ri Aurobindo College of Dentistry

Indore, Madhya Pradesh

INDIA

Module plan

- Topic : DENTAL COMPOSITE RESINS
- Subject: Endodontics
- Target Group: Undergraduate Dentistry
- Mode: Powerpoint – Webinar
- Platform: Institutional LMS
- Presenter: DR.PALLAV PATNI

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INTRODUCTION

- The search of beauty can be traced to earliest civilization.
- Dental art has long been a part of the quest to enhance the esthetics of teeth and mouth.
- The constant desire of dental profession to achieve a natural appearance has led to development of various tooth colored materials, one among them being dental composites.

CRAIGS RESTORATIVE DENTAL MATERIALS -14TH EDITION

HISTORY

- Of all the innovative esthetic materials available today composite restorative materials have assumed a thrust in restorative dentistry.
- **Skinner in 1959** stated, " The esthetic quality of a restoration may be as important to the mental health of the patient as the biological and technical qualities of the restoration are to his/her physical or dental health".

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Three individuals who made the most significant contributions in this aspect are:

MICHAEL BUONOCORE: Introduced the acid–etch technique and demonstrated the concept of bonding acrylic resin to the surface of enamel.

RAFAEL BOWEN: Developed composite resin matrix –BISGMA (Bis Phenol A Glycidyl Methacrylate)

NOBUO NAKABAYASHI: His efforts have led to the technique for bonding of resin composites to the surface of dentin

EVOLUTION

SILICATES DURING FIRST HALF OF 20 TH CENTURY

ACRYLICS

IN EARLY 1950

1956 DR . BOWEN FOMULATED BIS -GMA

1962: DR.RAY L BOWEN OF THE ADA RESEARCH UNIT

COUPLING AGENTS- MACROFILLED

1970 LIGHT CURED UV LIGHT

1972 VISIBLE LIGHT CURE

1976: MICRO FILLED COMPOSITE RESINS

SECOND GENERATION OF COMPOSITE.

Mid 1980 HYBRID COMPOSITES

THIRD GENERATION OF COMPOSITES.

1991: MEGA – FILLED COMPOSITES WITH GLASS CERAMIC INSERTS COATED WITH SILANE

1992 FIBER – REINFORCED COMPOSITES

1996: FLOWABLE COMPOSITES

PRIMM- POLYMER RIGID INORGANIC MATRIX MATERIAL 1997-98

1998: INTRODUCTION OF COMPOMER,

GLASS IONOMER AND COMPOSITES

1998 ORGANICALLY MODIFIED CERAMICS

2003-NANO COMPOSITES

DEFINITION

- According **Skinners** “A highly cross linked polymeric material reinforced by a dispersion of amorphous silica, glass crystalline or organic resin filler particles and/or short fibers bonded to the matrix by a coupling agent.

- According to **Baum and Phillips** – they are defined as 3 dimensional combinations of at least two chemically different materials with distinct interface.

- According to **McCabe** – A composite material is product which consists of at least two distinct phases normally formed by blending together components having different structures and properties

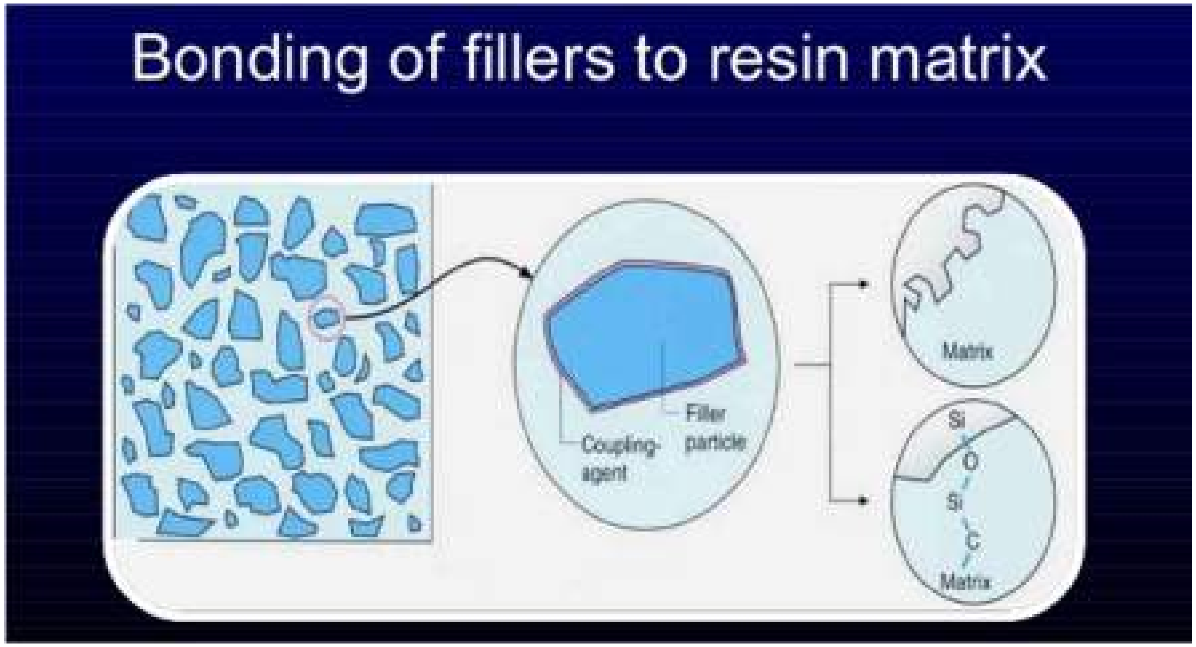
COMPOSITION

COMPOSITION OF COMPOSITE RESIN

Matrix: Plastic resin material which forms continuous phase and binds filler particles (Inorganic phase)

Filler: Reinforcing particle and/or fibers dispersed in the matrix.

Coupling agent: Bonding agent that promotes adhesion between filler and resin matrix.



Bonding of fillers to resin matrix

COMPOSITION

Activator initiator system –

Chemical activation

Light activation

Inhibitors:

(Prevent premature polymerization)

Optical modifiers:

(Obtain opacity and translucency).

