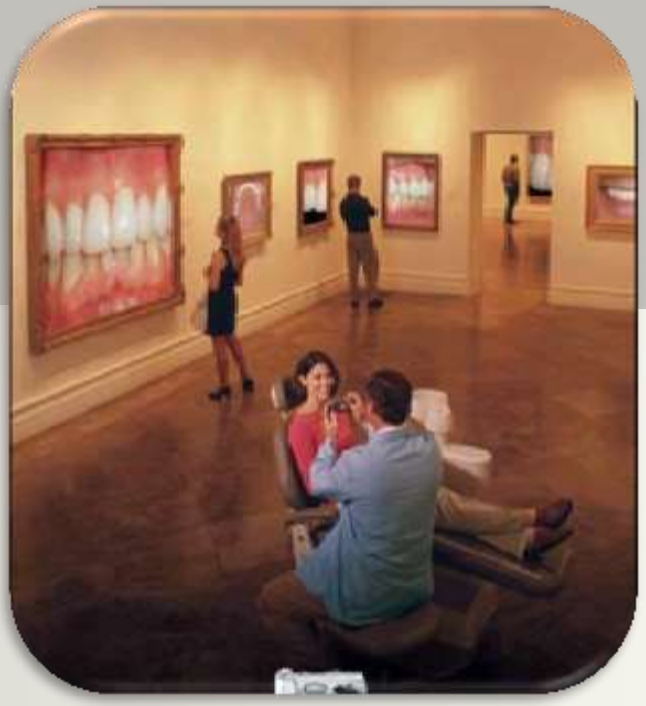

# Dental Composites

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# Reference

- Craig's restorative dental materials, 12th edition, John M. Powers, Ronald L. Sakaguchi

  Chapter 9

# What is dental composite?

# Definition

- A composite material is a product which consists of at least two distinct phases normally formed by blending together components having different structures and properties.

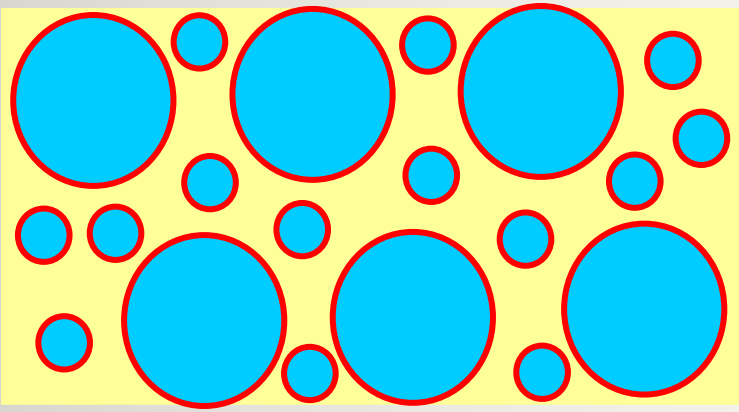
- The purpose of this is to produce a material having properties which could not be achieved from any of the individual components alone.

