Tooth Color Restorations (Composite)

٢٠١٨-٢٠١٩

3th stage

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بسم‌الله الرحمن الرحيم

وَاحْلُلْ عُقْدَةً مِّن لِّسَانِي {٢٧}

يَفْقَهُوا قَوْلِي {٢٨} العظيم صدق الله

Tooth Colerd Restorations

Those esthetic materials that are tooth colored.

Anterior Restorative Materials

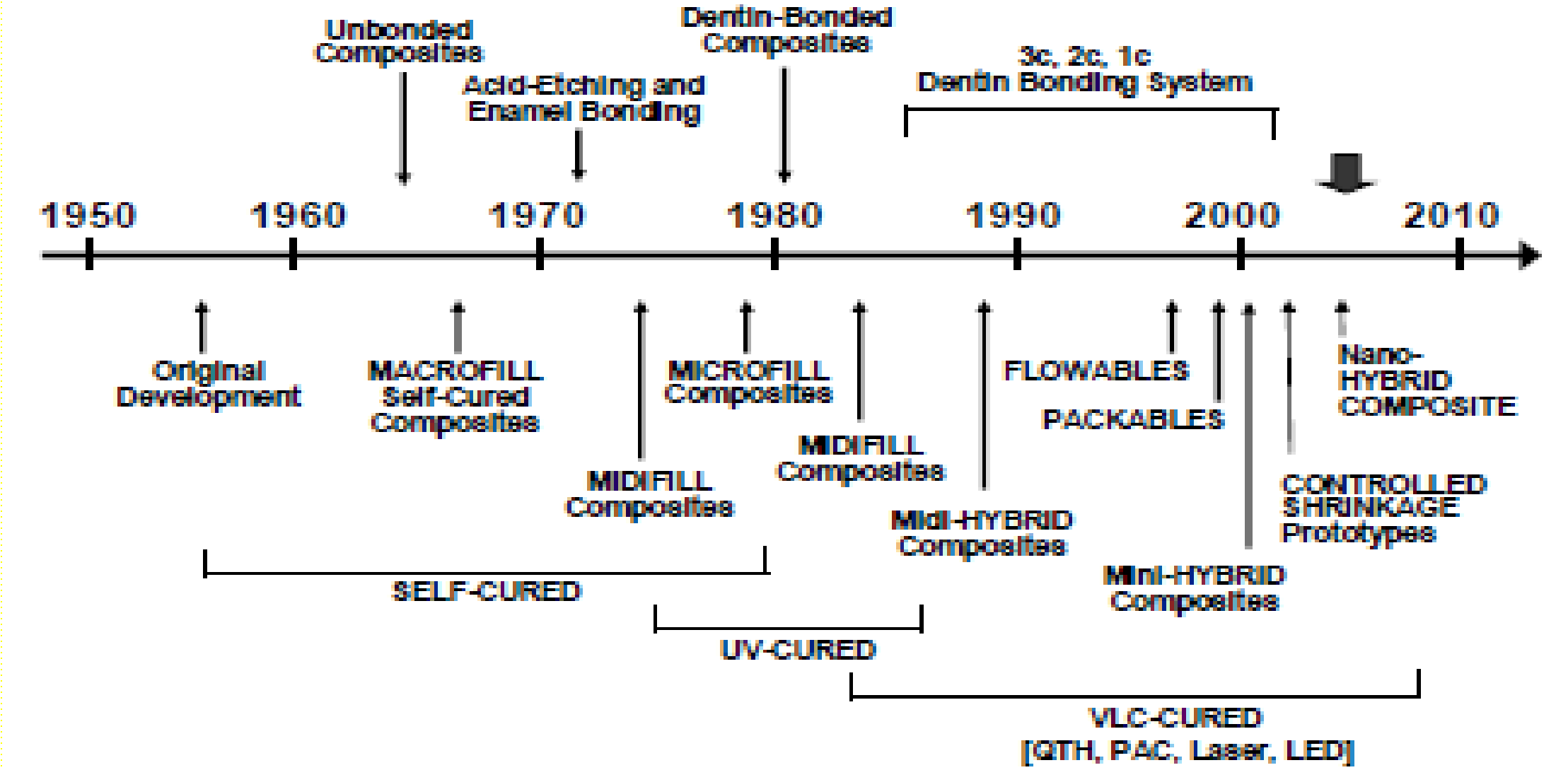
- Silicate cements (Historical).
- Unfilled Resin (Historical).
- Filled Resin (Composite).
- Glass Ionomer.
- Glass ionomer cements (GIC).
- Resin modified.
- Compomers.

History:

- 1871 – silicates
  - alumina-silica glass & phosphoric acid
  - very soluble
  - poor mechanical properties

- 1948 - acrylic resins
  - polymethylmethacrylate
  - high polymerization shrinkage

- 1962 – Bis-GMA
  - stronger resin
- 1969 – filled composite resin
  - improved mechanical properties
  - less shrinkage
  - paste/paste system
- 1970’s – acid etching and microfills
- 1980’s – light curing and hybrids
- 1990’s – flowables and packables
- 2000’s – nanofills



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Ideal Requirements:

1. It should match the tooth in **color, translucency and refractive index**.
2. It should **not stain or discolor** by time.
3. It should **not be irritant** to the pulp or to the gingiva.
4. It should **not dissolve** in saliva or in fluids taken into the mouth.
5. It should have **adequate mechanical properties** to withstand the forces of mastication:

A. It should have **strength and modulus of elasticity** similar to those of enamel and dentin.
B. Good **abrasion resistance** to dentifrices and constituents of food.

Ideal Requirements:

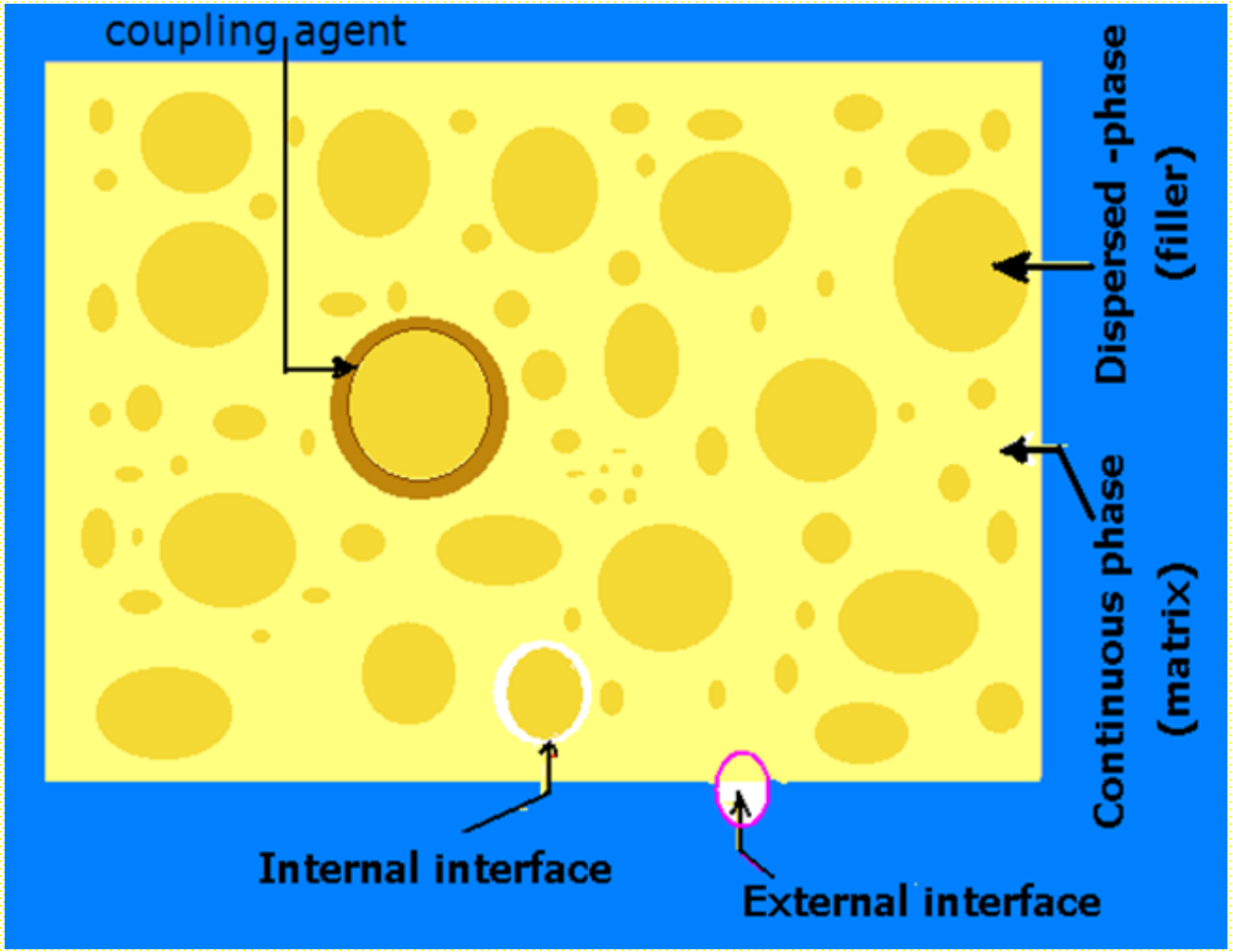
1. It should have **similar coefficient of thermal expansion** to that of enamel and dentin.
2. It should undergo **minimal dimensional changes** on setting.
3. It should **take and retain a smooth surface finish**.
4. It should be **radiopaque** to enable detection of secondary caries, identification of overhanging ledges and detection of incompletely filled cavities.
5. Ideally, **adhesion between the filling material, enamel and dentin** should occur.