Colouring agent

(Pigments) to provide appropriate shade.

RESIN MATRIX

- It is chemically active component which undergoes polymerization to convert carbon double bonds in a monomer to single bonds of polymer .
- There are different types of resin matrix:

  1.Methacrylate monomers

  2.low shrink methacrylate monomers

  3.Low shrink silorane monomer

RESIN MATRIX

METHACRYLATE MONOMERS:

- The vast majority of monomers used for the resin matrix are dimethacrylate compounds.
- Two monomers that have been commonly used are 2,2-*bis[4(2-hydroxy-3-methacryloxy-propyloxy)*-phenyl] propane (Bis-GMA) and urethane dimethacrylate (UDMA)

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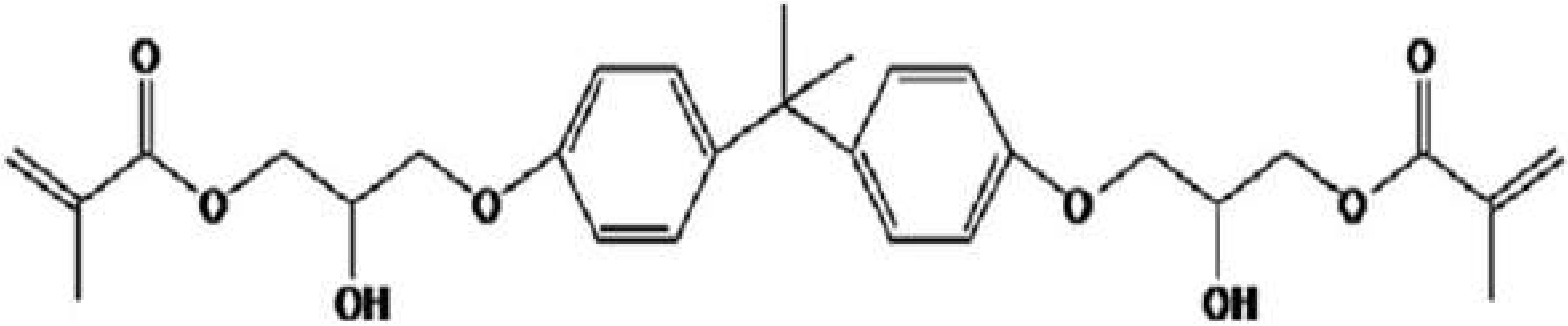
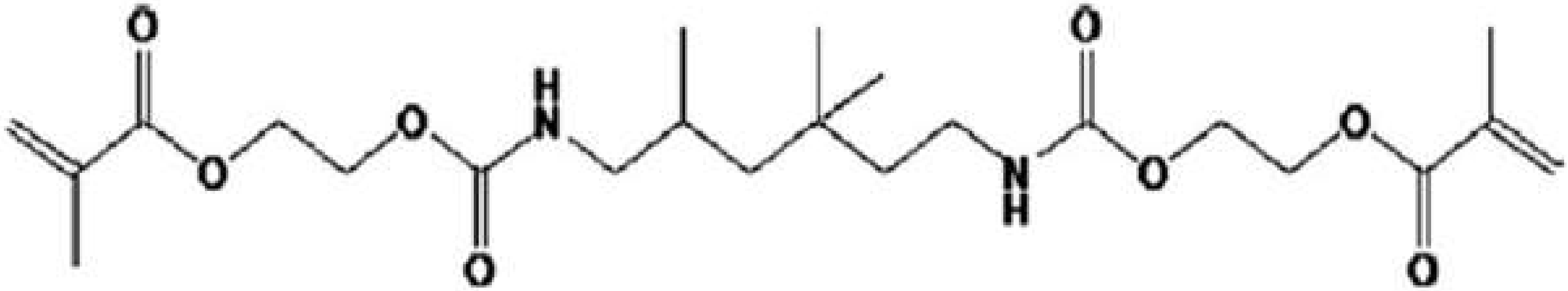


Structure of Bis-GMA.



Structure of UDMA.

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- The viscosity of the monomers, especially Bis- GMA, is rather high and diluents must be added, so a clinical consistency can be reached when the resin mixture is compounded with the filler.
- EXAMPLES:

1. Triethylene glycol dimethacrylate (TEGDMA), or

2. Bis-EMA6 , are added by the manufacturer to reduce and control the viscosity of the compounded composite.

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VISCOSITY CONTROLLERS

- Many dimethacrylate resins, such as Bis-GMA, are highly viscous liquids. If very small monofunctional monomers (eg, methyl methacrylate) were used to lower viscosity, these more volatile components could shorten the shelf life of the composite, as well as increase polymerization shrinkage.

  EX: TEGDMA, urethane dimethacrylate, and EDMA (ethyleneglycol dimethacrylate

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- Of these, TEGDMA is the most common and comprises 10 to 35% of most macrofilled composites and 30 to 50% of most microfilled composites.
- Using TEGDMA makes the resin more flexible and less brittle, improves its marginal edge strength, and reduces the resin’s resistance to abrasion.
- Since TEGDMA is smaller than Bis-GMA, it shrinks more when polymerized

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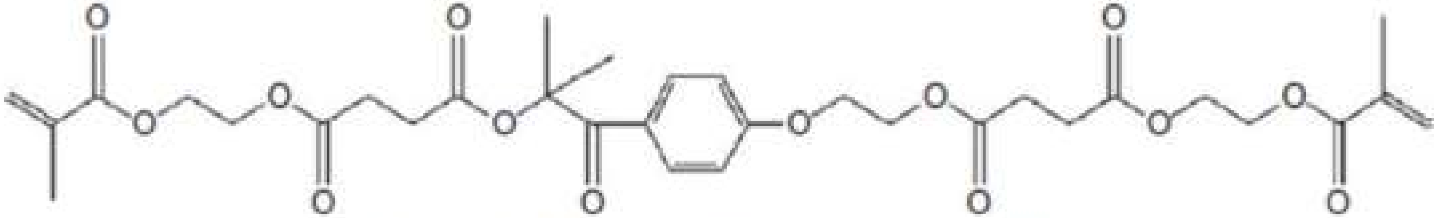
LOW-SHRINK METHACRYLATE MONOMERS

•Introduced for controlling the volumetric shrinkage and polymerization stress of composites.