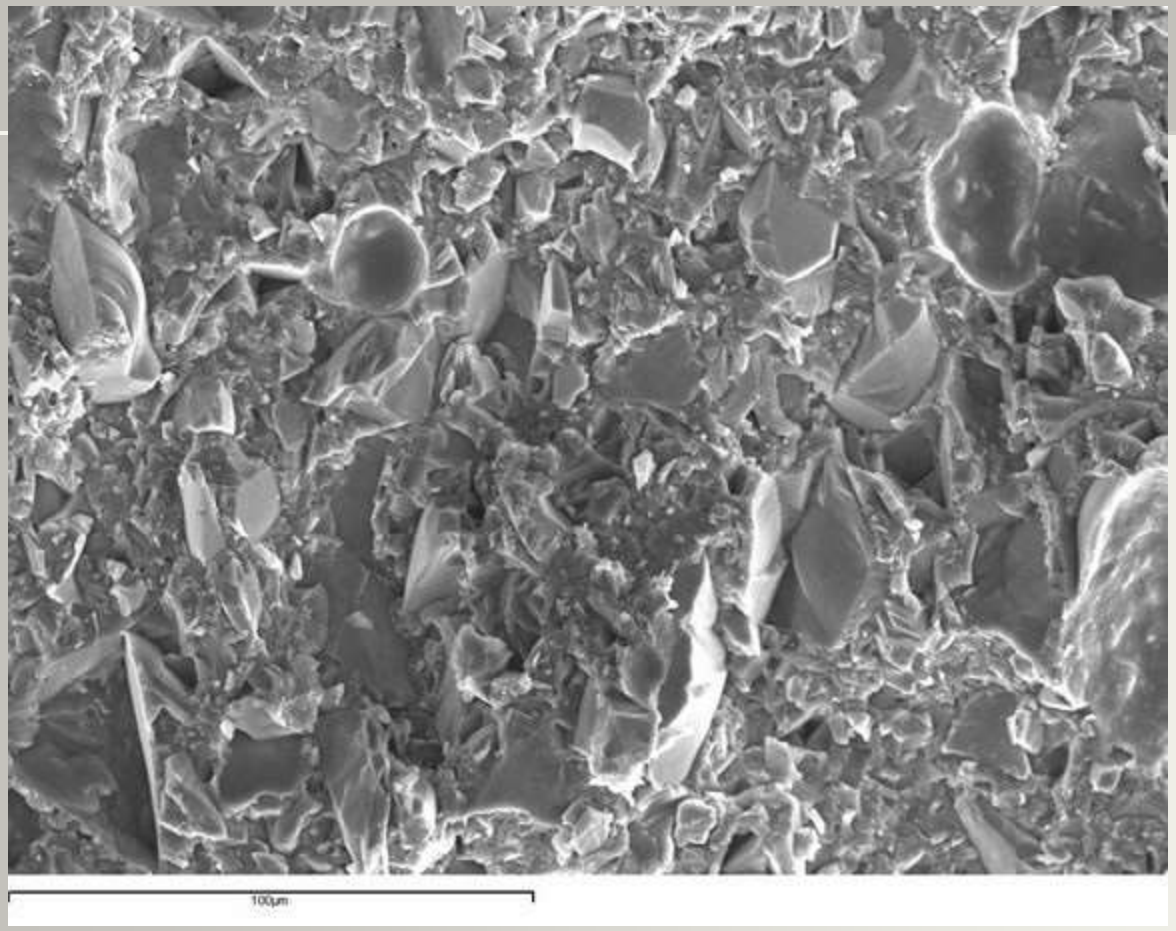
- Dental composites were developed in the 1960s. They quickly replaced acrylic resin and silicate restorative materials. Their use continues to expand and replace other materials.


- Components of Dental Composite:

1. Matrix

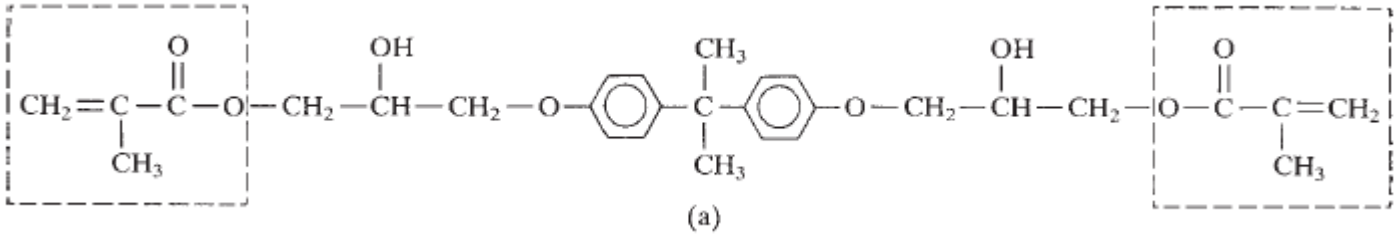
2. Fillers




100µm

# The Matrix:

- The matrix consists of:
    a. Principle monomer
    b. Diluent monomer
    c. Initiator/activator
    d. Silane coupling agent




- The **principle monomer** is an oligomer typically *bis-GMA* (Bisphenol A and glycidylmethacrylate) or urethane dimethacrylate (UDMA).