Filled Resin
Composite filling material

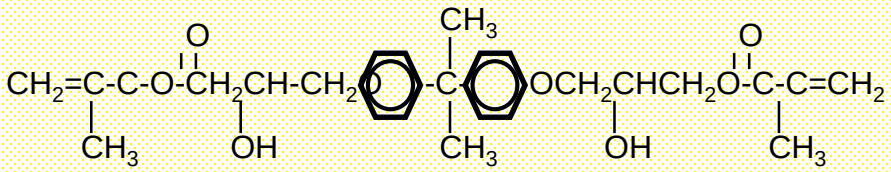
A composite
is a combination of two or more chemically different materials with a distinct interface separating the components and having properties which could not be achieved by any of the components alone.

Composition:

1. Coupling agent which binds the inorganic fillers to the organic matrix.
2. Inorganic filler phase.
3. Organic matrix phase.
4. Initiator activator systems.
5. Other components
   A. Inhibitors .
   B. Ultraviolet stabilizers.
   C. Pigments.



- Resin matrix
  - monomer
  - initiator
  - inhibitors
  - pigments
- Inorganic filler
  - glass
  - quartz
  - colloidal silica
- Coupling Agent



Monomers: Binds filler particles together Provides “workability”

1- Bis-GMA

- extremely viscous
- large benzene rings

2- Lowered by adding TEGDMA:

- freely movable, increases polymer conversion, increases crosslinking , increases shrinkage

3-Ring-opening monomers:

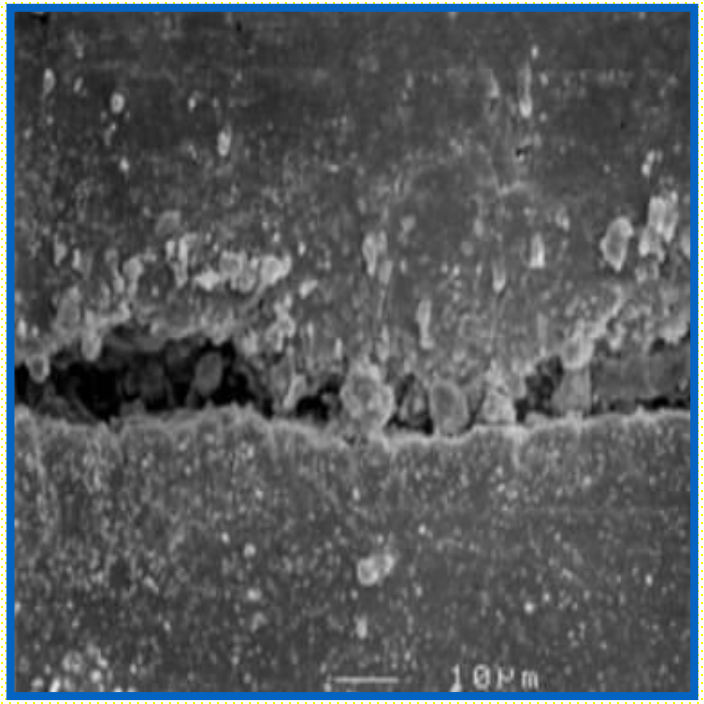
were developed to reduce or overcome the polymerization shrinkage of resin-based composites. Most recently, oxiranes and siloranes (a combination of siloxanes and oxiranes) are being discussed more and more, with a siloran-based product being marketed at present.

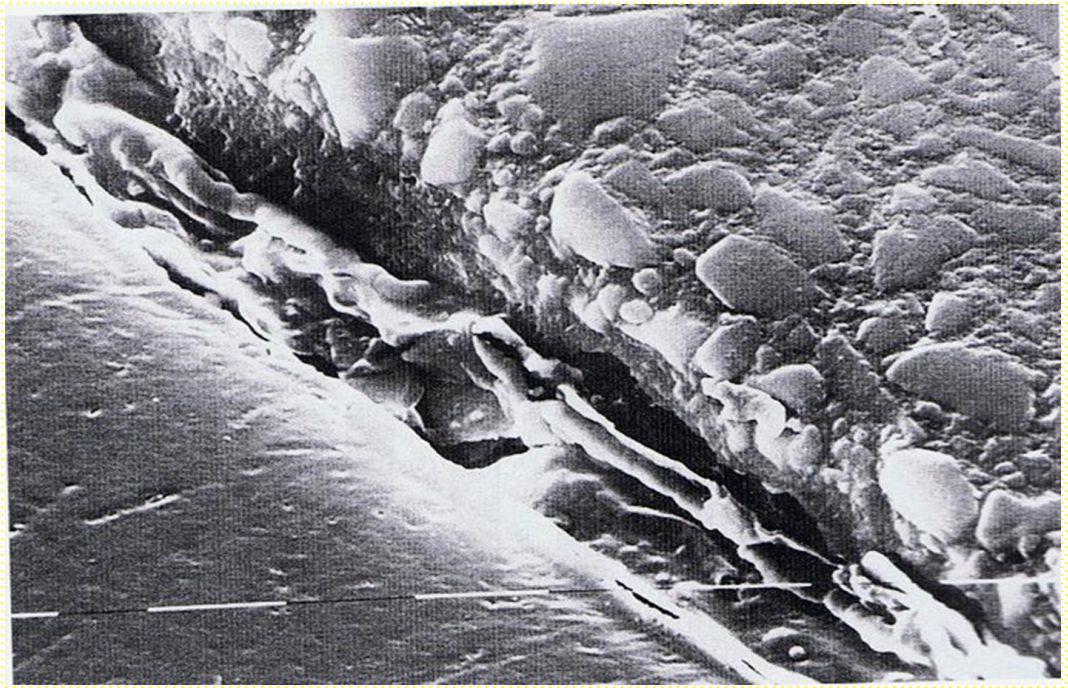
Resin-based composites release residual monomers (and other substances) because of a **conversion rate of 35–77%.** Released compounds can **directly cause** biological reactions. Polymerization shrinkage is a material property that may **indirectly influence the** tissue compatibility .

This volume change may cause marginal gaps that may allow penetration of bacteria with subsequent pulpitis. Shrinkage of modern filling resins generally ranges between 2 vol.% and 3 vol.% .

Monomers:

- Shrinkage
  - 2 – 7 %
  - marginal gap formation





1- Organic matrix phase

a) MW Oligomer :

Either Bisphenol A-glycidyl methacrylate (BIS-GMA), Bowen's resin, or urethane dimethacrylates (UDMA). In some products mixture of the two oligomers is present.

Oligomers are superior to methyl methacrylate monomers by:

- Lower polymerization shrinkage (due to higher molecular size and less double bond available).
- Lower volatility (Due to its chemical structure)
- More rapid hardening
- Production of stiffer and stronger resin due to higher molecular weight and more cross - linkage

Advantages of UDM over BIS-GMA:

1. Lower viscosity.
2. Lower water sorption.
3. Greater toughness.
4. Greater susceptibility to visible light curing.

Oligomers contain reactive carbon double bonds at each end → free radical addition polymerization → rigid cross-linked polymer.

oligomers are viscous and the incorporation of the inorganic fillers is difficult.

The viscosity is reduced to a useful clinical level by the addition of lower molecular weight monomers called diluents.

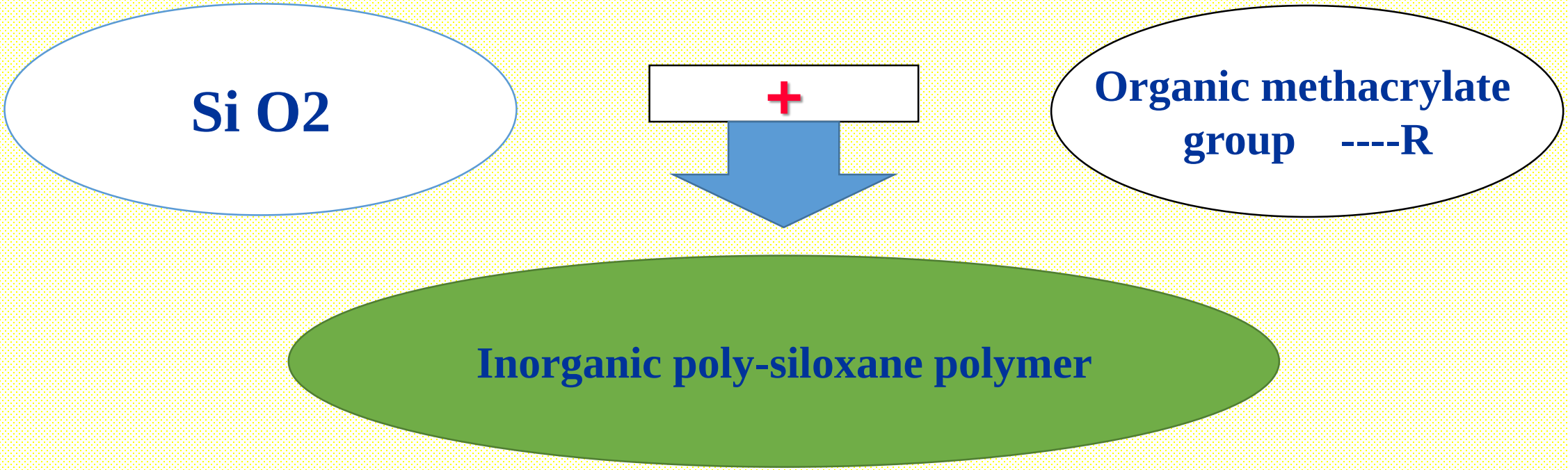
b- Low MW Monomer (Diluent)

diethylene glycol dimethacrylate or trietheylene glycol dimethacrylate:

