COMPOSITES

Composite is a 3-dimensional combination of at least two chemically different materials with different discrete interphase separating the two materials.

Composition

- Resin matrix phase or continuous phase (KERALA-2015)
- Reinforced or filler or dispersion phase.
- Coupling agent

Composite Resins Contain	
Resin Matrix	▪ BIS-GMA, urethane dimethacylate ▪ TEGDMA (Viscosity controller)
Fillers	▪ Colloidal silica or quartz ▪ Glasses of barium,zirconium give radiopacity
Coupling Agent	▪ Organosilanes, ziconates and titanates. ▪ The function of coupling agent is to allow bonding between filler and resin

Resin Matrix

- Resin matrix phase also consists of **Colouring agent,Initiator & Inhibitor**.
    - **Inhibitor** – hydroquinone ,Prevents premature polymerization
    - **Opacifiers and coloring pigments** - Titanium dioxide (TiO2) and aluminum oxide are the opacifiers
- Bis-GMA/TEGDMA is responsible for polymerization shrinkage.

Techniques to reduce polymerization shrinkage:

- Use of a flowable composite or resin modified GIC as a liner (low young's modulus of elasticity liner).
- Use of an incremental or layering technique.

Filler Size

- Addition of fillers, increases the strength, hardness, abrasion resistance and decreases the polymerization shrinkage and water resorption.
- **Homogenous composites** contain simply filler and uncured matrix material
- **Heterogenous composites contain** precured composite fillers or other unusual filler and uncured matrix material

Mega fill	Very large particle
Macro fill	▪ 10 - 100µ. ▪ Used in traditional or fine particle composite
Midifill	1 - 10 µ
Minifill	0.1 - 1 µ
Microfill	▪ - 0.1 µ ▪ Used in finishing composites
Nanofill	▪ 0.005 - 0.01 µ ▪ Ultra small fillers.

Composites	Filler Particle Size (µm)
Conventional Composite	8-12
Small Particle Filled	1-5
Microfilled Composites	0.04-0.4
Hybrid Composite	0.6-1

Coupling Agent

- Organosilanes, zirconates and titanates are the coupling agents.
- They bond filler particles to the resin matrix.
- It increases strength, reduces solubility and water absorption.

Indication of Composites

- Classes I, II, III, IV, V and VI restorations.
- Sealants and preventive resin restorations.
- Foundations or core build ups.
- Luting agent
- Temporary restorations
- Esthetic procedures
    - Partial veneers
    - Tooth contour modifications
    - Full veneers
    - Diastema closures
- Periodontal splinting

Contraindications for of Composite Restorations

- Isolation is not possible.
- If all the occlusal forces will be on restorative material.
- Restorations that extends on the root surface.
- Heavy occlusal stresses.

Classification of Composites and their Properties

Conventional composite	▪ Contain filler particle size of 8-12 micrometers. ▪ It is the composite with largest filler size. ▪ High strength and hardness. ▪ Less water sorption and co-efficient of thermal expansion ▪ Polishing is difficult and results in rough surface that tends to retain stains.
Micro filled composite	▪ Contain smallest fitter particle size 0.04-0.4 micrometers. ▪ Colloidal silica is used as a filler ▪ It has lowest filler content of 50% Wt ▪ Lowest strength and hardness ▪ Highest thermal expansion Co-efficient and water Sorption ▪ Excellent esthetics due to the increased smoothness
Small particle	▪ Contain Filler particles of size 1-5pm

	▪ It has the good surface smoothness like micro-filled composites and improved physical properties like conventional composite ▪ It has the highest compressive strength of all the composites
Hybrid composite	▪ It has filter particle size of 0.6-lmicro meters ▪ They have smooth finish and better esthetics than small particle but yet have similar physical properties.

Classification of Composites based on Method of Curing

- Self-cure composites
- Visible light cure composites
- UV light cure composites
- Dual cure composites (self + light cure)
- Staged curing composites

Self-Cure Composites

Supplied in two pastes

Base plate	Contains the initiator Benzoyl peroxide.
Accelerator paste	Contains tertiary amine (N-dimethyl-P-toluidine) as activator.