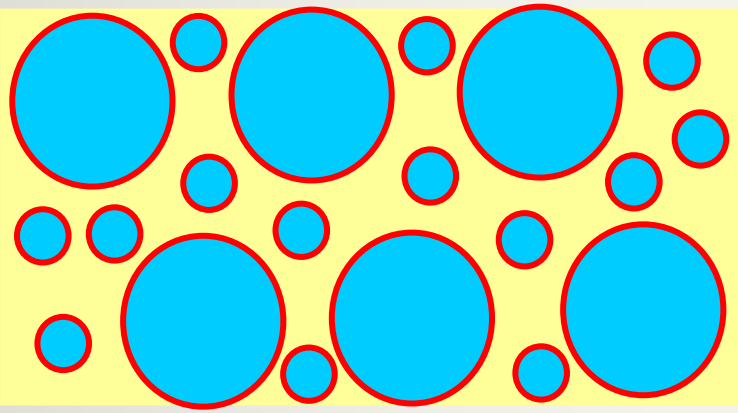
- The **diluent** is an organic chemical added to control the viscosity of the final product (e.g triethylene glycol dimethacrylate (TEGDMA)).

- *C = C* is the functional group of both principle monomers and the diluents.

- *Activator/initiator*: Polymerization is achieved via a *chemical reaction* (chemical cure) or *light activation* (light cure).

# The Matrix , cont..

**Coupling agent:** Silanes are the most widely used. It very important for the reinforcement of the polymer by the fillers. The two constituents should be bonded together. To achieve this, the filler is usually treated with silane agent.



# The Matrix , cont..

- The matrix of a dental composite polymerizes via chemical reaction or light activation and is called *addition polymerization.*

- New monomers (siloranes) were introduced. Reduced shrinkage and internal stress build up was claimed.

# Shortcomings of the Matrix:

- The matrix of dental composite has several important functions. The matrix is the phase that is moldable, polymerizes to form a solid mass at ambient temperatures and bonds to tooth structure.

- However, the matrix has many shortcomings:
  1. The weakest
  2. The least wear-resistant phase of dental composite
  3. Absorbs water
  4. Stains and discolors

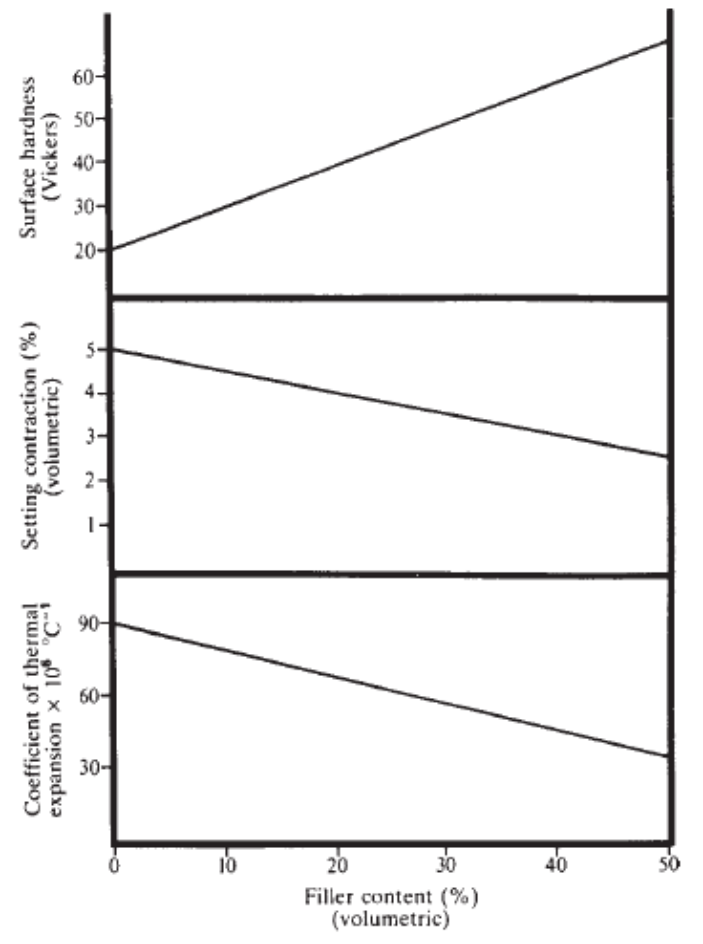
# Shortcomings of the Matrix, cont..