A. **Reduce the viscosity of the material to enable proper blending with the inorganic constituents.**
B. **Facilitate clinical manipulation.**

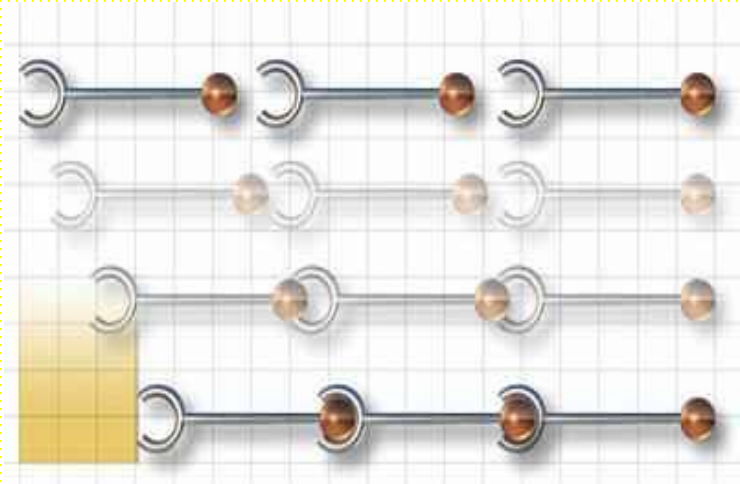
Advancement in resinous matrix:

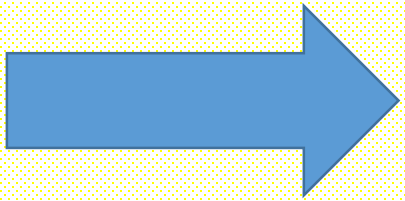
1. Ormocers (organically modified ceramics) 1990
   Polymeric inorganic/organic hybrid matrix

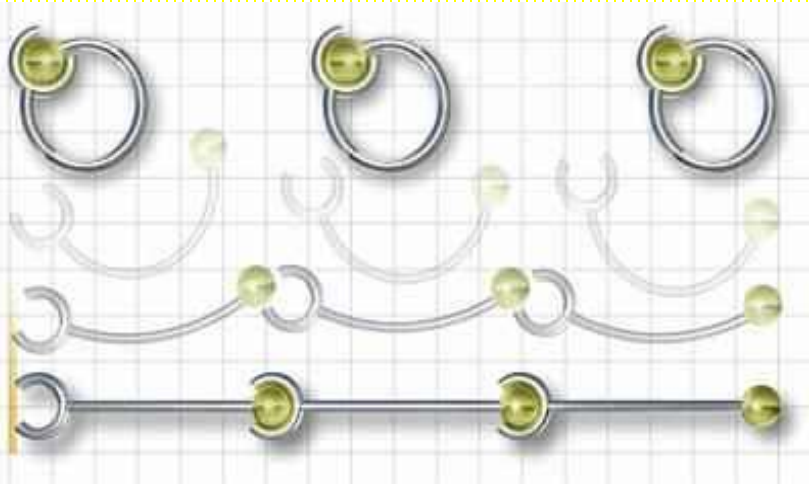


- Very rigid composite
- Low shrinkage composite

polymerization shrinkage?







Methacrylate-based
The molecules of these "linear monomers" connect by actually shifting closer together

Oxirane- based:
The "ring-opening" monomers connect by opening, flattening and extending toward each other.

- Coupling agents:

what happens if bond between resin and filler is weak:

  - The material would be weak and susceptible to creep and fracture and
  - The interface between filler and resin will be a source of fracture, stress will not be distributed properly.

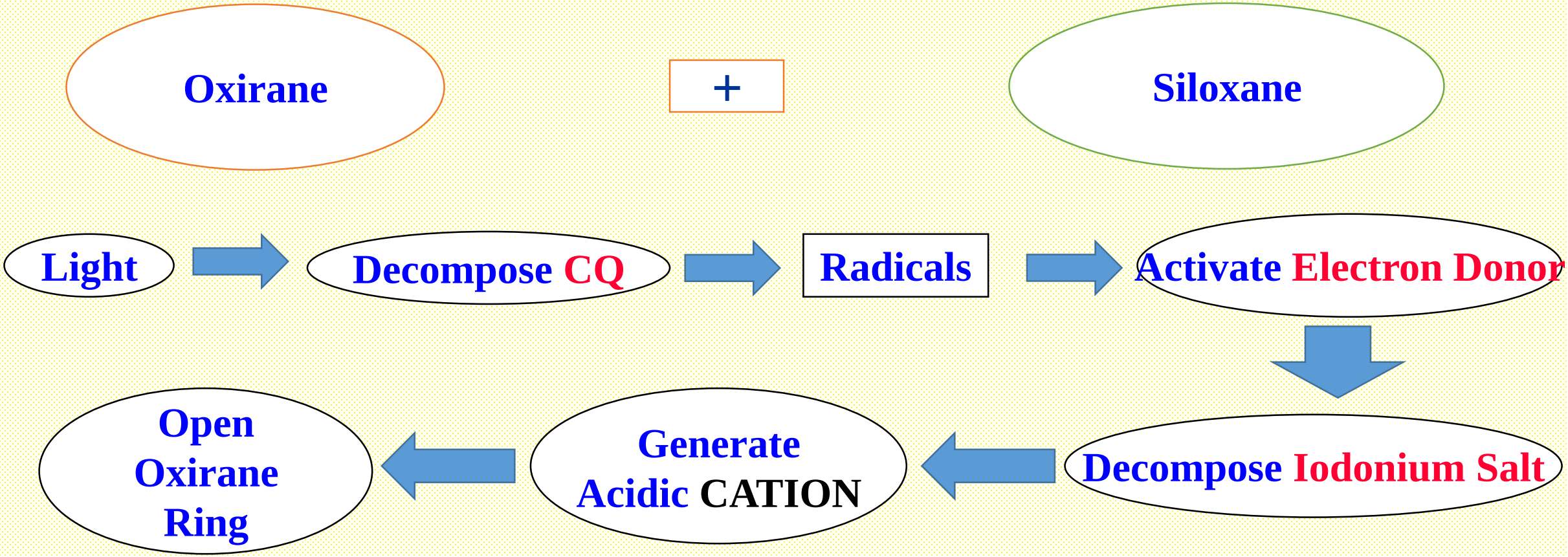
- Silane coupling agents:

has a hydrophobic end (methacrylate group) to bind the resin and a hydrophilic end (OH^- group) to bind glass fillers

- Silanes have disadvantages. They age quickly in a bottle and become ineffective. Silanes are sensitive to water so the silane filler bond breaks down with moisture.

- Water absorbed into composites results in hydrolysis of the silane bond and eventual filler loss.

2. Silorane(2000)



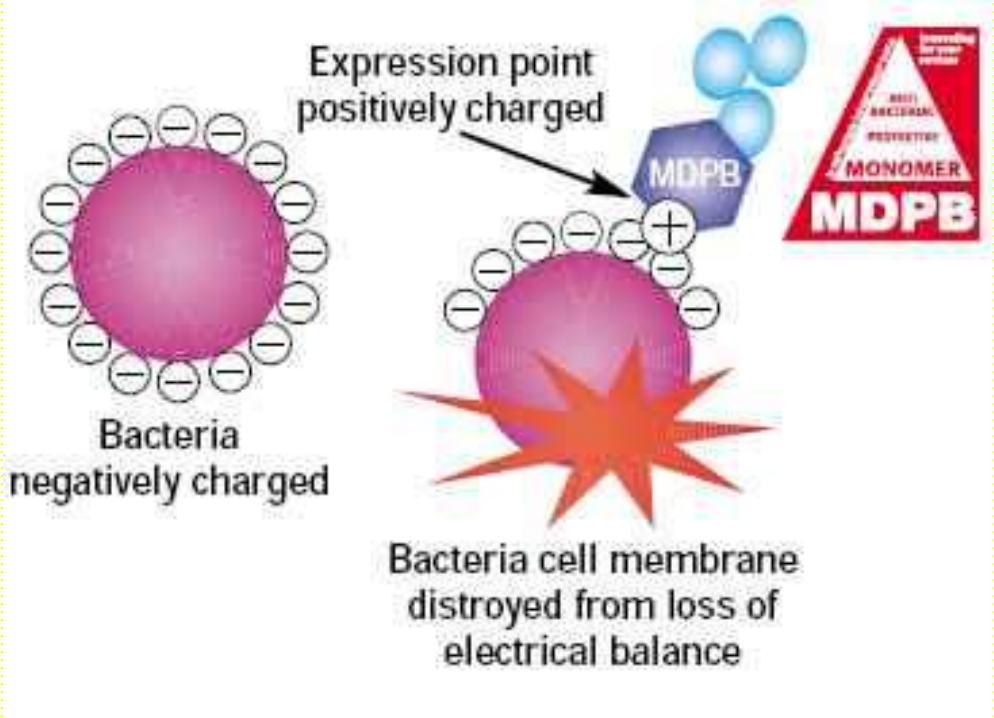
Advantages of silorane-based composite :

1. Low polymerization shrinkage.
2. Lowest polymerization stress.
3. Lowest cusp displacement.
4. Higher bond strength.
5. Lowest water sorption and very low tendency for exogenous staining.
6. Increased compressive and flexural strength.
7. Stable and insoluble in biological fluids.

