matrix, so stresses are transferred to the stiffer filler particles through the weaker resin.
1- Improve the mechanical properties of the composite resin.
2- Prevent the fillers from being dislodged from the resin matrix.
3- Hydrolytic stability prevents the water from penetrating along resin - filler interface.

**Initiator - Activator System:**

a) **Self cured composite resin**
Two paste system: one paste contains 1% benzoic peroxide initiator second paste contain 0.5% of tertiary amine activator.
Reaction leads to formation of free radical, which will initiate polymerization.

b) **Light activated composite resin**
One paste system
The first light cures system made use ultraviolet radiation to initiate polymerization. Then UV light is then replaced with visible light cure system, which is safer, less expensive and improve ability to polymerize thicker
increment up to 2 mm. Photoinitiator is added to initiate polymerization, it absorbs visible light of wavelength (400-500 nm) (blue light) forming free radical which initiate polymerization.

c) Laser activated system

Photochemical initiator found to initiate polymerization when subjected to Argon laser (456-495 nm) wavelength energy. This provides curing up to 10 mm form the tip over a large focusing area and it can produce a complete curing in only 8 seconds.

5- Inhibitors

Butylated hydroxytoluene (0.01 /wt) inhibitor is added to prevent spontaneous polymerization of monomers they have strong reactivity potential with free radicals that has been formed by brief exposure to light when the material are dispersed.

6- Pigments

Inorganic oxide like aluminum oxide or titanium oxides are added in small amount to provide shades that match the majority tooth shades.

PROPERTIES OF COMPOSITE RESTORATIVE MATERIALS
1. Linear co-efficient of thermal expansion (LCTE): LCTE of improved composite is approximately three times of tooth structure. Bonding the composite to etched surface reduces the potential negative effects due to the difference between LCTE of tooth and materials.
2. Water absorption: Composite with higher filler content exhibits lower water absorption and, therefore, exhibits better properties, than composite with lower filler content.
3. Wear resistance: Wear resistance is a property of filler particles depending on their size, shape and content. The location of restorations in dental arch and occlusal contact relationship also affect the potential wear of these materials. Wear resistance of composite materials is generally good.
4. Surface texture: The size and composition of filler particles determine the smoothness of the surface of a restoration. Microfill composites offer the smoothest restorative surface. This property is more significant if the restoration is in close approximation to gingival tissues.

5. Radiopacity: Most composites contain radiopaque fillers like barium glass to make the restoration sufficiently radiopaque in order to detect the radiolucent image of recurrent caries around or under the restorations, when seen on a radiograph.

6. Modulus of elasticity: Rigidity or stiffness of a material is directly proportional to its modulus of elasticity. Microfill composites have greater flexibility than hybrid composite. If restoring Class V lesions or defect composites with lower modulus of elasticity (less rigid and more flexible) should be used, if the tooth is subjected to heavy occlusal forces. In such cases, stress concentration occurs in cervical area. More flexible composite material protect the bonding interface.

7. Solubility: Composite materials do not show any clinically significant solubility in oral fluids.

8. Polymerization shrinkage: Composite materials shrink while curing. This can lead to failure of interfacial bonding. It is usually more significant when the cavity preparation extends up to the root surface causing a V shaped gap formation between the composite and root surface due to polymerization shrinkage. A dentinal adhesive can be used to reduce the effect of polymerization shrinkage and prevent bond disruption; also incremental technique is useful.

**TYPES OF COMPOSITE RESINS**

Composite resin can be divided into three types based on the size, amount and composition of the inorganic filler:

1. Conventional composite resins.
2. Microfilled resins.
3. Hybrid composite resins.
4. Flowable composites.
5. Packable condensable composites.

1. Conventional composite resins: Average particle size of conventional composite resins is 8 microns (from 5-25 micron) approximately. It contains
It exhibits a rough surface texture because of the relatively large size and extreme hardness of the filler particles. The surface becomes more rough as the resin matrix-being less hard wears at faster rate. Due to roughness, discoloration and wearing of occlusal contact areas and plaque accumulation take place quickly than other types of composites (Fig. 24.2).