- Therefore, manufacturers minimize the matrix content of composite materials by **maximizing the filler content.**

# The Fillers:

- Filler materials are:
  1. Quartz materials (sand), or
  2. Engineered glass materials

- Fillers affect the mechanical and physical properties of composites:
  - Hardness (Rigidity, Strength)
  - Coefficient of thermal expansion
  - Setting contraction



# The Fillers, cont..

- The first type of fillers was natural **quartz** materials (sand). They are strong, hard and chemically stable in the oral environment.

- The second type; **engineered glass materials** which are formulated to have the proper strength, hardness, chemical and optical properties for use in dental composite.

# The Fillers, cont..

- The glass is ground to have properly sized particles and **<u>it is silanated</u>** .

- The silanated filler is mixed with monomers, diluents, coloring agents, and other chemicals to form the paste received from the manufacturer.

# The Fillers, cont..

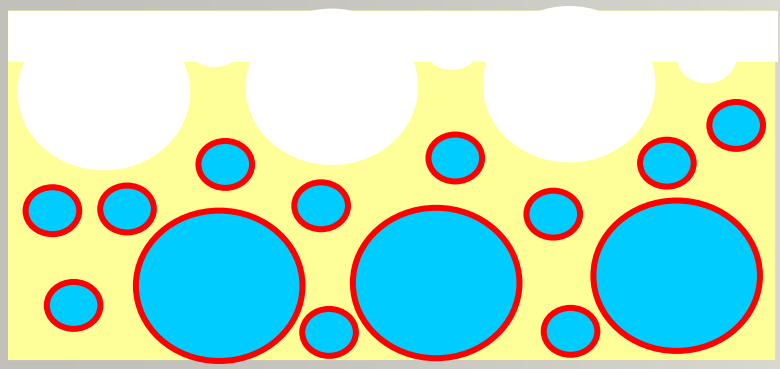
- The type, concentration, particle size and particle size distribution of the filler used in a composite material are major factors controlling properties.

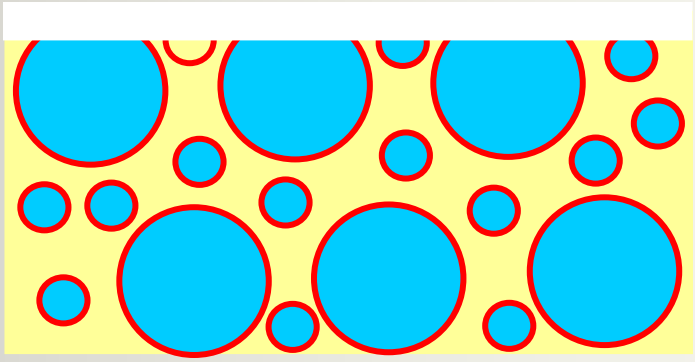
- *The size of the filler* in a dental composite determines the surface **smoothness** of the resulting restoration. Larger particles result in a **rougher** surface.

- Composites are most often classified by the **size of their filler particles**

# The Fillers, cont..

- When abrasion occurs, if a particle is pulled out, the surface is now soft resin that will wear away quickly.
- If the particle wears and stays partially embedded in the matrix, the surface has a greater abrasion resistance and wears at a slower rate.





# Types of Dental Composite:


1. Chemical Cure composite
2. Light cure composite
3. Dual cure composite

# Chemical Cure Materials:


- They are **two-paste systems**. One paste contains the *tertiary amine (activator) (e.g., N, N-dimethyl-p-toluidine),* while the other paste contains the *Benzoyl peroxide (Initiator).*
- The pastes have different colors and are mixed at chair-side until the two colors blend into one.
- The pastes are supplied in small plastic jars or screw-type syringes.