Structure of a Monomer with Cycloaliphatic Units



Structure of Monomer with Photocleavable Units

EX:DIMER ACIDS , INCORPORATION OF CYCLOALIPHATIC UNITS, AND PHOTOCLEAVABLE UNITS

LOW-SHRINK SILORANE MONOMER

- *Silorane has been* developed to reduce shrinkage and internal stress build-up resulting from polymerization.
- The name *silorane was coined from its chemical building blocks siloxane and oxirane (also known as epoxy).*

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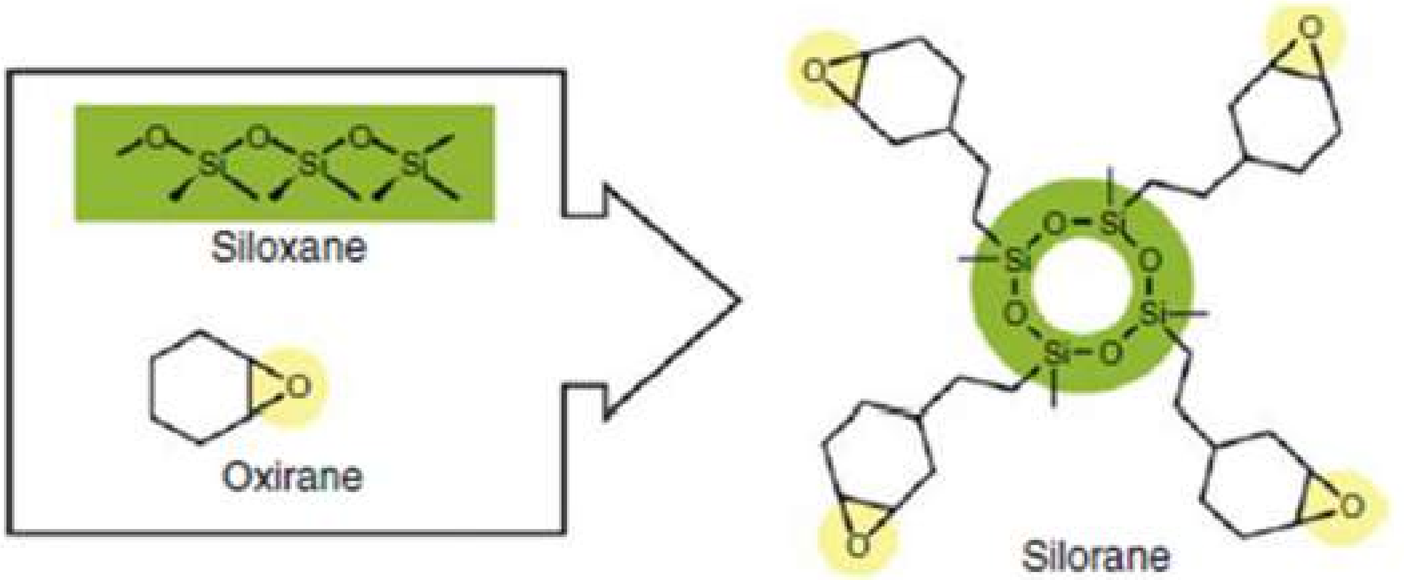
- The siloxane functionality provides hydrophobicity to the composite. The oxirane functionalities undergo ring-opening cross-linking via cationic polymerization



Structure of Silorane

- The oxirane functionalities undergo ring-opening cross-linking via cationic polymerization.
- If the filler surface has any residual basicity (as with some glasses and sol-gel derived systems), the composite may become unstable.
- Furthermore, a specific adhesive system has to be used for bonding these materials during clinical placement.

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A NEW RESIN MATRIX FOR DENTAL COMPOSITE HAVING LOW VOLUMETRIC SHRINKAGE

Y. Kim etal 2003

- **AIM**:A comparison of the volumetric shrinkage of dental composites containing bis-gma, tmbis-gma (2,2-*bis[3,5-dimethyl, 4-(2-hydroxy-3-methacryloyloxy* propoxy) phenyl] propane)), and TEGDMA with that prepared from a bis-gma and TEGDMA mixture
- **CONCLUSION**: They concluded that volumetric shrinkage by newer resins reduced by 50%

ESTROGENICITY OF BISPHENOL A RELEASED FROM SEALANTS AND COMPOSITES: A REVIEW OF THE LITERATURE

STEFANO ERAMO ETAL 2010

- ✓ There is also evidence that some dental sealants, and to a lesser extent dental composites, may contribute to very low-level BPA exposure.
- ✓ The ADA fully supports continued research into the safety of BPA but, based on current evidence, the ADA does not believe there is a basis for health concerns relative to BPA exposure from any dental material”.

FILLERS

- ✓ Incorporation of filler partially into a resin matrix significantly improves the properties of the matrix material.

Benefits of filler:

- ➢ A primary purpose of filler is to strengthen a composite.
- ➢ Increased hardness strength
- ➢ Decreased wear
- ➢ Reduction in polymerization shrinkage

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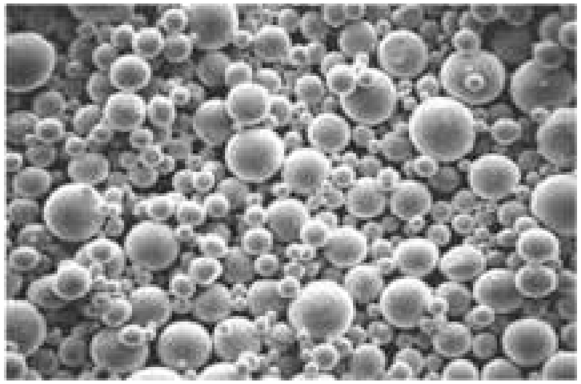
TYPES OF FILLERS

- Reduction in thermal expansion and counteraction
- Increased viscosity ,improved workability

- Quartz
- Fused silica
- Aluminium silicate
- Barium glasses
- Fluoro silicates
- Boro silicates
- Aluminium silicates



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- Fused silica
- Strontium glasses
- Lithium aluminium silicate, pyrogenic silic
- Zirconium glasses
- Yttrium trifluoride
- Ybbrium trifluoride
- Tri calcium phosphate
- Zirconium di oxide
- Silorane treated fillers

CRAIGS RESTORATIVE DENTAL MATERIALS -14TH EDITION

METHODS OF FILLER MANUFACTURE

- Fillers larger than 0.1 micron are typically made by grinding larger particles of glass or quartz to size and, sometimes, by precipitating crystals out of a solution.