3. Bio-active restorative materials with antibacterial monomer

A. **Antibacterial monomer MDPB (methacryloyloxydodecylpyridinim bromide) is a polymerizable bactericide, which is immobilized after the resinous materials are cured.**

B. **Cured resins containing MDPB inhibit the growth of bacteria on their surface, thereby acting as a so-called "contact inhibitor" against actinomyces and Candida albicans.**



4. Self adhesive flowable composite(2009)

UDMA,
+
HEMA
+
4-META

Nano-sized amorphous silica
+
Silane treated bariumborosilicate glass fillers

The negatively charged carboxylic acid groups of the methacrylate monomers + the mineral ions in the tooth structure ⇒ neutralize carboxylic acid groups ⇒ monomers polymerized ⇒ incorporated into the dentin surface ⇒ dentin bonding and sealing ability.

Advantages of self-adhesive flowable composite:

A. Increased productivity by reducing the time, steps and materials needed.
B. Seals dentin ⟹ reduced sensitivity.
C. Versatile.
D. Self adhesive.

2- Inorganic (reinforcing) Fillers

1. Improvement in **mechanical properties** (must be in high concentration) to achieve good mechanical properties.
2. Reduction in **coefficient of thermal expansion.**
3. Glass is able to **reflect the color** of the surrounding tooth material so the filler contributes to the aesthetics. The refractive index should match that of the organic matrix to secure translucency.
4. Reduction in the **polymerization shrinkage**.
5. **Less heat** evolved in polymerization.
6. The composite is radiopaque if barium or strontium glasses are used.

Filler particle size and properties:

Historically, (conventional large 20-30μm).

The disadvantage of conventional composites are:

i. Discoloration and staining tendencies
ii. Difficulty in finishing and polishing such composites.

Current composites are:

1-Fine composites: with smaller filler particles (0.5-3μm).

Good mechanical properties and can be finished and polished

2-Microfine composites: (0.04-0.2μm).

i. Perfect surface quality → lustrous surfaces on finishing.
ii. But poor mechanical properties.

3-Blend (hybrid) composites:

Containing mixture of fine and microfine fillers.

i. High mechanical properties as fine composites and
ii. Perfect surface finish as microfine composites.

Nano filled composites: (60-70%)

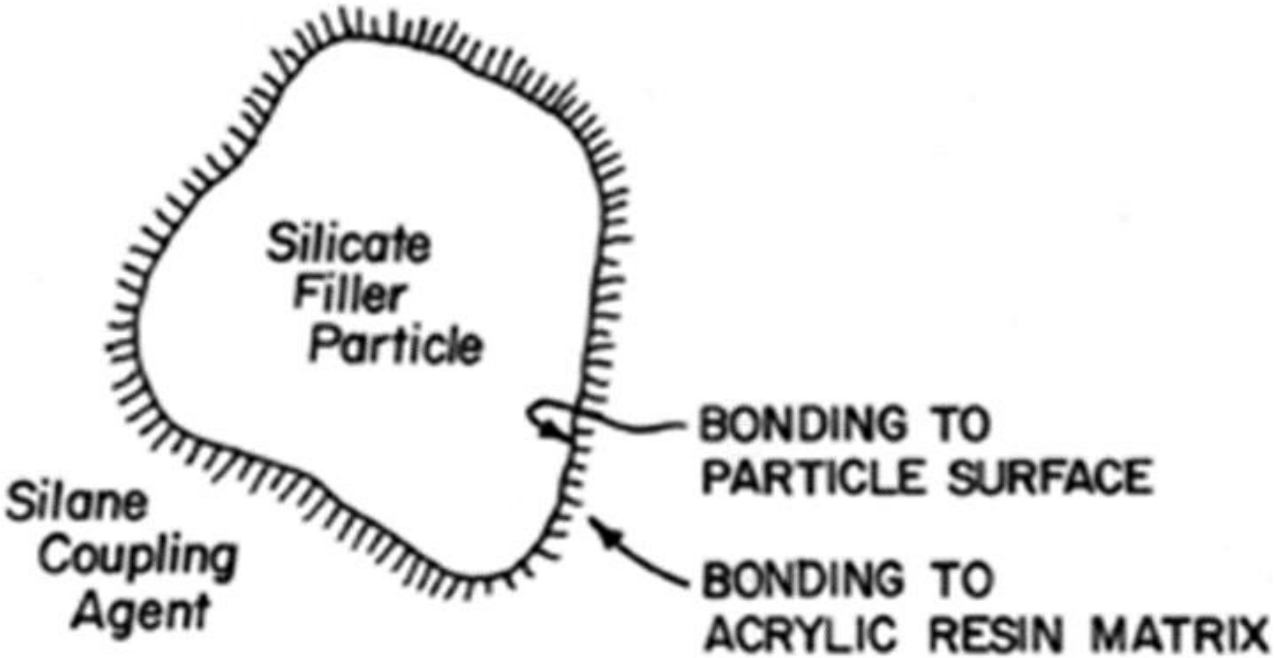
Containing nano sized particles (20-75

i. High translucency, finish and polish.
ii. Lower polymerization shrinkage.
iii. Higher depth of curing.
iv. High mechanical properties as hybrid c.t
v. Excellent handling properties Excellent.

3- Coupling agent

Vinyl silane compound:

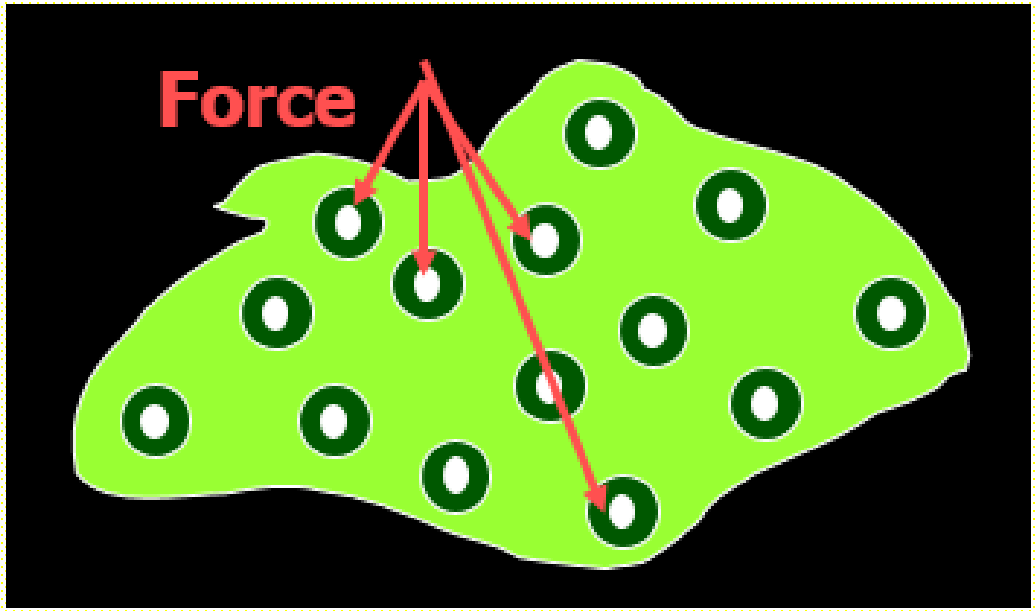
Two functional groups, an inorganic group that react with the filler and an organic group that react with the organic matrix; the filler and matrix are coupled.



Role of a coupling agent:

i. **Improves** the **mechanical properties** of composite by transferring the stresses from the weak resin to the stronger filler.

ii. **Reduces early loss of the filler particles** caused by penetration of water between the resin and filler.



4- Initiator activator systems

Chemical or Light activation

Historically

Ultra Violet Light Activation:

i. **Limited depth of polymerization than the visible light.**
ii. **Potential harmful effects such as skin cancer and eye damage.**

Depth of cure is dependent on several variables such as:

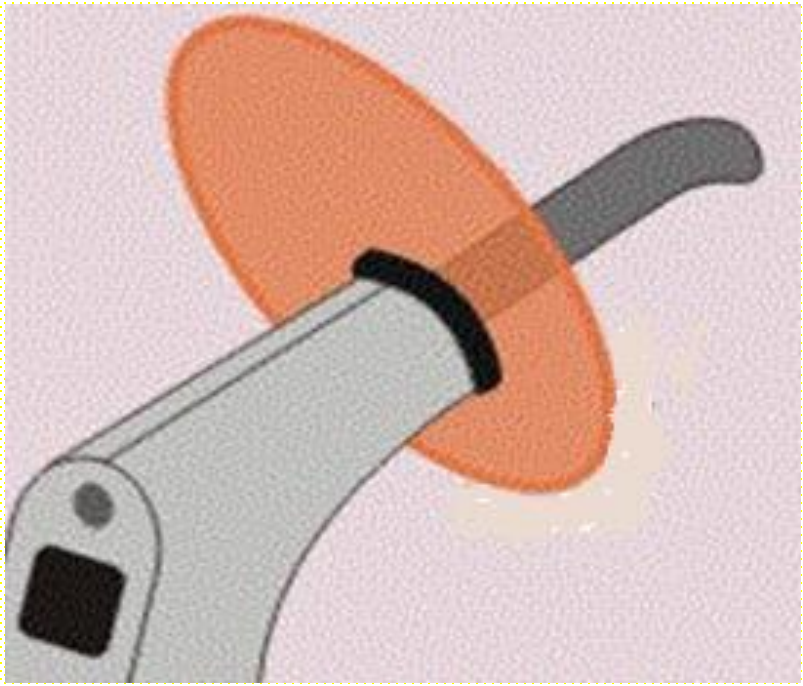
i. The **light source** e.g. a new bulb would give the highest intensity.

ii. The **distance** between source and composite resin surface (note that light intensity varies as the inverse square of the distance).

iii. The **time** of exposure.

iv. The **initiator system** absorption characteristics.