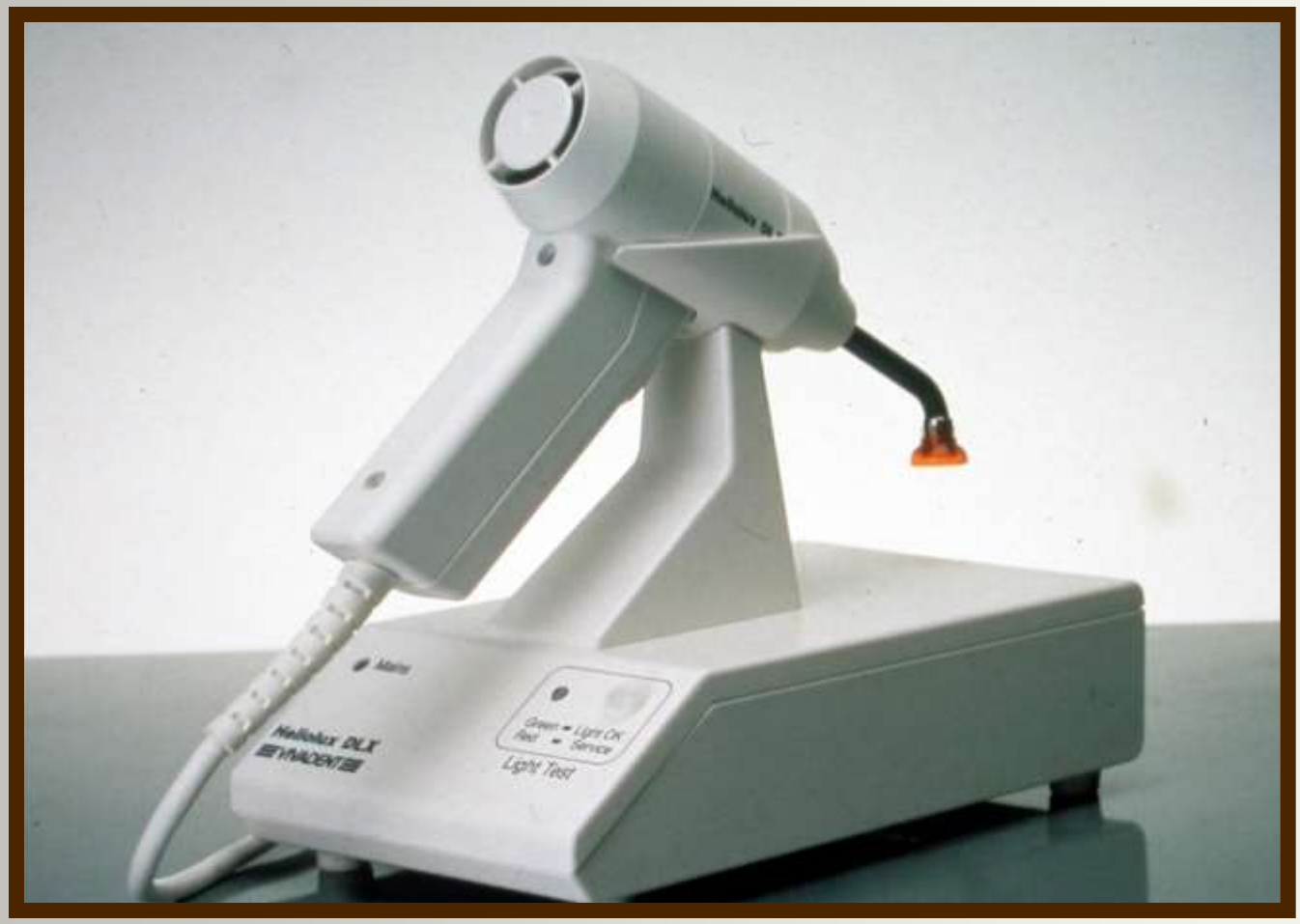
# Chemical Cure Materials, cont..

- When  the materials are mixed, air bubbles are unavoidably incorporated. Care must be taken to minimize these defects in the final mix.