Fig. 24.2: Polished surface of conventional composite restoration as seen in scanning electron micrograph (SEM)

2. Microfilled resins: Microfilled resins or polishable composites were introduced in the 1978. Average particle size of microfilled resins ranges from 0.01 to 0.04 microns. This small particle size in place of large size as present in conventional composites results in smooth polished surface which is plaque, debris and stain resistant. Microfilled resins have inorganic filler content of approximately 35 to 60 percent by weight. Most of the studies have observed that the microfilled resins are less susceptible to wear than conventional composite resins. As they contain less filler content, some of their physical properties are inferior.

3. Hybrid composite resins: In order to combine the advantages of conventional and microfilled composites hybrid composites have been developed. The average inorganic particle size is 0.4 to 1 micron. These materials have an inorganic filler content of approximately 75 to 85 percent by weight. The physical properties of hybrid are similar to those of conventional composites with the advantage of smooth surface texture.

A. Considering all factors hybrid type composites are most commonly used.

B. Because of their smoothness, they are especially indicated in anterior restorations, but can also be used in posterior restorations. The main disadvantages of hybrid composites are as follows:

A. Not suited for heavy stress-bearing areas in posterior teeth

B. Not highly polishable as microfilled because larger particles are also present in between smaller. In spite of above disadvantages, due to their advantages hybrid composites are most commonly used. Where no specific type of composite is mentioned, it means it is hybrid type.

4. Flowable composites: As the name indicates, their consistency is such that they can be flowed into the deep pit and fissure, very small class I, class III, class V and class VII, marginal defects and as a base under hybrid or condensable composites. Their features are as follows:
A. Filler content is less about 30 percent by weight resulting into inferior physical properties like poor strength and wear resistance in comparison to composites having more fillers. Due to this, their viscosity is reduced and flow is increased.
B. It sticks to the instrument, hence difficult to smoothen the surface.
C. High stress areas should not be restored with it.

Condensable (packable) composites: To improve the compressive, tensile and edge strength and handling, condensable composites have been developed. They are more viscous. Their basis is Polymer Rigid Inorganic Matrix Material (PRIMM). In this, the components are resin and ceramic inorganic fillers are incorporated in network of ceramic fibers. The consistency of the condensable composites is like freshly triturated amalgam. The composite is carried to the cavity by a carrier whose nozzle is preferably made from or coated with wear, resistant teflon polymer. Each increment is condensed similar to silver amalgam. The cavity is slightly over filled. The excess is removed with a carver. The restorations is light cured for 30 to 40 seconds and finished and polished.

**Advantages of condensable composites over the conventional composites are as follows:**

A. Increased wear resistance: Wear resistance is directly proportional to the amount of ceramic fibers present.
B. Deeper depth of cure: Due to light conducting property of the individual ceramic fibers depth of cure is more.
C. Increased flexural modulus due to presence of more ceramic fibers per unit area: Flexural modulus is directly proportional to number of the ceramic fibers present.
D. Decreased polymerization shrinkage: Polymerization shrinkage is indirectly proportional to the number of ceramic fibers present.
E. Reduced stickiness: Stickiness is indirectly proportional to the number of ceramic fibers present.

**Contraindications of Composites**

Composite restorations are contraindicated in the following conditions:
1. When operating field cannot be maintained dry.
2. Where very high occlusal forces are present (especially in case of class I, class II and class VI)
3. Some class V restorations that are not esthetically critical.
4. When proper technic cannot be applied.
5. The restorations that extend up to the root surface.
6. Invisible, very small lesions on distal surface of canines where metallic restoration is treatment of choice.
7. Patients with high caries susceptibility and poorly controlled caries activity.

**Advantages of Composites**
1. Maximum conservation of tooth structure is possible.
2. Esthetically acceptable.
3. Less complex cavity preparation is required.
4. Insulative, have low thermal conductivity hence no insulation base is required.
5. Restorations are bonded with enamel and dentin hence have good retention.
6. Can be finished immediately after curing.
7. It is reparable.
8. Has low microleakage.
9. Can be used almost universally.