- It is manipulated by mixing the proper proportion on a mixing pad with an agate spatula (metal spatula discolors the composite).
- Cavity should be slightly overfilled.
- Shrinkage occurs towards center of the material.

UV Light Activated System

- Curing occurs due to activation of Benzoin methyl ether when exposed to UV Light.
- Potential health hazard to clinician and patient by UV Light.
- Retinal and soft tissue damages.

- Intensity of tight source gradually decreases in strength with use.
- Require more time to cure - 60 secs.
- It can cure to a thickness of 1.5mm.

Visible Light Activated Composites

- Consist of a single paste
  - Initiator - Camphoroquinone , It has an absorption range between **410 - 500 nm** that is in the blue Light region of visible light spectrum and predominantly at **474 nm.**
  - Activator - Diethyl-amino-ethyl methacrylate (amine) or Diketone.
- Most popular composites today are the visible light cure composites.
- Light curing can be accomplished with Quartz-Tungsten-Halogen curing units or Light Emitting Diode (LED) curing units.
- Heath hazard is virtually eliminated.
- No warm up time is required.
- Requires a minimum of **;** for adequate curing
- The tip should be kept as close as possible to the restoration and should be cured in increments. The tip should be within **2mm** of the composite.
- It can cure to a depth of 2mm and if large area is to be cured, it is carried out in increments.
- For darker shades, curing time should be increased
- Darker shades require longer exposure time.
- Shrinkage occurs towards the light source.

Different curing lights of composite resin:

- Halogen bulb combined with filter
- Blue Light emitting diode (LED)
- Laser curing
- Argon laser with intensity of **250mW ± 50mW for 10 seconds** per increment is the commonly used laser.

Dual Cured Composites

- It has self-curing and visible curing components in the same material.
- Recommended for ceramic inlays that may be too thick to allow sufficient amount of light to radiate through to produce adequate conversion of the monomer.

Generation of Composites

1st generation	▪ Consists of macroceramic reinforcing phases in resin matrix. ▪ They have highest surface roughness and mechanical properties. ▪ Flowable composite have low filter levels and should be used as pit and fissure sealant and as a liner under class I and class II composite restoration
2nd generation	▪ Consists of colloidal and microceramic reinforcing phases in resin matrix. ▪ They exhibit the smooth texture of all the composite resins. ▪ Properties of strength and coefficient of thermal expansion are unfavourable due to less filler loading. ▪ They have higher filler levels and improved properties. These can be used to restore small (minimally invasive) class I and class II restorations.
3rd generation	▪ Hybrid composites in which there is a combination of macro and micro (colloidal) ceramics as reinforcers in 75:25 ratio. ▪ The properties are a compromise between 1st and 2nd generations.
4th generation	▪ These are also hybrid types, but instead of macroceramic fillers, these contain heat cured irregularly shaped, highly reinforced composite macro particles. ▪ They produce superior restorations but are very technique sensitive.

5th generation	▪ Hybrid system in which resin phase is reinforced with micro-ceramics and macro, heat cured spherical, highly reinforced composite particles. ▪ Because of the specific shape of the macro-molecules, the workability is improved. ▪ Surface texture and wear of these materials are comparable to 2nd generation composites. ▪ Physical and mechanical properties are similar to 4th generation composites.
6th generation	▪ Hybrid type in which resin phase is reinforced with micro (colloidal) ceramics and agglomerates of sintered micro (colloidal) ceramics. ▪ It has the best physical and mechanical properties of all the composites.