With the development of light sources of improved intensity at least a 2 mm depth of material polymerized in 20 seconds.



Avoid unpolymerized material in the base of cavities or undercuts. Therefore, directing the light from both sides of an anterior restoration or building up by layers may be advisable.

Composite resin which is not fully polymerized will show:

i. Reduced mechanical properties.

ii. Poorer color stability and greater susceptibility to stain.

5- Polymerization inhibitors:

Hydroquinone: Avoid polymerization on storage, an inhibitor is necessary to prevent hardening on storage.

6- Ultraviolet stabilizers +fluorescent agent:

i. **Absorb electromagnetic radiation.**

ii. **Improve color stability.**

Classification System

A-Based on Curing type

1-Chimical Cure

2-Visible Light Cure

3-Duable Cure

Classification of composite:

a- According to particles size, shape &distribution:

Composite type	Particles size	% by weight of filler	*Properties*
Macro-filled composite	20 – 30 µm	78 %	▪ Good mechanical properties ▪ Lowest aesthetics
Fine-filled composite	0.5 – 3 µm	70 – 86 %	▪ Better mechanical properties ▪ Higher aesthetics

Classification of composite:

a- According to particles size, shape &distribution:

Composite type	Particles size	% by weight of filler	*Properties*
Microfilled composite	0.04 - 0.2 µm	25 – 63 %	▪ Least mechanical properties ▪Best aesthetics
hybrid composite	3 - 0.04 µm	77 - 88 %	▪Best mechanical ▪properties ▪ Good aesthetics
Nanofilled Composite	2 - 75 nm		▪ The highest mechanical properties ▪ Best aesthetics

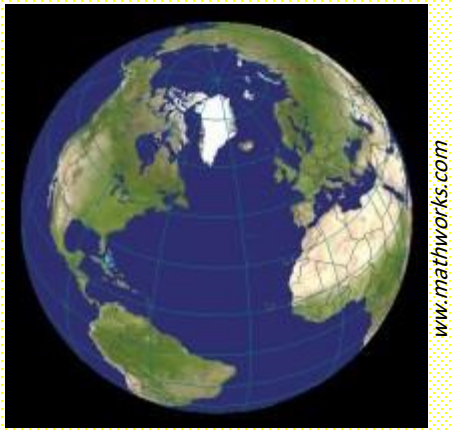
RESIN-BASED COMPOSITE CLASSIFICATION AND PHYSICAL PRPERTIES.

COMPOSITE TYPE	AVERAGE PARTICLE SIZE (MICROMETERS)	FILLER PERCENTAGE (VOLUME %)	PHYSICAL PROPERTIES		
			Wear Resistance	Fracture Toughness	polishability
Microfill	0.04-0.01	35-50	E	F	E
Hybrid	1-3	70-77	F-G^{+}	E	G
Microhybrid	0.4-0.8	56-66	E	E	G
Packable	0.7-20	48-65	P-G^{+}	P-E^{+}	P
Flowable	0.04-1	44-54	P	P	F-G^{+}

