Composites, Glass Ionomers, and Compomers

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Direct-Placement Esthetic Restorative Materials

Placed directly into the cavity preparation (direct restorative)

Esthetic - tooth-colored

Common materials
- Composite resin
- Glass ionomer cement
- Resin-modified glass ionomer cement
  - Hybrid ionomer
- Compomer
Composite Resin

Ideal properties of composites include the following:

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 & elastic modulus
6. High radiopacity
7. High bond strength to enamel and dentin
8. Good color match to tooth structure
Composite Resin

9. Ease of manipulation
10. Ease of finishing and polishing
11. Biocompatibility
12. Degree of Conversion
Composition

Mixture of two or more materials

Tooth-colored restorative materials

Composition

- Organic resin matrix
- Inorganic filler particles
- Silane coupling agent
- Initiators and accelerators
- Pigments
Composition - Organic Resin Matrix

Resin matrix - thick liquids made up of two or more types of organic molecules (polymers) that form a matrix around filler particles,

- bis-GMA (most common)
- UDMA
- TEGDMA (triethylene glycol dimethacrylate) added to reduce viscosity
The weak link in any composite resin is the resin component which brings to the material the same undesirable characteristics associated with acrylic resin.

The higher the resin content (or, said another way, the lower the filler content)...

• the lower the hardness
• the lower the wear resistance
• the greater the coefficient of thermal expansion
• the greater the polymerization shrinkage
• the lower the compressive strength
• the higher the water sorption
• the lower the elastic modulus
Composition - Inorganic Filler Particles

Filler particles - fine particles of quartz, silica, or glass that give strength and wear resistance to a material.

Composites are defined by the size of the filler particles they contain. Two main classes of materials based on particle size:

- Fine - .2 - 3 µm (micrometers)
- Microfine - .04 µm

Nanofilled composites - 1 - 10 nm

Two-dimensional diagrams of microhybrid composite (A) and microfilled composite (B)

Classification of Composites by Filler Size:

- Macrofilled composites
- Microfilled composites
- Hybrid composites
  - Microhybrids
  - Nanohybrids
- Universal composites
- Nanocomposites
The two main classifications of composite resin restorative materials (based on the particle size they contain) are:

Microhybrid - Combination of fine and microfine particles (up to 84% filler by weight; 70% by volume); stronger & more durable

Microfine (aka microfill) - microfine particles only (30 - 50% filler by volume; more would reduce viscosity too much); weaker, but more esthetic
Conventional or Macrofilled Composites

20-30 micron avg. size of quartz filler

60% avg filler volume

Macrofilled resins were the original composite resins.

4X the compressive strength, 5X the elastic modulus, 2X the tensile strength, and 4X the hardness of unfilled acrylic resin

Rarely used in US
Microfilled Composites

0.04 micron avg. filler size

Silica and prepolymerized composite resin fillers

Physical and mechanical characteristics inferior to macrofilled resins

50% avg filler volume

Used in applications where esthetics are paramount and physical demands on the restoration are minimal. In stress-bearing areas where esthetics are important, microfilled resins are used as a veneer over hybrid composite resins.
Hybrid Composite Resins

Quartz (and other radiopaque glasses) and silica filler used.

Contain a combination of small and large particles
65% avg. filler volume

Physical and mechanical characteristics are intermediate between macro- and microfilled composite resins

Used as a general all-purpose composite resin
<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>MICROHYBRID COMPOSITE</th>
<th>MICROFILLED COMPOSITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymerization shrinkage (% linear)</td>
<td>1.0–1.7</td>
<td>2–3</td>
</tr>
<tr>
<td>Thermal conductivity ($10^{-4}$ cal/sec/cm²[°C/cm])</td>
<td>25–30</td>
<td>2–15</td>
</tr>
<tr>
<td>Linear coefficient of thermal expansion ($\times$ $10^{-6}$/°C)</td>
<td>25–38</td>
<td>55–68</td>
</tr>
<tr>
<td>Water sorption (mg/cm²)</td>
<td>0.3–0.6</td>
<td>1.2–2.2</td>
</tr>
<tr>
<td>Radiopacity (mm Al)†</td>
<td>2.7–5.7</td>
<td>—</td>
</tr>
<tr>
<td>Compressive strength (MPa)</td>
<td>200–340</td>
<td>230–290</td>
</tr>
<tr>
<td>Diametral tensile strength (MPa)</td>
<td>34–62</td>
<td>26–33</td>
</tr>
<tr>
<td>Flexural strength (MPa)</td>
<td>90–140</td>
<td>—</td>
</tr>
<tr>
<td>Elastic modulus in compression (GPa)</td>
<td>8–14</td>
<td>3–5</td>
</tr>
<tr>
<td>Flexural modulus (GPa)</td>
<td>5–18</td>
<td>—</td>
</tr>
<tr>
<td>Knoop hardness (kg/mm²)</td>
<td>55–80</td>
<td>22–36</td>
</tr>
<tr>
<td>Bond strength to enamel and dentin with bonding agent (MPa)</td>
<td>14–30</td>
<td>14–30</td>
</tr>
</tbody>
</table>
Coupling Agent

A chemical that helps to bind the filler particles to the organic matrix.