- Therefore, grinding of glass fillers has become one of the most important and most highly sophisticated procedures in the production of macrofilled composites.

TOOTH-COLORED RESTORATIVES PRINCIPLES AND TECHNIQUES-9TH EDITION -HARRY F. ALBERS,

- Different methods of manufacture are :

1.Mill grinding

2.Air abrasion

3.Ultrasonic interaction

4.Erosion

MILL GRINDING

- Milling is the traditional method of grinding glass.

- In this process, glass particles are crushed between two harder and tougher surfaces.

- Mill grinding produces particles with sharp edges.
- The major limitation of this method is the impurities contributed by the grinding wheels.
- These impurities are difficult to remove and can destroy the esthetics of the final composite

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AIR ABRASION

- In air abrasion, filler particles grind themselves as they collide and fracture in two forced streams of particles.
- In theory, this process is similar to blasting sand against itself or another more solid object.
- The difficulty with this technique is that as the particles get smaller they miss each other more often

- Hence, it takes a long time to grind fine particles.
- The advantage is that larger particles are quickly eliminated since they readily collide with other particles.
- Particles created by fracture have sharp edges

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ULTRASONIC INTERACTION

- In this method, glass particles collide in suspension in a solvent undergoing ultrasonic vibration.

- This method can produce small particles from almost any filler

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- Particles produced by this process have rounded edges because of the mechanical effects of particle-to-particle interaction.
- The disadvantage is that the process takes considerable time.
- The process is similar to polishing rocks in a rotating can: they continually get smoother.

TOOTH-COLORED RESTORATIVES PRINCIPLES AND TECHNIQUES-9TH EDITION -HARRY F. ALBERS,

EROSION

- Erosion grinding is based on the solubility of glass particles in acidic solutions.
- Erosion combined with vibration (usually ultrasonic) makes particles smaller at a rapid rate.

TOOTH-COLORED RESTORATIVES
PRINCIPLES AND TECHNIQUES-9TH
EDITION -HARRY F. ALBERS,

- The technique is similar to polishing rocks in a vibrating tumbler that contains chemicals to speed up the erosive process while the fillers are ground mechanically.
- These particles have rounded edges and, depending on the chemicals used, may have a porous surface.

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FILLER CLASSIFICATION

Basically there are 3 sizes of fillers

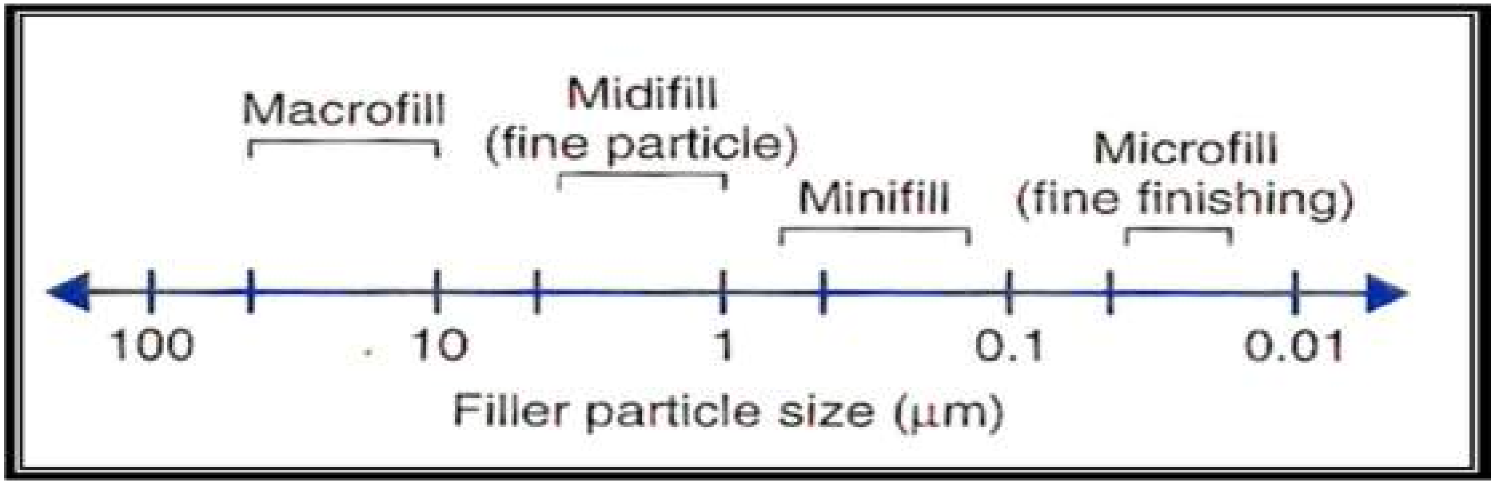
- Traditional macrofiller 15-30μm.
- Microfiller (pyrogenic silica) 0.04μm
- Microfiller based complexes
  - Sintered prepolymerized microfilled complex (1-200μm)
  - Spherical polymer based microfilled complex (20-30μm)
  - Agglomerated microfilled complexes (1-100μm)

TOOTH-COLORED RESTORATIVES PRINCIPLES AND TECHNIQUES-9TH EDITION -HARRY F. ALBERS,

ACCORDING TO STURDEVANT

BASED ON FILLER CONTENT(WEIGHT/VOLUME%)