E: Excellent G: good F: fair P:poor

$^{+}$ Varying among the same type of resin-based composite

What is Nanoscale



www.mathworks.com

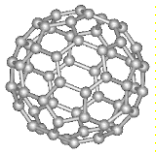
12,756 Km

1.27 × 107 m

22 cm

0.22 m

Fullerenes C_{60}



0.7 nm

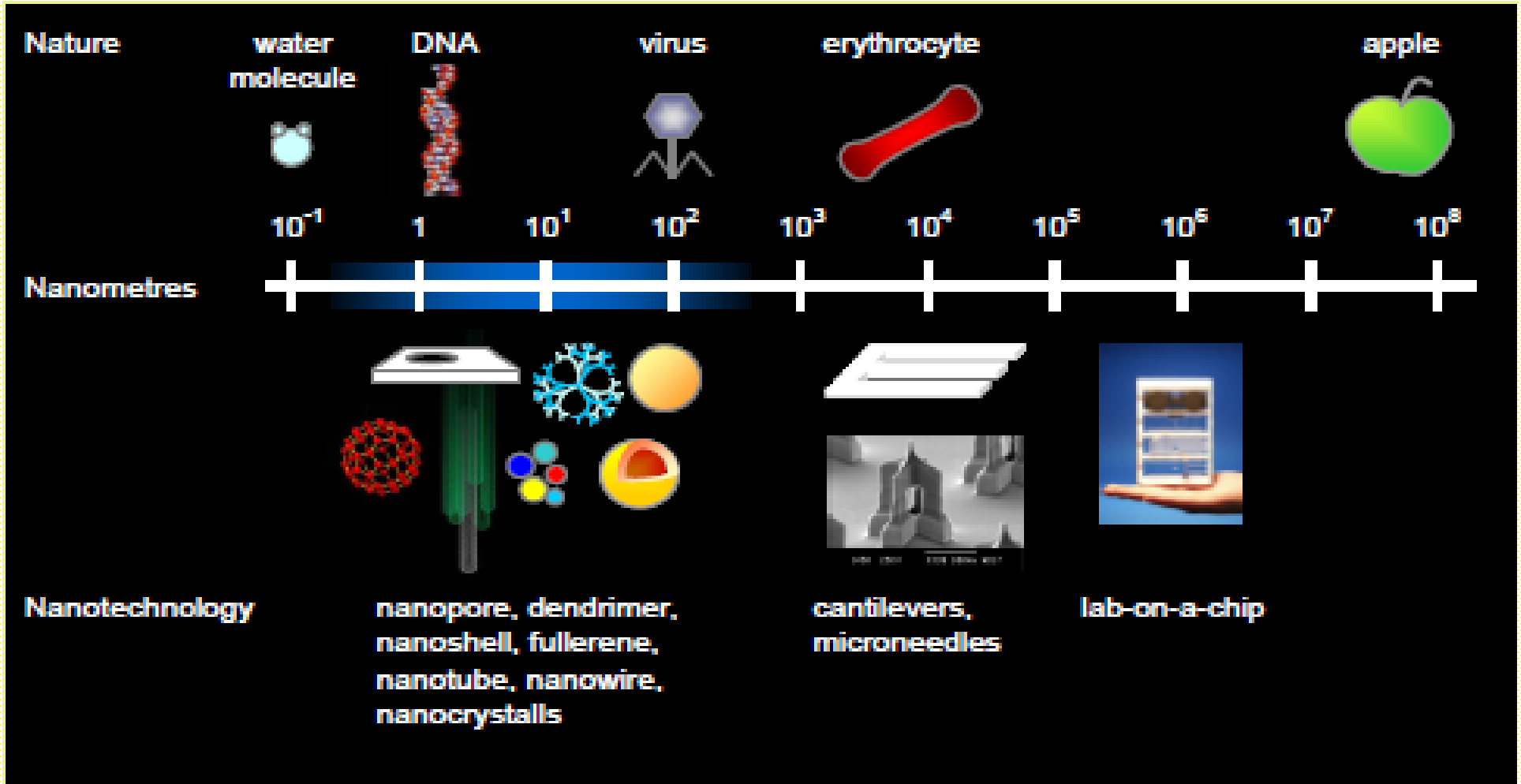
www.physics.ucr.edu

0.7 × 10-9 m

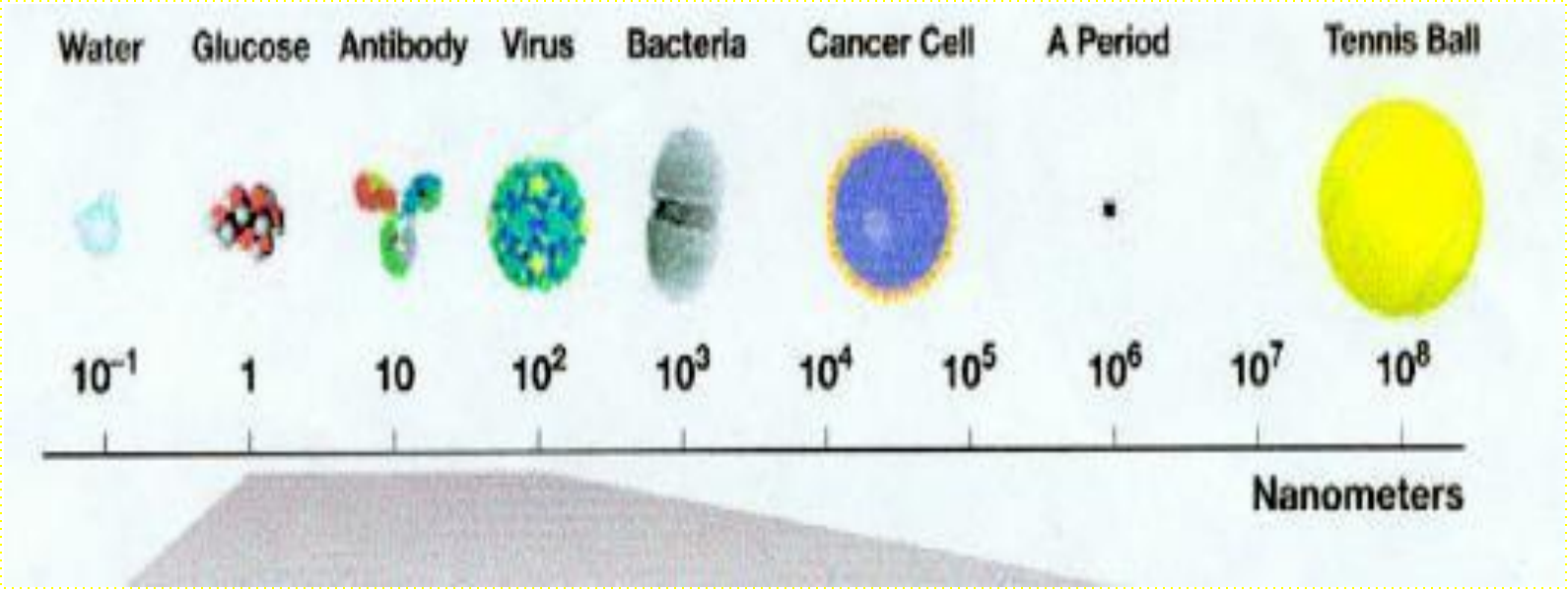
10 millions times smaller

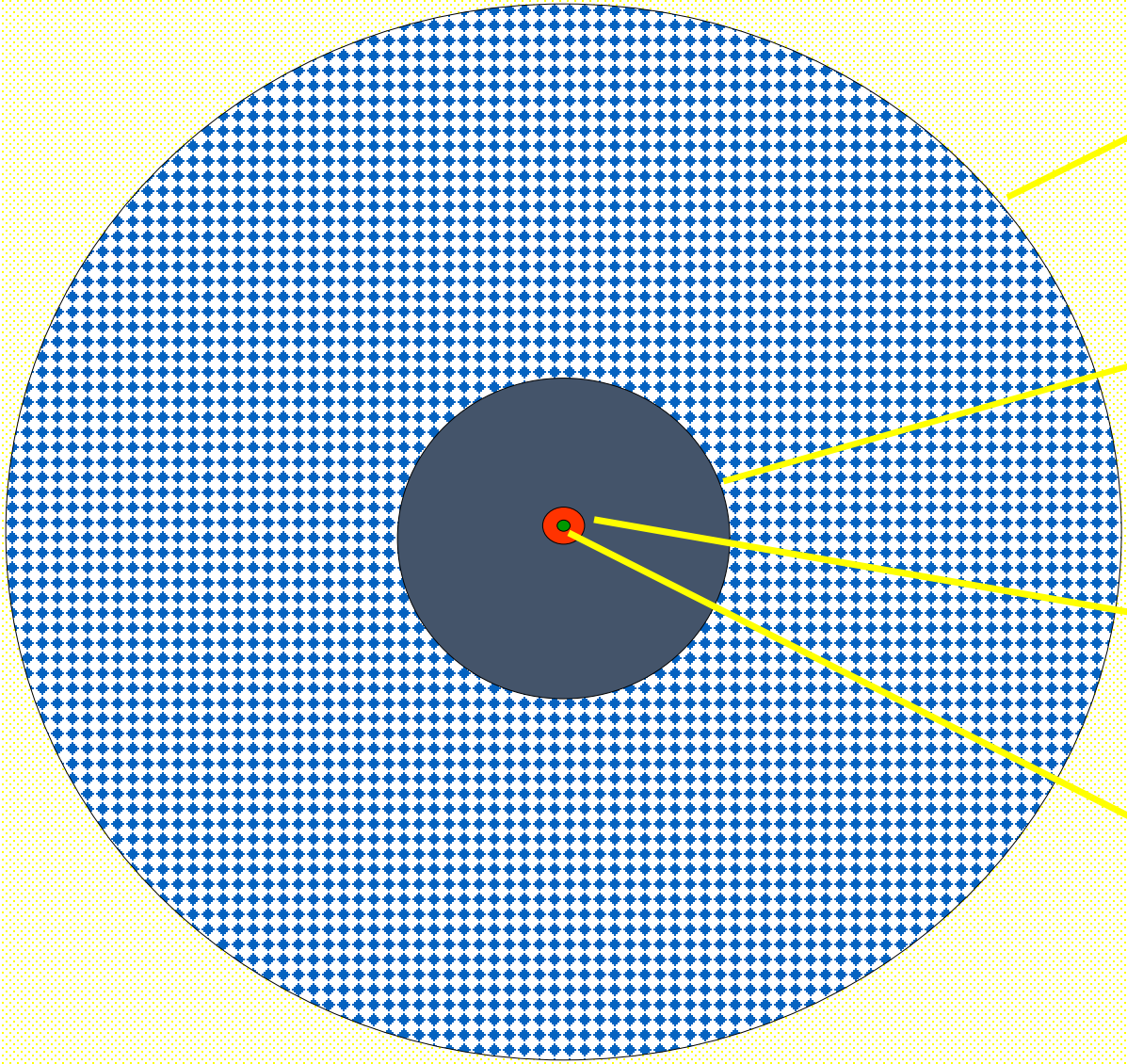
1 billion times smaller

Nanometre scalenanopore



The following chart will give our audience some idea of scales and nanoscales. One can visualize the scale from tennis ball, a period(.), and virus.





Midi- filler

2 um

beachball)

Mini - filler

0.6 um

canteloupe)

Microfiller

.04 um

(marble)

Nanofiller -

.02 um (pea)

Relative Particle Sizes

b- According to methods of Activation:

- **Chemically cured composite**
- **Light cured composite**
- **Dual cured composite**

Properties of composite:

1- Biological considerations.

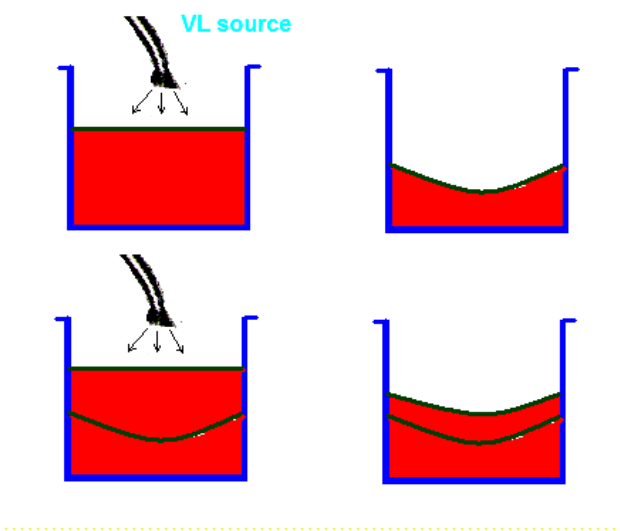
2- Solubility.

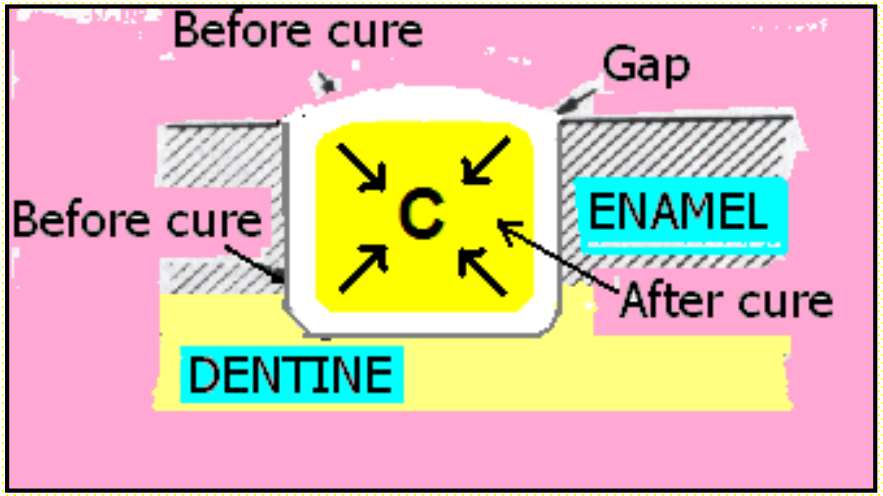
3- Water sorption.

4- Thermal properties.

5- Mechanical properties.

6- Polymerization shrinkage.





7- Esthetic and optical properties:

- Composite materials are **translucent materials which can match the color** of teeth and have good aesthetics.

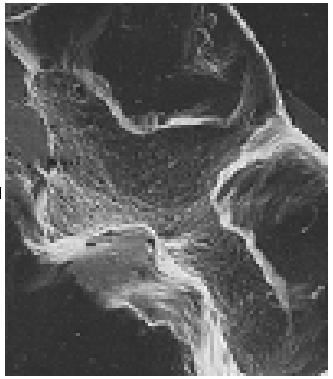
- The materials can be radiopaque by the addition of glasses having high atomic numbers such as barium, strontium and zirconium. Radiopacity helps in diagnosis.

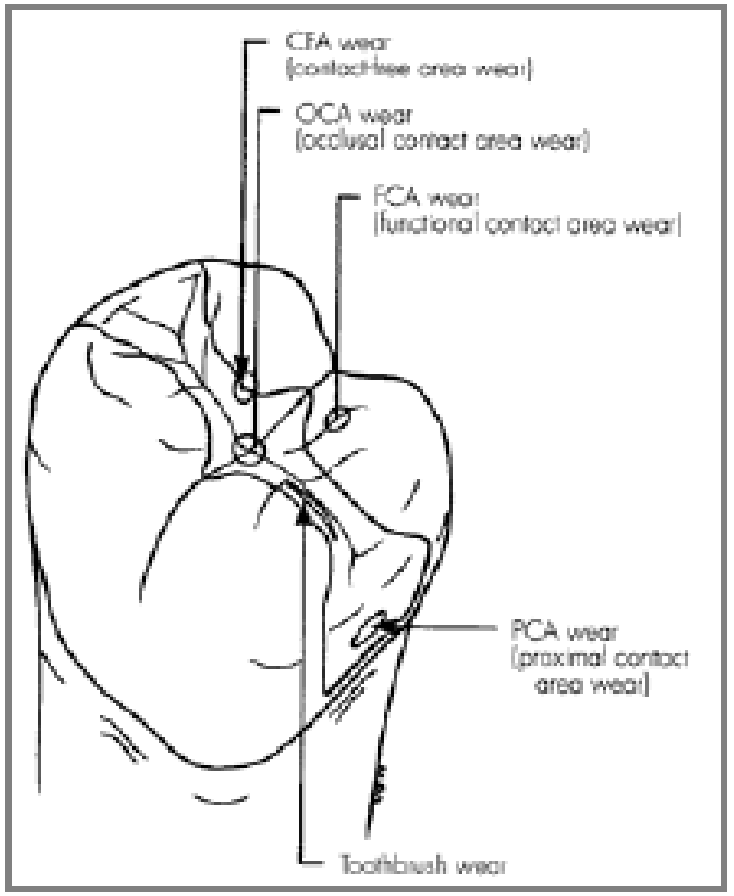
- Abrasive wear may lead to **surface roughness** of the material, because the polymer phase wears more rapidly than harder ceramic fillers. This may lead to **discoloration with time**. However, micro fine and hybrid types can take and retain smooth surface finish for long periods in the mouth.