Silane - bifunctional, silicon-organic compounds that couple inorganic filler particles and resin matrix.

Filler particles are silanated to increase bond to resin.
Pigments

Coloring agents that give composites their color

Provide a variety of colors from yellow to gray

Additional shades are available for enamel, dentin, and ranges of opacity.

Often matched to popular Vita shade guide
Polymerization

Chemical-cured: Chemically activated

Light-cured: Light activated

Dual-cured: Combination of chemically and light activated
Modes of Cure

Three types of composite materials are used in dentistry:

Chemical cure

Light cure

Dual cure
Flowable Composites

Low-viscosity, light-cured resins

Lightly or heavily filled

Place a thin layer of PermaFlo Dentin Opaquer over the exposed metal and light cure for 10 seconds with VALO®.
Pit and Fissure Sealants

Low-viscosity resins

Vary in filler content

Product Details

UltraSeal XT hydro is a light-cured, radiopaque, fluoride-releasing composite sealant. It is stronger and more wear resistant because it is a 53%-filled resin and has less polymerization shrinkage than competitive products. The spiral brush action of the Inspira® Brush tip causes shear thinning of the filled, thixotropic UltraSeal XT hydro, reducing its viscosity as it is placed. The resin firms when shear thinning ceases and placement is complete, preventing it from running before it can be light cured. The hydrophilic chemistry with its characteristic thixotropic nature chases moisture (that in hydrophobic sealants can cause sealant failure) deep into the pits and fissures on a microscopic level. Once there, the advanced adhesive technology securely bonds the sealant to the enamel, increasing marginal retention and reducing microleakage.

- Hydrophilic chemistry
- Advanced adhesive technology
- Fluorescent properties
- Highly filled resin
- Two shades: Opaque White and Natural
- Thixotropic/ideal viscosity
Bulk-Fill Composites

Developed to speed up placement process of composite restoration

Challenges

Translucency

Filler particles
Packable Composites

Highly viscous microhybrids

High volume of filler particles

Posterior teeth restoration
Core Buildup Composites

Heavily filled composites

Can be:
- Light-cured
- Self-cured
- Dual-cured
Clinical Handling of Composites

Uses of composite resins

Selection of materials

Determined by the best material to use in a particular situation

Anterior part of the mouth (non-stress-bearing)

Stress-bearing areas
Shade Guides

Color tabs used in shade selection

Natural light source

Drying out of teeth (desiccation)

Mixing shades
Incremental Placement

Used in moderately sized or large cavity preparations

Placed in small increments

Minimizes polymerization shrinkage

Permits adequate curing

Clinical Handling of Composites

Shelf life

Dispensing and cross-contamination
Matrix Systems
Matrix bands
Wedges
Sectional matrix systems
Circumferential matrix systems
Cervical matrices
Light-Curing

Factors affecting the cure

Short curing times

Inadequate light output

Wrong wavelength of light

Incorrectly positioned light guide

Eye protection
Composite Repair

New composite repair versus an older composite

Finishing and polishing

Surface sealers
Indirect-Placement Composite Resins

Laboratory-processed composites

Materials for indirect composites
  Conventional composite
  Fiber-reinforced composite
  Particle-reinforced composite

Indirect chairside technique

Courtesy of Alton Lacy, University of California School of Dentistry (San Francisco, CA).
Glass Ionomer Cements

Packaging
- Hand-mixed powder and liquid
- Encapsulated powder and liquid
- Two-paste systems

Release fluoride
Hybrid (Resin-Modified) Ionomers

Improved physical properties

Dual cure materials

Stronger

Easier to polish

More wear resistant

Fluoride release
Nano-ionomers

Improved esthetics

Increased wear resistance

Improved polishability

Fluoride release
Compomers
Modified with polyacid

Fluoride release

Light-activation chemicals included
Giomers
New hybrid

Slow fluoride release, rechargeable

Packaged as single paste syringes or flowables
Giomer's continuous fluoride release and recharge capability contributes to long-term caries inhibition.
Summary

Composite resins:

Direct-placement restorative materials with a wide variety of uses

Have applications in all classes of cavity preparations and many cosmetic applications
Questions?