Based on range of filler particle size
Mega fill-β quartz , large size
Macro fill – 10-100 micro meter
Midi fill – 1-10 micro meter
Mini fill – 0.1-1 micro meter
Micro fill – 0.01-0.1 micro meter
Nano fill – 0.005-0.01 nano meter



TRADITIONAL COMPOSITES

- 1970’s
- Ground amorphous silica and quartz (8-12mm) in 60-70% volume

SMALL PARTICLE

- Modification of traditional composite resins
- Here broad sized particle distribution is used to get high filler load (80-90wt%). SIZE 0.5-3 mm
- Glass particles with heavy metals
- Colloidal silica

MICROFILLED

FILLED

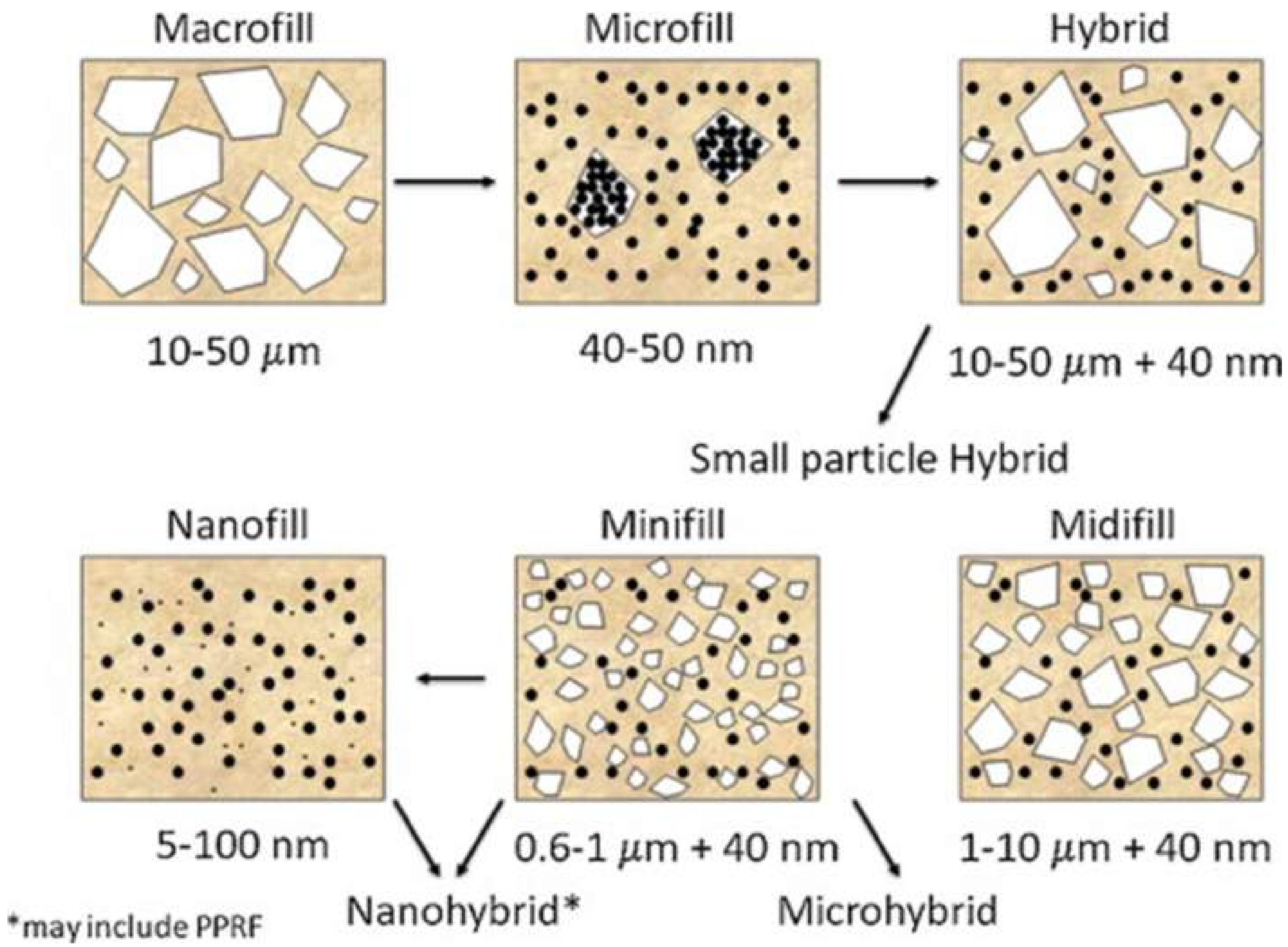
- The problems of surface roughening and low translucency overcome by.
- Colloidal silica particles added to resin matrix by two ways: sintering of colloidal silica
- And prepolymerized colloidal silica

HYBRID

COMPOSITES

An effort to obtain better surface smoothness with good physical properties.

- **Colloidal silica (10-20%) and glass particles with heavy metals (75-80%).**
- **Filler size 0.4 –1.0mm.**


Macrofill
Microfill
Hybrid
10-50 μm
40-50 nm
10-50 μm + 40 nm
Small particle Hybrid
Nanofill
Minifill
Midifill
5-100 nm
0.6-1 μm + 40 nm
1-10 μm + 40 nm
Nanohybrid*
Microhybrid
*may include PPRF

MACROFILLS

- The early composites were macrofills.
- These composites contained large spherical or irregular shaped particles of average filler diameter of 20 to 30 µm.
- The resultant composites were rather opaque and had low resistance to wear

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HYBRID COMPOSITES

- The hybrid composites are two types of fillers that are blended together: (1) fine particles of average particle size 2 to 4 µm and

(2) 5% to 15% of microfine particles, usually silica, of particle size 0.04 to 0.2 µm.

- When particles and resin are mismatched in the refractive index, which measures the ability of the material to transmit light, the particles will scatter light and produce opaque materials

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MICROHYBRID COMPOSITES

- fine particle size (0.04 to 1 µm) are blended with microfine silica.
- The fine particles may be obtained by grinding glass (e.g., borosilicate glass, lithium or barium aluminum silicate glass, strontium or zinc glass), quartz, or ceramic materials and have irregular shapes.
- The distribution of filler particles provides efficient packing so that high filler loading is possible while maintaining good handling of the composite for clinical placement

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- Microhybrid composites may contain 60% to 70% filler by volume, 77% to 84% by weight in the composite.
- Hybrids and microhybrids have good clinical wear resistance and mechanical properties and are suitable for stress-bearing applications.
- They lose their surface polish with time and become rough and dull.

