Silicate cement

It is not used nowadays because:

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

Acrylic resin filling materials

Unfilled acrylic polymer where introduced about 1945 and were improved so that they were in moderate usage in the 1960s. The unfilled acrylic material possessed improved resistance to solubility and has no problems with dehydration, although staining was a problem. The undesirable qualities of unfilled acrylies were:

- large dimensional change on setting and with temperature, resulting in percolation of saliva at margins
- low mechanical strength and stiffness
- low resistance to wear
- recurrent decay.
Composite materials

The term composite material 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. It was developed in the 1960s to overcome the disadvantages in physical and mechanical properties of acrylic filling and of silicate cement. It is most popular anterior filling material. Nowadays, composite is used as anterior and posterior filling materials.

Composition and structure

The essentials are:

1. **Resin matrix (binder)**
   Bisphenol-A-glycidyl methacrylate monomer (Bis-GMA) or urethane dimethacrylate. Bis-GMA monomer is most commonly used. Its properties were superior to those of acrylic resins. It has a high viscosity which required the use of diluent monomers. The commonly used diluents monomer is tetraethyl glycol dimethacrylate (TEGDMA).

2. **Filler particles**
   Types of filler:
   a. Ground quartz
They are obtained by grinding or milling the quartz. They are mainly used in conventional composites. They are chemically inert and very hard. This makes restoration more difficult to polish and can cause abrasion of opposing teeth and restoration.

b. Colloidal silica
They are microfiller; added in small amount (5 wt %) to modify the paste viscosity. Colloidal silica particles have large surface area thus even small amount of microfiller thicken the resin. In microfilled composites, it is only inorganic filler used.

c. Glasses or ceramic containing heavy metal
These filler provide radiopacity to resin restoration. Its refractive index is 1.5 e.g. barium, zirconium, and strontium glasses. The most commonly used is barium glass. It is not as inert as quartz some barium may leach out.

**Filler particles will significantly improve the properties:**
1. As less resin is present, the curing shrinkage is reduced.
2. Reduced water sorption and coefficient of thermal expansion.
3. Improves mechanical properties like strength, stiffness, hardness, and abrasion resistance.

**Factors 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

3. Coupling agents
Coupling agents bond the filler particles to the resin matrix. This allows the more plastic resin matrix to transfer stress to stiffer filler particles. The most commonly used coupling agent is organosilane.

Function:
a. They improve the physical and mechanical properties of resin.
b. Prevent the filler from being dislodged from the resin matrix.
c. They prevent water from penetrating the filler-resin interface, microleakage of fluids into filler-resin interface led to surface staining.

4. Hydroquinone
acts as inhibitor to prevent premature polymerization.
5. **UV-absorber**
   It adds to improve color stability.

6. **Opacifiers**
   This is like titanium dioxide and aluminum oxide.

7. **Color pigments**
   adds to match tooth color.

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**Types of composite**

**Based on curing mechanism:**

1. **Chemically activated composite:**
   This is two paste systems:
   - Base paste: contains benzoyl peroxide initiator.
   - Catalyst paste: tertiary amine activator.
   When two pastes are spatulated the amine reacts with the benzoyl peroxide to form free radical which starts the polymerization.

   Approximately equal amounts of two pastes are taken out of the containers using a plastic spatula and then they are mixed together on a paper pad.
2. Light activated composite:

UV- light activated system

The earliest system used, but it is not used nowadays because of:

a- Limited penetration of the light into the resin.
b- Lack of penetration through tooth structure.
c- Irritant to the soft tissue.

Visible light activated system

These totally replaced the UV-light system. They are widely used than the chemically activated resins. These are single paste system containing:

- Photo-initiator (Camphoroquinone 0.25 wt %).
- Amine accelerator: diethyl-amino-ethyl-methacrylate (DEAEMA) 0.15 wt %.

Under normal light they don’t interact. However, 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 ability to room light or dental operatory light.

On the right we see the syringe format and on the left we see the capsule format.