- Stress cracks within the polymer matrix and partial debonding of the fillers as a result of hydrolysis tend to change the color.

Composite physical property

COMPOSITE WEAR



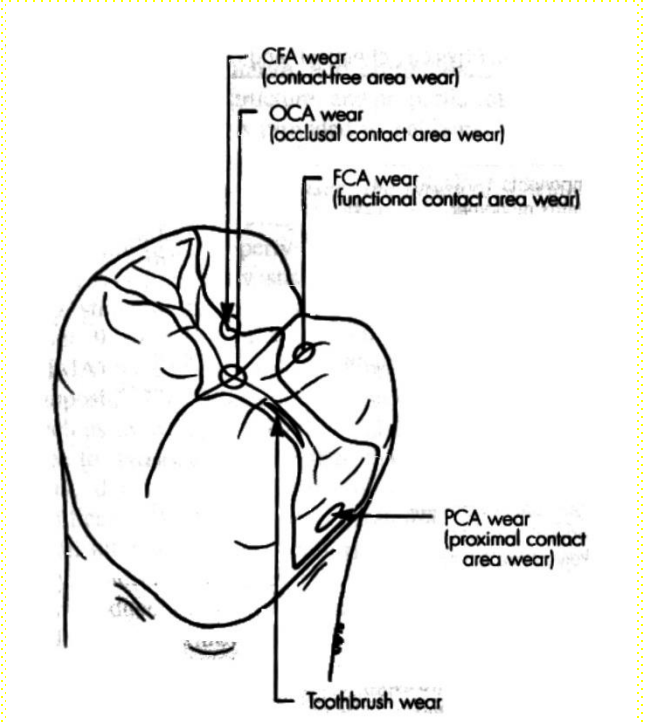


5 Wear Types:

CFA = food bolus wear
OCA = impact wear
FCA = sliding wear
PCA = sliding wear
TBA = abrasive wear

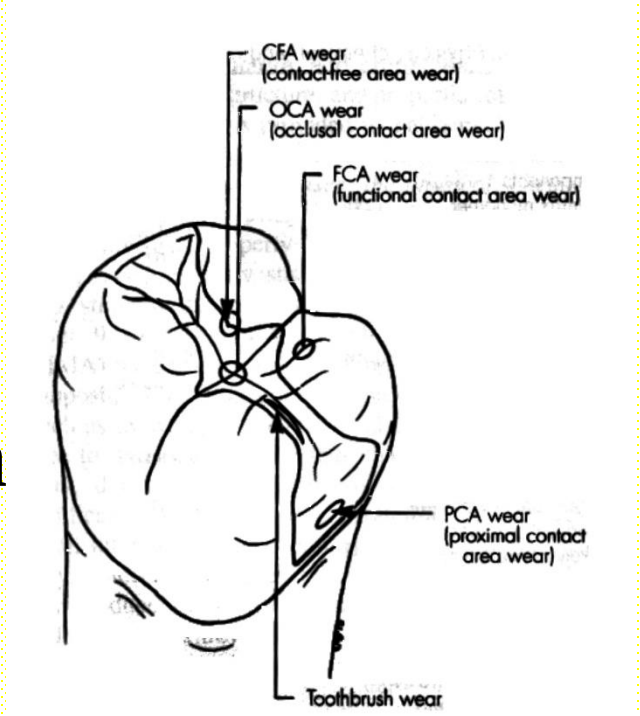
Composite physical property

- CFA: Contact free area wear.
- Wear by food particles.
- PCA: proximal contact area wear.
- Wear by rubbing of tooth contact i



Composite physical property

- **OCA**: occlusal contact area wear.
- Wear by tooth contact in centric.
- **FCA**: functional contact area wear.
- Wear by sliding tooth contact in function

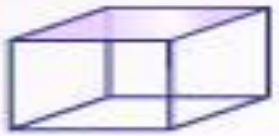
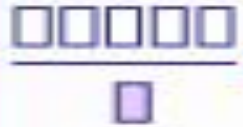
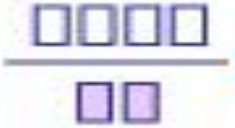


Composite physical property

C-factor is…

- ratio between bonded and unbounded surfaces
- an increase in this ratio results in increased polymerization stress

-Three-dimensional cavity preparations (Class I) have the highest (most unfavorable)

Cavity Pattern	C factor = Bonded surface / Unbonded surface
I	   =5
II III	   =2
V	   =1.9
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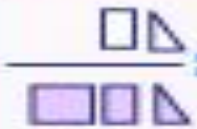
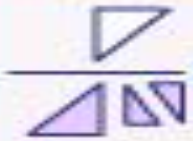
IV	   =0.5
IV	   =0.4

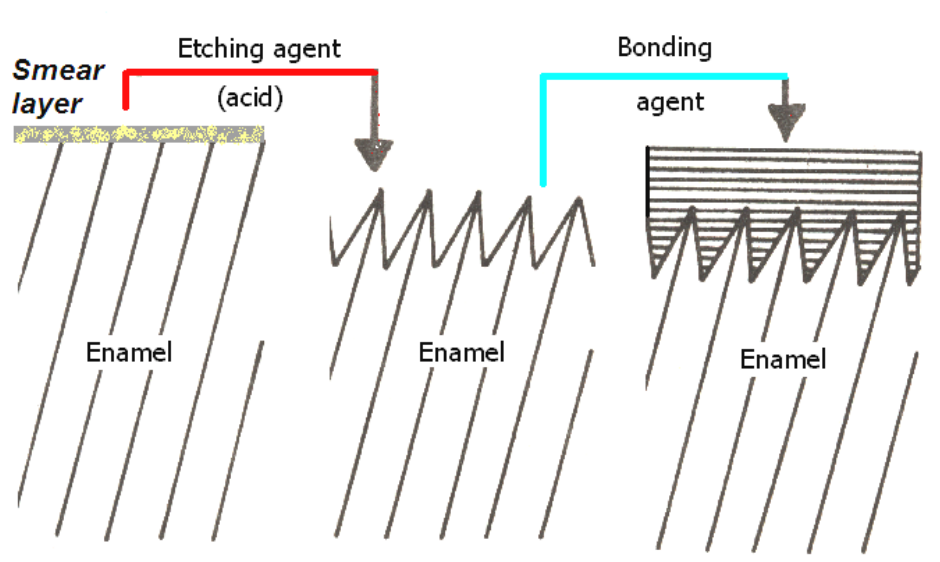
Bonding and retention to tooth structure:

Bonding to enamel:

A. Bonding is obtained by **mechanical retention to acid - etched enamel.**

B. After acid etching and washing of enamel, bonding agent is applied to penetrate sufficiently into the etched areas, to produce a good bond.

Bonding agents usually consist of **BIS - GMA or UDMA** systems that have been diluted to lower molecular weight monomers to decrease the viscosity thus help penetration.

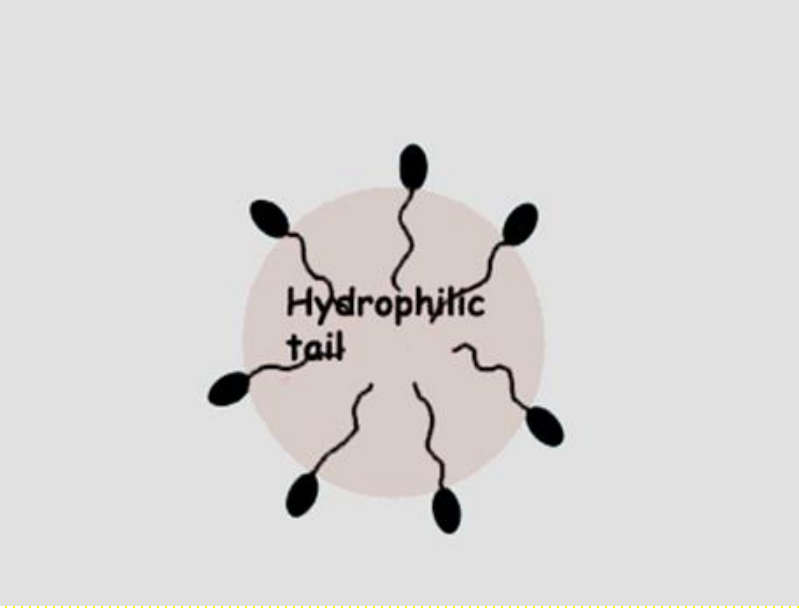


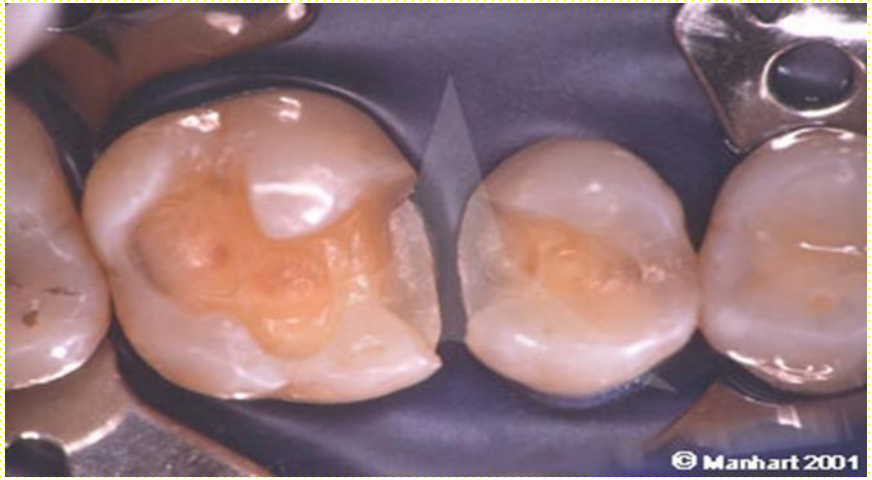
Bonding to dentin:

- Resin dentin bonding agents are now available, they are **used like enamel bonding agents to provide micromechanical retention** resulting from good wetting and penetration of the bonding agent into dentin.