# Light Cure materials:

- Light -cure materials are **single-paste** materials mixed by the manufacturer.
- Because no chair-side mixing occurs, manufacturers can make the paste thicker with less matrix and more filler particles.
- In addition, voids are minimized by the manufacturing process and then a stronger restoration results.

# Light cure unit (machine)



# Light Cure Materials, cont..

- The wave length of the light source is matched to the chemical initiator in the composite.
- The initiator system comprises a mixture of a diketone and an amine. **Camphorquinone** is a commonly used diketone which rapidly forms free radicals in the presence of an amine and radiation of the correct wavelength and intensity.
- The wavelength of the light source is around **470 nanometers.** The light with a wavelength of 470nm is **blue** light that is visible to a human eye.

- As the light is very bright, direct viewing of the light source will damage the eye, so even indirect (reflected) observation of the curing light is contra-indicated ⇒ light shields should be used.

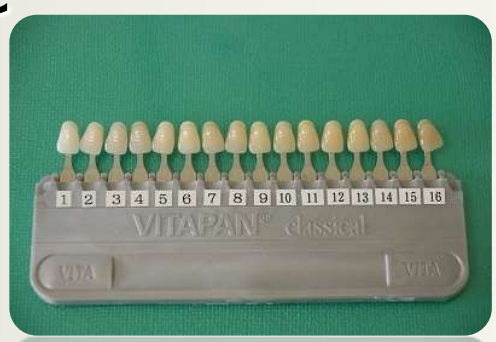
# Inhibitors

- Inhibitors are added to the resin systems to minimize or prevent spontaneous or accidental polymerization of monomers.
- Inhibitors have a strong reactivity potential with free radicals.
- Thus inhibitors have two functions: they extend the storage lifetime for all resins and they ensure sufficient working time.

# The Depth of Cure:

- The  thickness of composite cured by a typical light source is called the depth of cure.

- The depth of cure varies depending on:
    1. The time of light exposure
    2. The composite products
    3. The shade of the composite

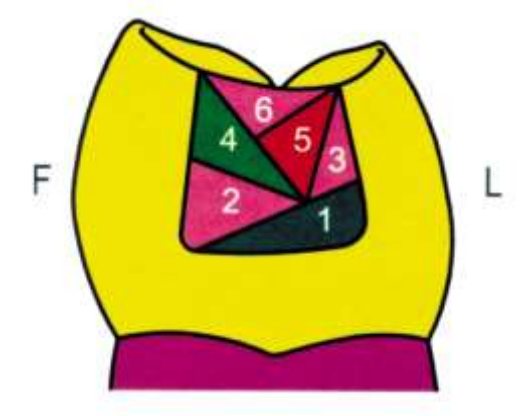


# Incremental addition:

- Placing dental composites in layers or what is commonly called incremental addition has two benefits:

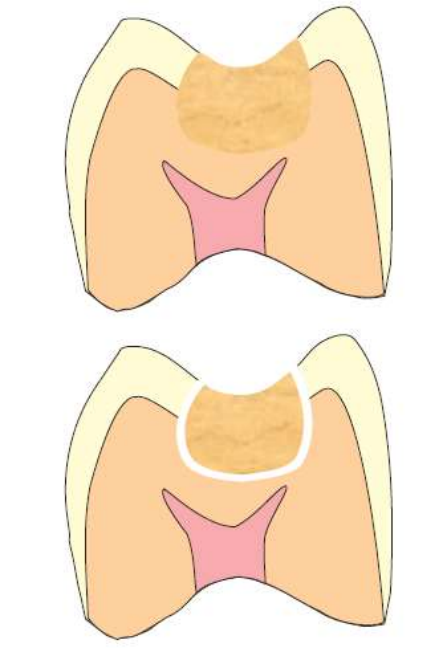
1. Assures adequate polymerization.

2. Minimizes polymerization shrinkage.



# Incremental addition, cont..

- Composites shrink approx 2% when they set. Polymerization shrinkage continues to be problem with dental composites just as it was with acrylic resin materials. The first layer is placed into cavity preparation and cured. The second layer and any subsequent layers are placed and cured until the tooth is adequately restored.