**Disadvantages of Composites**
1. Gap formation on margins may occur, usually on root surfaces. This occurs because the force of polymerization shrinkage is greater than the initial bond strength of composite to dentin.
2. More difficult, time consuming and costlier than amalgam.
4. Greater occlusal wear in areas of high occlusal stress.
5. High LCTE may result in marginal percolation around composite restorations.

**POLYMERIZATION METHODS**

**Self-curing Composite Resin**
It is available as a two-paste system composed of a catalyst and a base material. One part contains an organic amine accelerator and the other part includes a peroxide initiator. Catalyst and base materials are usually mixed in a ratio of approximately 1:1. Their polymerization process is chemically activated.

**Light-Activated Composite Resins**
Composite resins can be polymerized either by ultraviolet or by visible light. Benzoyl methyl ether is an initiator of polymerization when exposed to ultraviolet light and diketones are used as a photochemical initiator (Fig. 24.8).

Advantages: Light-activated composite resins have many advantages over the self-curing composites: a. Flexible working time. b. Better resistance to wear and abrasion c. Reduced porosity

**Laser Curing**

Among all the lasers, Argon laser is most suitable for curing composite. The time required is 10 seconds per increment of 2 mm thickness.

Table 24.1: Comparison of visible light-activated and ultraviolet light-activated systems of composite curing

<table>
<thead>
<tr>
<th>Visible light-activated system</th>
<th>Ultraviolet light-activated system</th>
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<tbody>
<tr>
<td>1. The health hazard is virtually eliminated</td>
<td>1. Possibility of retinal and soft tissue damage from direct ultraviolet radiation exits.</td>
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<tr>
<td>2. No warm up time is required</td>
<td>2. UV light generation requires several minutes of warm up</td>
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<tr>
<td>3. Less time (20 to 30 sec) required to cure the resin.</td>
<td>3. Approximately 60 seconds are required to cure the resin.</td>
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<tr>
<td>4. Composite material cures to a depth of 2 to 2.5 mm</td>
<td>4. Composite material cures to a depth of 1.5 mm only.</td>
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Table 24.2: Comparison of laser curing with halogen light curing of composites

| Laser curing | Halogen curing |
Advantages
1. Curing for about one-third time period is required (10 sec) per increment.

2. Quality of polymerization is superior. Uniform polymerization is achieved as proximity of laser source to the composite is not necessary.
3. Deepest layer is also completely cured.
4. Repairing work is more easy.
5. Curing of all shades is uniformly achieved in lesser time.

Disadvantages.
Chances of pulpal damage due to heat are more.
2. Have adverse affects on adjacent restorations.

Disadvantage
1. Curing for about three times of time period is required (30 sec).

2. Quality of polymerization is inferior as closeness of the halogen light is a must for complete curing.
3. Usually deepest layer is not completely cured.
4. Repairing work is difficult.
5. Darker shades require more time for curing as they have to be cured in thinner layers due to less conduction of light in darker shades.

Advantages
1. Chances of pulpal damage are less.
2. Does not affect adjacent restorations.
Glass Ionomer cement

- They are supplied as a powder and liquid system
- They release fluoride into the surrounding tooth structure yielding a more anticariogenic effect.
- The liquid is polyacrylic acid which is less irritant and less soluble as compared to that of silicate cement.
- It has a good adhesion to the tooth structure (chemical adhesion).
- Clinically, G.I.C.
  1. relatively technique sensitive regarding mixing and insertion procedure.
  2. it may be used in C and root surface caries.
  3. can be used as anterior restoration with a patient high caries activity.
  4. Low wear resistance so can't be used in CII and CIV cavity preparation.
  5. Used widely in deciduous tooth.

Resin Modified G.I.C.

1. it is a glass ionomer to which resin have been added.
2. it is easier to use and possesses better strength, wear resistance and esthetic than conventional G.I.C.
3. Clinically it is indicated for CII restoration in adults because the sustained fluoride release and for CI and CII restoration in primary teeth that not require long term seine.

Compomer (poly acid – modified composite).

It is a composite to which some glass ionomer components have been added
- physical properties are superior to traditional G.I.C. and R.M.G.I.C. but inferior to those of composite.
- compomer capable of releasing fluoride and the release is not sustained at a constant rate and anticariogenicity is questionable.