Dentin bonding protocol is:

- Etching/conditioning - Step 1
- Application of primer - Step 2
- Application of bonding agent - Step 3

Generations of Dentin bonding agents	
1st generation	Uses glycerol-phosphoric acid dimethacrylate
2nd generation	▪ Uses chloro substituted phosphate esters of various monomers ▪ In 1+st and 2nd generations there is no distinction between conditioning, primer and bonding agent
3rd generation	3 step procedure i.e., conditioning, priming and bonding
4th generation	▪ Relies on formation of hybrid layer. Combines Steps 1 and 2 and are called as self etching primers ▪ Total etch, multibottle (3 bottles) i.e. etch primer + bonding agent
5th generation	▪ Steps 2 and 3 are combined, total etch, single bottle etch + primer and bonding agent in one bottle

6th generation	▪ 1 step procedure. All 3 solutions in one bottle. They are of two types. • Self etch primers i.e. Etch and primer in one bottle + Adhesive agent in other bottle. • Self etch adhesives or type II 6th generation adhesives. Two bottles or unit dose containing acidic primer and adhesive are first mixed and then applied
7th generation	Fluoride releasing bonding agents

Self Etch Primer v/s Total Etch Adhesives

- Etching both enamel and dentin using **37% phosphoric acid** simultaneously is called total etch technique.
- This concept was introduced by **Fusayama.** Since the total etch technique usually involves etching with an acid followed by rinsing to remove the acid, this technique is also known as etch and rinse technique.
- Self etch primer does not remove smear layer instead they modify it and gets it embedded into the hybrid layer
- Advantages :
  - Less technique sensitive
  - Less postoperative sensitivity
  - User friendly as there is no etching and rinsing steps
- Disadvantage:
  - Bond strength to enamel is less

Etching & Bonding

- Bonding of composites to tooth structure occurs by micromechanical retention
- For a bonding agent to be effective wetting angle should be Minimum with dental hard tissue

- Acid etching creates microporosites into which the resin penetrates resulting in resin tag formation.
- These tags penetrate to a **depth of 5 - 1.0 µ m** but their lengths are dependent on the enamel etching time.
- The thickness of the bonding resin should be **atleast 50 µ m** to prevent diffusion of oxygen from the atmosphere through the coating and there by prevent oxygen inhibition of the primer and the adjacent bonding resin during polymerization.
- Mateic acid, citric acid and oxatic acid are used to etch both enamel and dentin simultaneously.
- Enamel bond agents are usually low viscous unfilled BisGMA resins and they enhances the wettability of etched enamel.
- DENTIN B0NDING AGENTS (DBA) are unfilled resins, which have a rote in formation and stabilization of hybrid layer (micro-mechanical attachment between resin and conditioned primed dentin).
- As most composites are hydrophobic in nature, DBA should be both hydrophobic to bond with composite and hydrophilic to interact with collegen of dentin.

QUE : DBA has both hydrophilic and hydrophohic end. Hydrophillic end binds with (AIPG - 2015)

a) Composite

b) Hydroxyapptite of enamel

c) Collagen of dentin

d) Calcium of tooth

ANS : 'C'

Etchant

- 37% phosphoric acid is used as an etchant.
- Standard **37%** phosphoric acid typically dissolves about **5-10 microns of enamel surface** and creates a zone of etched enamel rods for about 15-25 microns
- Acid etching is done with 37% phosphoric acid for **15 secs, in permanent teeth**.
- For **enamel only preparations,30 secs.** is considered normal.
- In **fluoridated and primary teeth longer etching time** is required due to the presence of more aprismatic enamel.
- Concentration above 50% results in formation of monocalcium phosphate monohydrates which prevents further dissolution. The etchant is supplied in a gel form to allow control over the area of placement.
- Concentration below 30% results in dicalcium phosphate dehydrate that cannot be easily removed.
- Microscopic examination of the saliva contaminated enamel shows the formation of organic pellicle that cannot be removed by rinsing with water. Re-etching for an additional 10 sec removes the pellicle.
- Mateic acid, citric acid and oxatic acid are used to etch both enamel and dentin simultaneously
- Enamel bond agents are usually low viscous unfilled BisGMA resins and they enhances the wettability of etched enamel.

Acid etching affects the enamel in the following ways:

- The surface area of the enamel will increase upto 2000 times that of its original unetched surface. Removes pellicle to expose the inorganic crystalline component.
- Creates a porous layer, the depth of the pores range from 5-10 µ m.
- Raises the surface area and increases the wettability.
- Raises the surface energy.