<table>
<thead>
<tr>
<th>Light activated</th>
<th>Chemically activated</th>
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</thead>
<tbody>
<tr>
<td>1. Required light of correct wave length for its activation.</td>
<td>1. Activated by peroxide-amine system.</td>
</tr>
<tr>
<td>2. Cure only where sufficient intensity of light is received.</td>
<td>2. Cures throughout its bulk.</td>
</tr>
<tr>
<td>3. Working time under control of operator.</td>
<td>3. Working time is limited.</td>
</tr>
<tr>
<td>4. Supplied as single component in light tight syringe.</td>
<td>4. Supplied as two component system.</td>
</tr>
<tr>
<td>5. Less chance of air entrapment during manipulation, more homogenous mix.</td>
<td>5. Air may get incorporated during mixing resulting in reduction of properties.</td>
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Based on size of filler particles:

1. Conventional composite (traditional or macrofilled composite):

   Ground quartz is most commonly used as filler. There is a wide distribution of particle size. Average size 8-12 μm, particles as large as 50-100 μm is also be present. Filler loading is 70-80 wt % or 50-60 vol %. The conventional composite have improved
properties compared to unfilled restorative resin, it has more compressive strength, tensile strength, elastic modulus, and hardness, and it has less water sorption and coefficient of thermal expansion. Although the conventional composites were superior to unfilled resin, but they had certain disadvantages as:

a. Polishing was difficult and results in a rough surface. This is due to selective wear of the softer resin matrix leaving the hard filler particles elevated.
b. Poor resistance to occlusal wear.
c. Tendency to discolor, the rough surface tends to stain.

2. Small particles composite:
These were introduced in an attempt to have good surface smoothness (like microfilled composite) and improve the physical and mechanical properties of conventional composite. The small particles composite use fillers that have been ground to smaller size.

The filler employed are:
a. Glass containing heavy metals.
b. Ground quartz.
c. Colloidal silica is added in small amount 5 wt % to adjust the paste viscosity.

The average fillers size is 1-5 μm; however the distribution is fairly broad (it helps to increase the filler loading).

The filler content: 65-77 vol % or 80-90 wt %.
Properties:
1. Due to the higher filler content the best physical and mechanical properties are observed with this type.
2. Due to their improved strength and abrasion resistance they can be used in areas of stress such as class II and class III restorations.
3. Some of the products have reasonably smooth surface for anterior are still not as good as the microfilled and hybrid composite in this regard.
4. Composites containing heavy metal glasses as filler are radiopaque.

3. Microfilled composite:
They were developed to overcome the problems of surface roughness of conventional composites. The resin achieved the smoothness of unfilled acrylic direct filling resins and yet had advantages of having filler. The smoother surface is due to the incorporation of microfillers. Colloidal silica is used as microfiller. The problem with colloidal silica was that it had a larger surface area that could not be adequately wetted by matrix resin. Thus addition even small amounts of microfiller result in thickening of the resin matrix. Thus it was not possible to achieve the same filler loading as conventional composite.

**Filler content:** with the inclusion of prepolymerized fillers, the filler content is 80 wt % or 70 vol %. However, the actual inorganic content is only 50 wt %.
Properties:
With exception of compress strength their mechanical properties are inferior to other type. This is because of their higher resin content (50 vol %). Their biggest advantage is their esthetic. The microfilled composite is the resin of choice for esthetics restoration of anterior teeth, especially in non-stress bearing area. In stress bearing situation like class IV and class II restoration, they have a greater potential for fracture.

4. Nanofilled composite:
The nanofilled composites are technically just a category of microfilled composite, the diameter of filler is less than 100 nanometers (nm), Nanofilled composites are the newest addition to the composite filling materials. They are becoming popular among dentists because they are advertised to have superior esthetic and wear characteristics, high polishability, and superior handling characteristics. The individual nano-particles fill in the spaces between the micro particles.

5. Hybrid composite:
These were developed so as to obtain better surface smoothness than that of small particles, but yet maintain the properties of latter. The hybrid composites have a surface smoothness and esthetics competitive with microfilled composite for anterior restoration.
**Two kinds of filler particles are employed:**

a. Colloidal silica: present in a higher concentration 10-20 wt % and contributes significantly to the properties.

b. Heavy metal glasses: average particles size is 0.6-1 μm. 75 % of ground particles are smaller than 1 μm.

**Filler content:** 70-80 wt % or 50-60 vol %, the overall filler loading is not as high as small particle composition.

**Properties:**

The particles size range between conventional and small particle. They are generally superior to microfilled composite. The hybrid composites are widely used for anterior restorations, including class IV, because of its smooth surface and good strength. The hybrid are also being widely employed for stress bearing restoration, even though its mechanical properties are somewhat inferior to small particle composites.

**Flowable composite:**

Low-viscosity, high-flow composites marketed as flowable composites are advocated for a wide variety of applications, such as preventive resin restorations, cavity liners, restoration repairs, and cervical restorations. These applications are not well supported with data, but their clinical use is widespread.