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NANOCOMPOSITES

- Recently the incorporation of nanotechnology into designing and manufacturing of composites has greatly improved their properties.

NANOFILLERS AND NANOCOMPOSITES:

- Nanotechnology is the production of functional materials and structures in the range of 1 to 100 nanometers (nm)—the nanoscale—by various physical and chemical methods

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- At present there are two distinct types of dental composites available that contain nanoparticles:

a. Nanofills—these contain nanometer sized

- particles (1-100 nm) throughout the resin matrix. Larger primary particles are not present.

b. Nanohybrids—these consist of large particles

- (0.4 to 5 microns) with added nanometer sized particles. Thus they are hybrid materials, not true nanofilled composites

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NANOFILL COMPOSITES

- All filler particles of true nanofilled composites are in the nanometer range
- First, the size of nanomeric particles is below that of visible light (400-800 nm), which provides the opportunity of creating highly translucent materials.
- In addition the surface area to volume ratio of the nanoparticles is quite large.

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- Two types of nanoparticles have been synthesized and used for preparing this class of composite.
- The first type consists of nanomeric particles that are essentially monodisperse nonaggregates and nonagglomerated particles of silica or zirconia
- The surface of the nanoparticles are treated with silane coupling agents that allow them to be bonded to the resin matrix when the composite is cured after placement.

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- Nanomers are synthesized from sols, creating particles of the same size. Because of this, if nanomeric particles alone are used to make highly filled composites, the rheological properties are rather poor.
- To overcome this disadvantage, one manufacturer has designed a second type of nanofiller, which is called *nanocluster*

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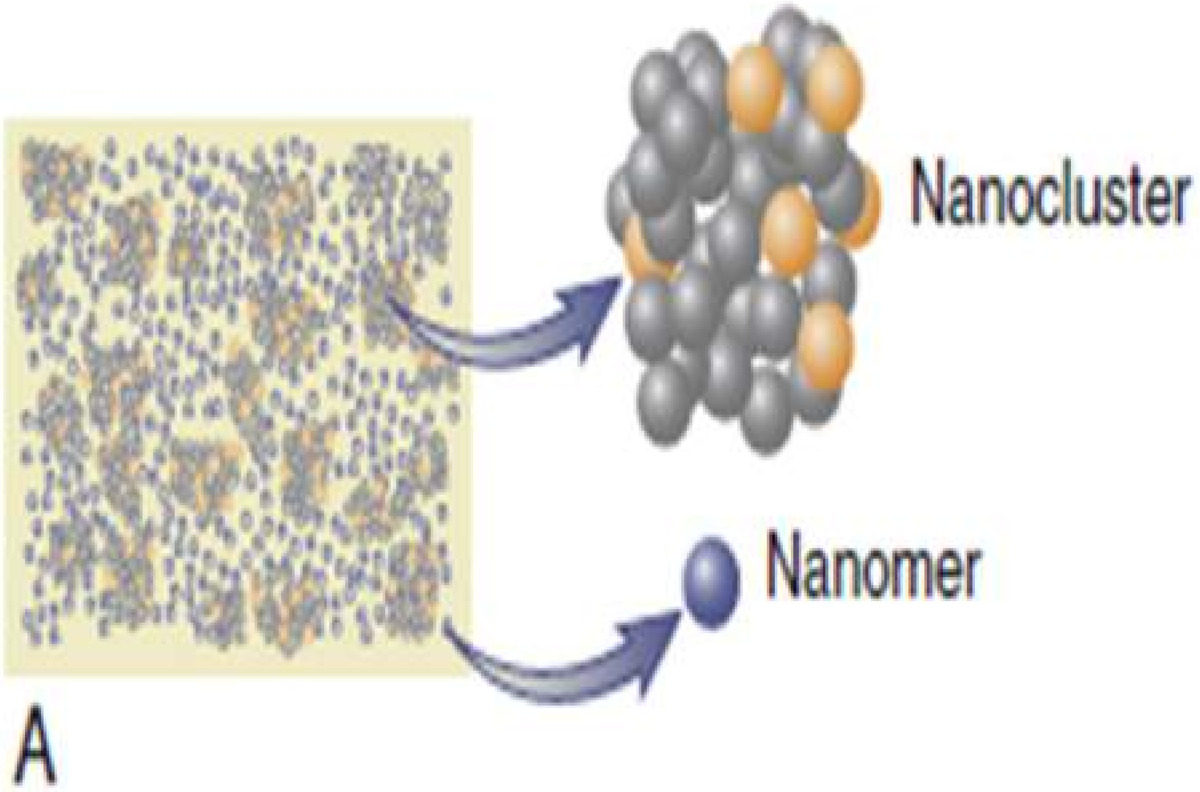

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- The nanoclusters are made by lightly sintering nanomeric oxides to form clusters of a controlled particle size distribution.
- Nanoclusters have been synthesized from silica sols alone as well as from mixed oxides of silica and zirconia.
- The clusters can be made to have a wide size distribution ranging from 100 nm to submicron level and have an average size of 0.6 micrometers

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- The uniqueness of the nanofilled composite is that it has the mechanical strength of a microhybrid but at the same time retains smoothness during service like a microfill.
- In contrast, in the nanofilled composite, the nanoclusters shear at a rate similar to the surrounding matrix during abrasion.
- This allows the restoration to maintain a smoother surface for long-term polish retention.

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- Nanofillers also offer advantages in optical properties.
- Nanomeric fillers particles are far smaller than the wavelength of light, making them unmeasurable by refractive index.
- When light enters, long wavelength light passes directly through and materials show high translucency

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- The ability to create a nanocomposite with very low opacity provides the ability to formulate a vast range of shade and opacity options from the very translucent shades needed for the incisal edge and for the final layer in multilayered restorations to the more opaque shades desired in the enamel, body, and dentin shades.
- This allows the clinician the flexibility of choosing a single shade or a multishade layering technique depending on the esthetic needs.