Acid etching affects dentin in following ways:

- Conditioning of dentin causes removal of smear layer, demineralizes superficial dentin of 3 - 7 μ ms, exposes, microporous collagen Scafford into which the resin will impregnate.
- 37% phosphoric acid, 10% citric acid, mataeic acid are the different acid conditioners

Silverstone classified etching patterns in to three types:

Type I etching:

- Selective dissolution of enamel rod centres (cores)

Type II etching:

- Dissolution of peripheral areas of enamel rods

Type II etching:

- It includes areas that resemble the other two patterns and areas whose topography is not related to enamel prism morphology.
- Irrespective of the type of etching patterns, resin tags are approximately 6 microns in diameter and 10 -20 microns in length thereby leading to micromechanical interlocking.

Advantages & Disadvantages of Composites over unfilled Resins

Advantages	Disadvantages
▪ Lower coefficient of thermal expansion. ▪ Low polymerization shrinkage. ▪ Low water absorption.	▪ Less colour stability. ▪ Less smooth finish than unfilled resins

▪ High abrasive resistance. ▪ Unfilled resins have high 6, coefficient of thermal expansion (81×10^{-6} /^{0}C). So they are very sensitive to thermal changes resulting in micro leakage.	

Disadvantages of Composites Restorations

- Gap formed, especially on root surfaces due to polymerization shrinkage.
- More technique sensitive.
- Exhibit greater wear (less abrasion resistance).
- High coefficient of thermal expansion resulting in microleakage if inadequate bonding technique is used
- Difficult, time consuming and costly procedure.

Guidelines for Selecting of Proper Shade

- Use natural light if possible.
- Select shade before applying rubber dam.
- Do not dry the tooth, as dry teeth become lighter in shade as a result of a decrease in translucency.
- If natural tight is not available, shade selection is done under colour corrected operating lights.
- Shade tab should be held beside the area to be restored and it should be partially covered by patient's lip.
- Selection is done with in how much time to avoid fatigue of eyes 5 seconds

Cavity Preparation

- There are three basic designs of preparations for composites. They are
  - Conventional
  - Beveled conventional

- Modified

Conventional Preparation Design

- It is similar to the cavity preparations done for amalgam restorations.
- It has box like cavity, slight occlusal convergence, flat floors and undercuts in dentin.
- The cavosurface angle is near to 90° (butt joint).
- If an existing amalgam restoration is removed, usually a conventional preparation is noted.
- This design can be used with posterior composites for class I, II and VI.
- When a class II cavity extends onto the root, cavity preparation design should be conventional only.

Conventional cavity design is done for

- Composites
- Amalgam
- Silicate
- Porcelain inlay

Beveled Conventional

- Incorporation of an enamel cavosurface bevel in preparations for composite is recommended, as it provides more surface area for bonding and it allows for the more preferred end-on etching of the enamel rods.
- These features improve retention, reduce leakage and strengthens the remaining tooth structure.
- The bevel is prepared with a flame shaped diamond instrument, 0.5mm wide and at an angle of 45° to the external enamel surface.
- It may be used for class I, II and VI cavities.

Modified Preparation Design

- It does not routinely extend into dentin and depth of preparation depends on the pulpal extent of carious lesion.
- Modified cavity preparations are more conservative than conventional, since mechanical retention is obtained by acid etching.
- **<u>Advantages of cavosurface margin beveling are:</u>**
  - It provides restorative margin to merge with tooth structure, so no margin discolouration is seen as that of conventional cavity.
  - Marginal leakage is reduced.
  - Minimal pulpal irritation.
  - Good aesthetics.
- Copal varnish, ZOE are contraindicated as a liner under composite or any resin because they interfere with polymerization reaction.
- Quick setting $Ca(OH)_2$ is recommended as a base under composites in deep cavities.
- Matrices used for composite resin are Mylar strip and compound supported metal matrix (0.04 mm).
- Finishing of composite resin is carried out with carbide bur, diamond bur, polishing disc or strip with to and fro motion.
- Glaze is a thin layer of bonding agent that is placed over the restoration which helps to create a smooth surface by filling the surface porosities.
- The retention grooves or coves in class III composite restorations are placed along the gingivo-axial. line angle and sometimes in the incisoaxial tine angle 0.5mm into dentin. They are never placed on the facio axial and linguo axial line angles.
- Before insertion of composite restorations, the operating site is cleaned with pumice slurry to remove plaque pellicle and superficial stains. Calculus removal with appropriate instruments is also needed. Prophypastes containing fluoride, glycerine and flavoring agents should be avoided to prevent conflict with the acid etch technique.