- Bonding agents usually consist of a **Bifunctional monomer** with **Hydrophilic groups to improve wetting to dentin, Hydrophobic groups to polymerize with the composite.** The bond strength of composite to **dentin is less than that for enamel.**

- Recently single component bonding agents have been introduced to be used for both enamel and dentin.

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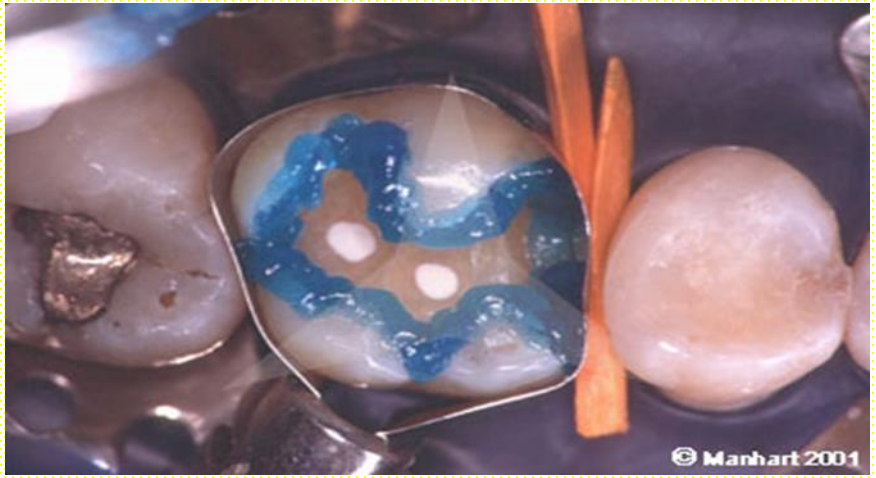
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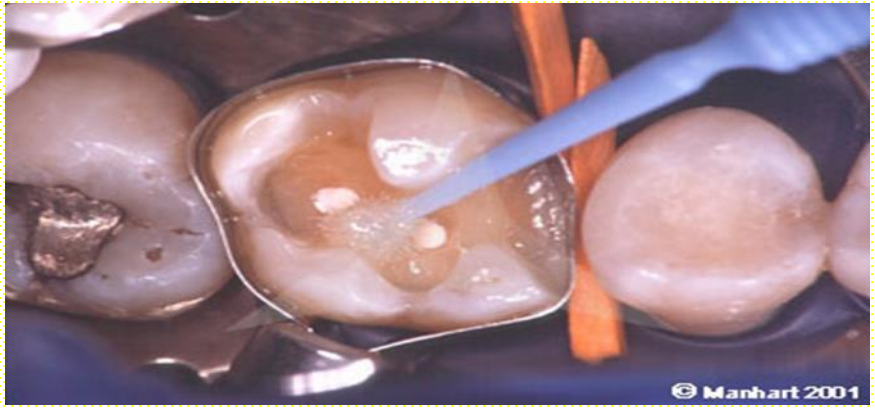
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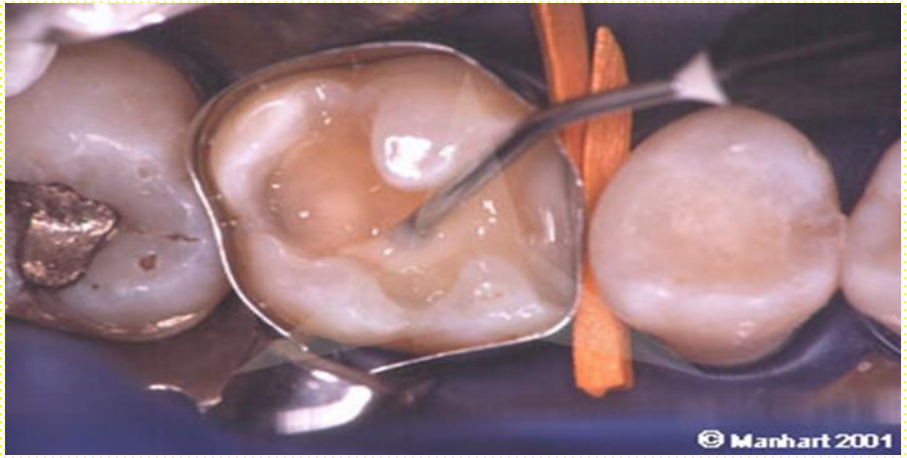
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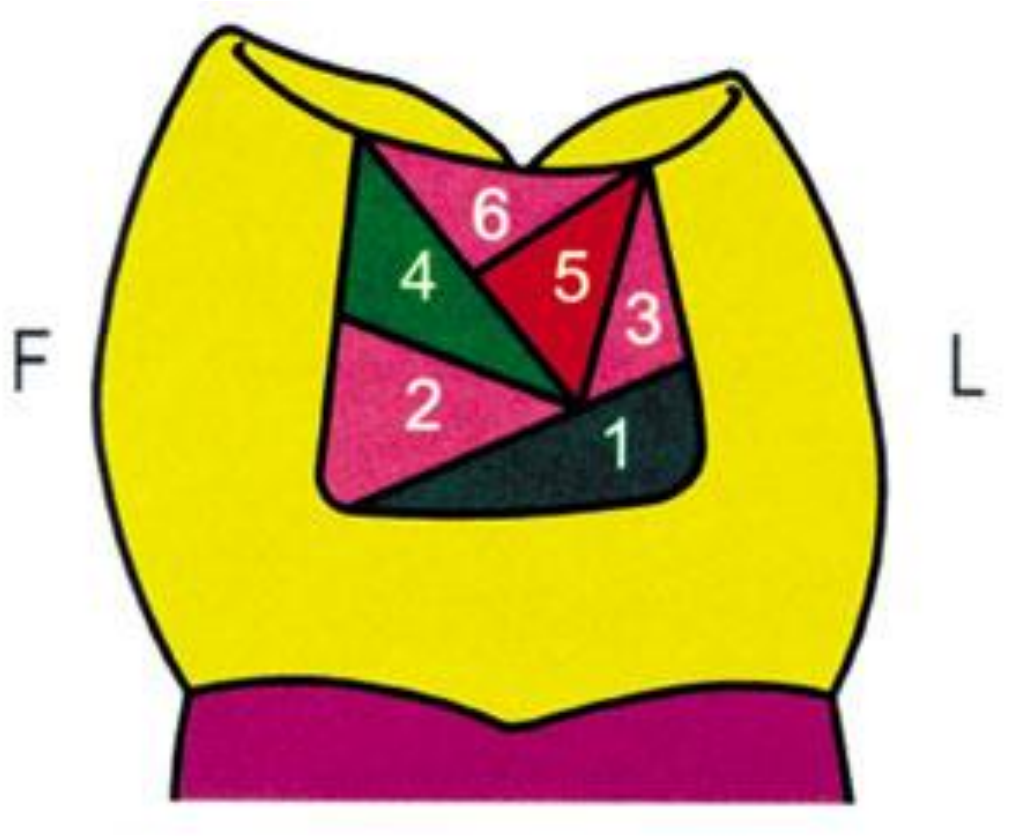
Schematic representation of wedge-shaped composite increments (1-6) used to build up the enamel proximal surface. F: Facial aspect. L: Lingual aspect.



Factors that influence the composite resin polymerization process.

Factor	Clinical repercussions
Curing time	It depends on: resin shade, light intensity, box deep, resin thickness, curing through tooth structure, composite filling.
Shade of resin	Darker composite shades cure more slowly and less deeply than lighter shades (60 seconds at a maximum depth of 0.5 mm).
Temperature	Composite at room temperature cure more completely and rapidly.
Thickness of resin	Optimum thickness is 1-2 mm
Type of filler	Microfine composites are more difficult to cure than heavily loaded composites.
Distance between light and resin	Optimum distance < 1 mm, with the light positioned 90 degrees from the composite surface.
Light source quality	Wavelength between 400 to 500 nm. A power density about 600 mW/cm^2 is required to ensure that 400 mW/cm^2 reaches the first increment of composite in a posterior box.
Polymerisation shrinkage	Depends on the amount of organic phase.

Tigris. Islam thrives in Iraq, with 55 percent of the population following the Shiite branch of Islam. About 40 percent are Sunni Muslims.