NANOHYBRIDS

- Several manufacturers have placed nano-sized particles in their microhybrids.
- These composites have been described as nanohybrids.
- Because the smoothness and wear of any composite is often determined by the size of its largest filler particles as with microhybrids, the surface of nanohybrids becomes gradually dull after a few years of clinical service.

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REFRACTORY INDEX: The translucency of filler particles should be similar to that of tooth structure to ensure acceptable aesthetics.

- Most of the filler have the refractive indices approximately 1.5 which adequate to achieve sufficient translucency.

RADIO OPACITY: is provided in a number of glasses and ceramics that contain heavy metal such as barium, strontium and zirconium. Most commonly used is barium glass (1.5 Refractive Index).

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- The quartz containing composites are difficult to polish and cause abrasion on opposing teeth or restoration.
- Composites with finer filler particles give better finishing than with larger filler particles size.
- The highly radio opaque filler particles like glasses and ceramics (barium glass, strontium, zirconium) are not inert as quartz and are slowly leached out from resin matrix when they come in contact with acids and oral fluids.

CRAIGS RESTORATIVE DENTAL MATERIALS -14TH EDITION

MODIFICATION OF FILLER SURFACE TREATMENT OF COMPOSITE RESINS USING ALTERNATIVE SILANES AND FUNCTIONAL NANOGELS

BRUNA MARIN FRONZA 2019

THE ACADEMY OF DENTAL MATERIALS.

AIM: This study probes how modifiedapproaches for filler surface treatment in dental composites based on alternative silanes and functional nanogel additives affects physico-chemical properties of these materials with a focus on polymerization stress development.

CONCLUSION: They concluded that filler surface treatment modified with reactive nanogels enables the potential for a significant reduction in ps, without compromise to degree of conversion or physical/mechanical properties of photocurable dental composites

COUPLING AGENTS

- The coupling agent provides the bond between organic resin matrix and the filler particle.
- This also helps in transferring stress from the flexible matrix to stiffer particles.
- coupling agent imparts improved physical & mechanical properties and inhibit leaching by preventing water from penetrating along the filler resin interface.
- Ex: organosilanes such as Y-methacryl-oxyprophyl trimethoxy silane

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- In the presence of water the methoxy groups (-OCH3) are hydrolyzed to silanol (-Si-OH) groups that can bond with other silanols on the filler surfaces by formation of a siloxane bond (-Si-O-Si).
- The methacrylate group of coupling agent forms covalent bond with resin when polymerized.

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FUNCTIONS:

- It forms an interfacial bridge that strongly binds the filler to the resin matrix.
- It enhances the mechanical properties of the composite and minimizes the plucking of the fillers from the matrix during clinical wear.
- The resulting interfacial phase provides a medium for stress distribution between adjacent particles and the polymer matrix.
- It provides a hydrophobic environment that minimizes water absorption of the composite.

CRAIGS RESTORATIVE DENTAL MATERIALS -14TH EDITION

INHIBITORS

- They are added to minimize or prevent spontaneous polymerization of monomers in resin system.
- This inhibitor has strong reactivity potential with free radicals and inhibits chain propagation by terminating the ability of the free radicals to initiate the polymerization process.
- Ex:Butylated hydroxy toluene (BHT) in concentration 0.01wt%.

Functions:

They extend the storage time

Ensures sufficient working time.

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OPTICAL MODIFIERS

- The optical modifiers are added so that the visual colourization shading and translucency of the composite resin simulate the tooth structure.
- Translucency or opacity is provided to simulate dentin and enamel and is achieved by addition of opacifier.
- The most commonly used opacifiers are
  - Titanium dioxide
  - Aluminium oxide (0.001 to 0.007%wt)

CLINICAL SIGNIFICANCE:

- Inadequate amount of opacifiers allow too much light to pass through the restoration less light is reflected back or scattered, thus making the restoration appear dark.
- Excessive opacifier leads to reflection of tooth much light making restoration look whiter.

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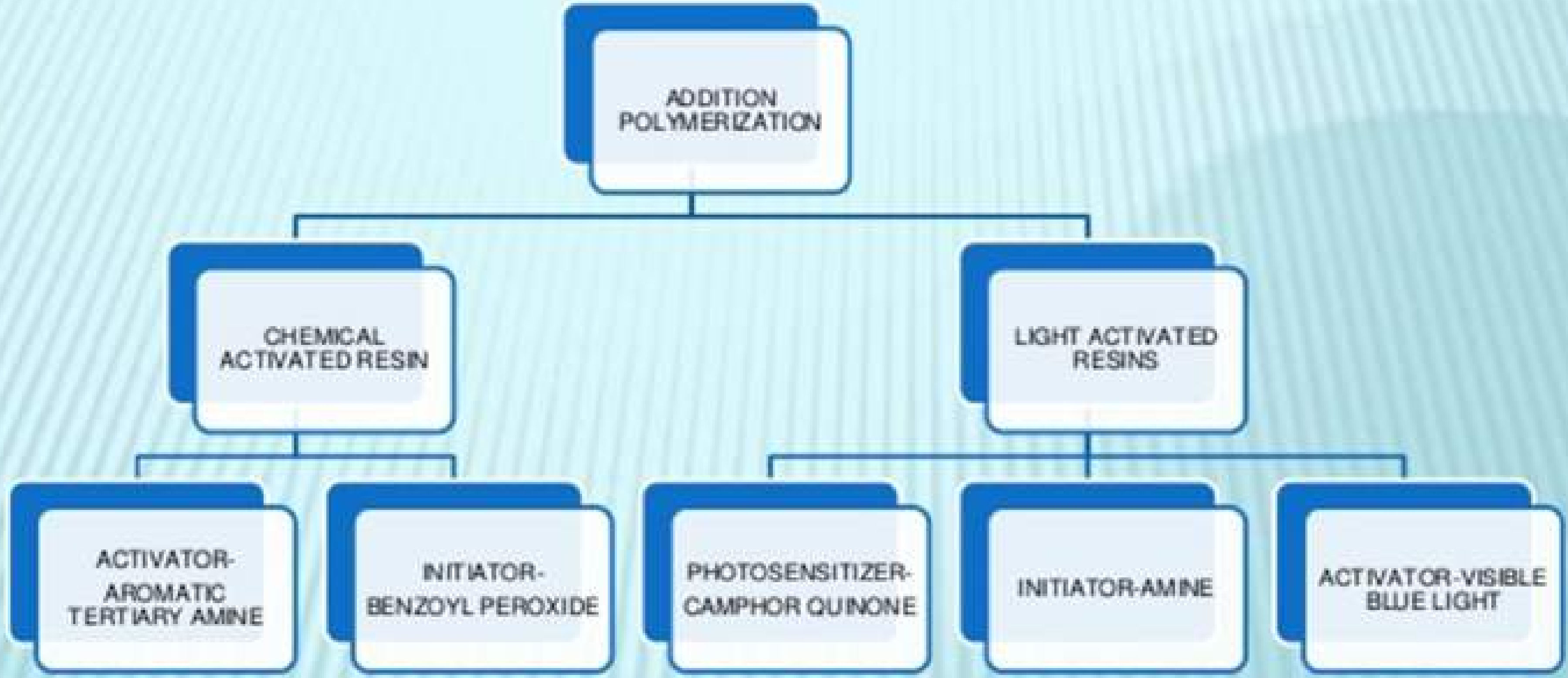
ACTIVATOR INITIATOR SYSTEM