- Any preparation (Inlay or onlay) for indirect tooth colored (composite, ceramic) should have the following requirements.
  - Adequate thickness of restorative material.
  - A passive insertion pattern.
  - A 90-degree cavosurface angle to ensure marginal strength of the restoration.
  - All internal and external line and point angles should be rounded.
  - The optimal gingival-occlusal divergence should be >2 to 5 degree per wall. (Note: For cast metal it is 2-5 degree). This is because tooth colored restorations are adhesively bonded and very little pressure should be applied during tryin and cementation.
  - Isthmus should be at least 2 mm wide to decrease fracture of restoration.

C Factor

Composites shrink while hardening. This is called as polymerization shrinkage. This leads to opening of a 'V' Shaped gap if the polymerization forces are greater than the bond strength to enamel and dentin.

The ratio of bonded to unbounded surfaces of a composite restoration is referred to as c factor

$$\text{Configuration}(\text{C} - \text{factor}) = \frac{\text{Bonded surace}}{\text{Unbonded surface}}$$

The higher the C-factor, the greater is the potential for bond disruption from polymerization effects.

Preparation	C-Factor
Class I (High Risk)	5/1=5
Class II	2/1=2
Class IV (Low Risk)	1/4 =0.25

Extra Cover

- Photopolymerization stress build up can be reduced by the following types of curing.
  - **Soft-start technique:** Curing begins with a low intensity and finishes with a high intensity. This technique allows a slow initial polymerization and high stress relaxation during early stages and ends at the maximum intensity.
  - **Ramped-up curing:** Intensity is gradually increased or "ramped up" during the exposure in stepwise mode.
  - **Delayed curing:** Restoration is initially incompletely cured at low intensity and after sculpting and contouring the resin second exposure for the final cure is applied. This delay allows stress relaxation to take place.
  - **Incremental built-up**

Causes of white halo or line around around enamel margin in composite restoration

- High intensity light curing, resulting in excessive polymerization stresses
- Inadequate etching and bonding of that area
- Traumatic finishing techniques

Potential solutions:

- Re-etch, prime and bond the area.
- Use slow start polymerization techniques
- Use atraumatic finishing techniques

E.g. Light intermittent pressure

Indications for glass FRC:

- Space maintainers
- Splinting of periodontally weakened teeth
- Endodontic posts
- Orthodontic retainers
- Resin bonded bridges
- Denture repairs

Hybrid layer:

- It is resin-dentin inter-diffusion zone in process of adhesion.

Beilby layer:

- Disorganized molecular surface layer of a highly polished metal produced by a series of abrasives of decreasing coarseness.

Ormocers	Organically Modified Ceramics
Ceromer	Ceramic Optimized Composites
Giomers	Pre-Reacted Glass Ionomer with composites
Compomer	Poly acid modified composites

Medicament/Linerar/Sealer			
	Shallow Excavation (RDT>2 mm)	Moderate Excavation (RDT 0.5-2mm)	Deep Excavation (RDT<0.5mm)
Amalgam	NO/NO/Sealer	NO/NO/Sealer	CH/Base/Sealer
Composites	NO/NO/DBS	NO/NO/DBS	NO/Base/DBS
Inlay	NO/NO/Cement	NO/Base/Cement	CH/Base/Cement
Sealer = Gluma (Glutaraldehyde + HEMA) DBS = Dentin Bonding System Cement = Luting Cement (Eg. Resin Modified GIC) CH = $Ca(OH)_2$			