# Composite Restoration

# Air Inhibition:

- When composite materials are placed in increments, each increment chemically bonds to the previous increment.

- Chemical bonding occurs because **addition polymerization is inhibited by the atmosphere's oxygen.** This inhibition of the reaction results in a thin layer of unreacted material on the surface of a newly set composite (if the surface was exposed to air when it sets).

# Air Inhibition, cont..

- The thin air-inhibited layer does not cure whether the material is light-cure or chemical cure.
- When a second layer is added, it excludes oxygen. The air-inhibited layer and the new material are chemically bonded together when the second layer is cured.
- The air-inhibited layer on a dental composite has a slimy or tacky feel.

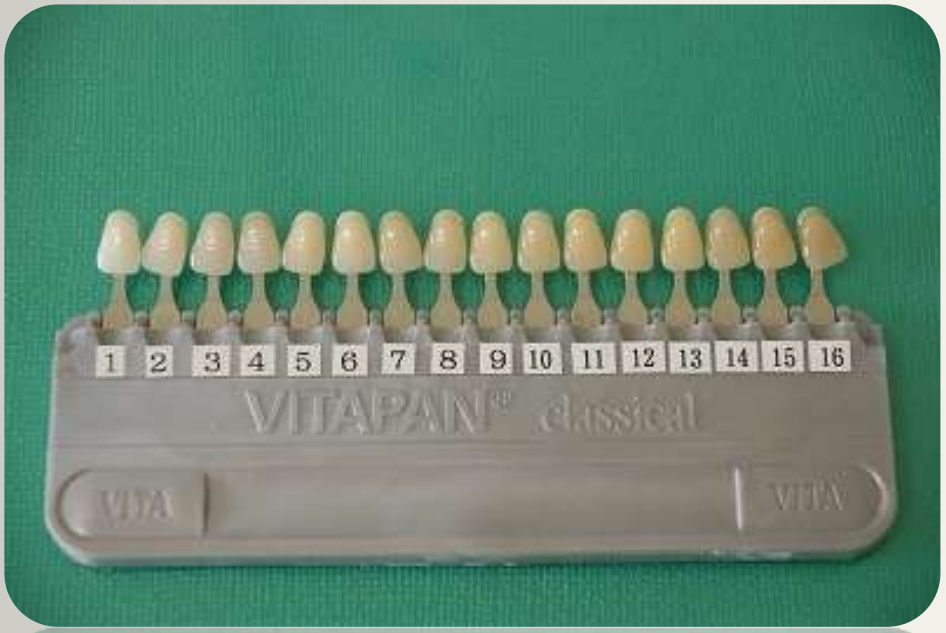
# Unreacted C=C Bonds:

- Not only can composite materials be placed in layers and bond together, but new composite will bond to old composite because not all C=C bonds react when a dental composite sets, typically only about 75% of the C=C bonds react.

- So, it is possible to repair or add to a composite restoration by cleaning the surface and properly adding new material.

# Shades:

- Dental composites are manufactured with several shades to match the color and translucency of teeth.



# **Shades**, cont..

- Opaque materials are designed to prevent the underlying color from showing through. They are used to hide stained or discolored dentin.

- To simulate the translucency of enamel, some products come with shades called *"incisal"* or translucent shades. These shades may actually be more translucent or they may just have a blue appearance that mimics incisal enamel.

# Detecting Composite restorations:

- They do feel a bit **softer** than enamel to a sharp explorer.
- They appear either **radiopaque** or **radiolucent** on radiographs depending on the filler in the product.
- They have evolved from being very radiolucent to having a radiopacity somewhat like tooth structure.
- **Barium** and other **heavier elements** have been added to the engineered glass that is the starting material in the manufacturing of fillers.

# Filler Content:

- With the exception of proper handling, the percentage of filler is the most important determinant of physical properties of dental composite.

# Types & properties of Dental Composite:

1. Marcrofilled Composites
2. Microfilled Composites
3. Small - particle Composite
4. Hybrid Composite
5. Flowable Composite
6. Condensable Composites

# Macrofilled Composites:

- The first type of composite to be developed in the 1960s.
- The filler is quartz material with particle size 20-30 μm.

# Macrofilled Composites, cont..

- Physical properties are determined by the volume percent so it is the most admirable for the scientists.
- The large size of filler results in restoration that feels rough to the dental explorer and can appear rough to the eye.
- Plaque accumulation and staining is greater than other types.

# Macrofilled Composites, cont..

- The typical macrofilled composite will turn slightly gray when rubbed with an instrument in procedures using a metal spatula to mix chemical cure composite.

- Excessive wear when used for posterior restorations

# Microfilled Composites:

- Was developed in late 1970s
- The **problem** with microfilled composites is the low percent of fillers **32 to 50%** by volume
- The particle size is far smaller than macrofilled composite, **0.04 to 0.2 µm**
- The very small filler particles are typically **fused silica**

# Microfilled Composites, cont..

- It can be polished to a very **smooth** and **lustrous** surface **similar** to enamel.
- The surface area of the very small filler particles requires much more resin to wet the surface of the filler particles.
- The high resin content results in an increased coefficient of thermal expansion and lower strength.

# Microfilled Composites, cont..

- Smooth, lustrous composite restorations were a significant improvement over the available macrofilled composites.
- It is used when esthetics are the dominant concern.
- It is used in class V restorations, at the CEJ, as it has a low modulus of elasticity and flexes with the tooth better than the stronger composites.

# Small-Particle Composites:

- Small or fine-particle composites were developed in 1980s.
- Small-particle composites were **1-5 µm in size**.
- It is acceptable for posterior teeth restorations.
- **Wear** and **strength** were the most significant improvements.

# Small-Particle Composites, cont..

- Small particles fit in the spaces between large particles.
- With the least amount of resin, small-particle composite have the least polymerization shrinkage and best physical properties.
- While the surface is not as rough as macrofilled composite restoration, it is not nearly as smooth as microfilled.

# Microhybrid Composites (Multipurpose)

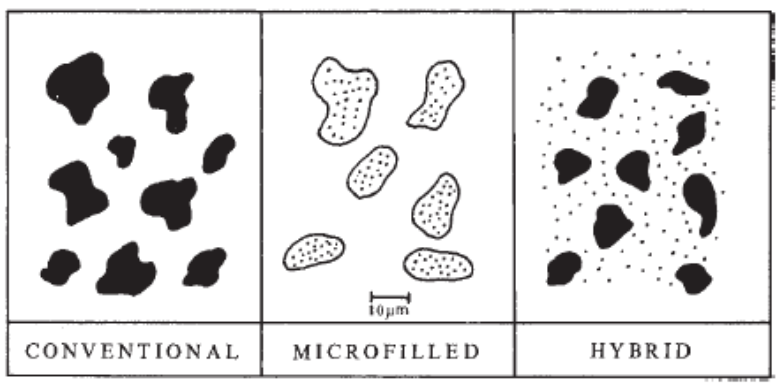
- It was developed late 1980s.
- Their filler content is 60-70% by volume.
- The filler particles size is 0.04 and 0.2- 3 μm
- They are strong and polish well.

# Hybrid Composites, cont..

- They are called hybrid or blended composites because they have particle sizes typical of small-particle and microfilled composites.

- They are very popular as their strength and abrasion resistance are acceptable for small to medium class I and II restorations.

- Their surface finish is nearly as good as microfilled, and thus they are used for class III and IV restorations.



# Flowable Composites:

- Flow into the cavity preparation due to their lower viscosity.
- Manufacturers have decreased the filler content of the material to reduce viscosity and increase flow of these materials ⇨ a weaker, less abrasion resistant material results.
- Filler size: 0.04 and 0.2-3 μm, filler loading 42-62% by volume
- Flowable composites are typically used as the initial increment of a composite restoration and then covered with a hybrid material.

# Condensable Composites:

- These composites are again an attempt to make placement of the material easier .
- They have a filler particle feature that inhibits the sliding of the filler particles by one another.
- Filler size: 0.04, and 0.2-20 μm, filler loading 59-80% by volume
- A "thicker, stiffer feel" results and the manufacturers call these products condensable.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