- ADDITION POLYMERIZATION
  - CHEMICAL ACTIVATED RESIN
    - ACTIVATOR- AROMATIC TERTIARY AMINE
    - INITIATOR- BENZOYL PEROXIDE
  - LIGHT ACTIVATED RESINS
    - PHOTOSENSITIZER- CAMPHOR QUINONE
    - INITIATOR-AMINE
    - ACTIVATOR-VISIBLE BLUE LIGHT

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CHEMICAL ACTIVATION:

Chemical activation resin system supplied in 2 paste systems.

- The one paste system contains

  Initiator: benzoyl-peroxide and

  Activator :aromatic tertiary amine

- When two pastes are mixed together the amine reacts with BP to form free radicals and thus addition polymerization reaction initiated.

CRAIGS RESTORATIVE DENTAL MATERIALS -14TH EDITION

DISADVANTAGES:

- Air entrapment which weaken resin matrix.
- No control of working time.

INDICATIONS:

- Restorations
- Large foundations (build ups)

Amine- discolouration: In chemical cure resin we can see sometimes change in colour of restoration in oral cavity.

This is due to mainly reaction of tertiary amine.

CRAIGS RESTORATIVE DENTAL MATERIALS -14TH EDITION

LIGHT ACTIVATED RESINS

- The first light activated systems were formulated for UV light to initiate free radicals.
- But UV light today replaced by visible light because
  - No depth of cure
  - Harmful to skin and eyes
  - Lack of penetration through tooth structure.

Visible light is nowadays most commonly used because it has good penetration power through thicker increments of composite resins (up to 2mm) and has good control over working time.

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- The light cured dental composites are supplied as a single paste system contained in syringe which consists of photo-initiator camphoroquinone. (400-500in the blue region of the visible light spectrum).
- The paste also contain amine activator i.e. dimethyl amino ethyl methacrylate (DMAEMA).
- When camphoroquinone is exposed to blue light with wave length 468nm it is excited and reacts with amine activator to produce free radicals.

CRAIGS RESTORATIVE DENTAL MATERIALS -14TH EDITION

ADVANTAGES

1. Single paste system, no mixing hence no porosity.
2. Suitable for incremental build up.
3. Adequate working time.
4. Improved marginal adaptation.
5. Faster cure depth.
6. Instant finishing possible.
7. Good color stability.

.8 No oxygen inhibition.

CRAIGS RESTORATIVE DENTAL MATERIALS -14TH EDITION

DISADVANTAGES

1. Technique sensitive
2. Polymerization may start under operating light
3. Additional equipment necessary
4. Polymerization shrinkage
5. Discoloration.
6. Limited depth of light penetration
7. Time consuming
8. Relatively poor accessibility in certain posterior and interproximal locations
9. Variable exposure times because of shade differences, resulting in longer exposure times for darker shades and/or increased opacity

Chemical	Light cure
Polymerization is central	Peripheral
Curing is one phase	Is in increments
Sets within 45 seconds	Sets only after light activation
No control over working time	Working time under control
Shrinkage towards centre of bulk	Shrinkage towards light source
More chances of air entrapment	Air may not get incorporated
More wastage of material	Less wastage
Not properly finished	Better finish

DUAL CURED COMPOSITES

- To over come problems of limits on curing depth and some other problems associated with light curing chemical curing and visible light components are combined in some resins .

Commercially available consists of two light curable pastes.

- 1st Paste contains benzoyl peroxide.
- 2nd paste aromatic tertiary amine.

When these two pastes are mixed and then exposed to light.

- The light curing is promoted by free amine and camphoroquinone
- Chemical curing is promoted by amine and benzoyl peroxide.

Indications:

Dual cure materials are intended for any situation that does not allow sufficient light penetration to produce adequate monomer conversion. *For example*: Cementation of bulky ceramic inlays. Air-inhibition and porosity are potential problems with dual cure cements.

➢Extra oral curing:

- Used to promote higher level of cure
- Used mainly for inlays: A heat of 150°C for 1 hour is employed.

CLASSIFICATION

ADA specification No. 27

- ○ Type I – unfilled and filled resins
- ○ Type II – composite resin materials to which a filler has been added

2. Skinner's classification (10th edition)

- Traditional composites (Macro filled) 8-12micro meter
- Small particle filled composite – 1-5micrometer
- Micro filled composite – 0.04 – 0.4 micro meter
- Hybrid composite – 0.6 – 1 micro meter

According to Anusavice (11th edition)

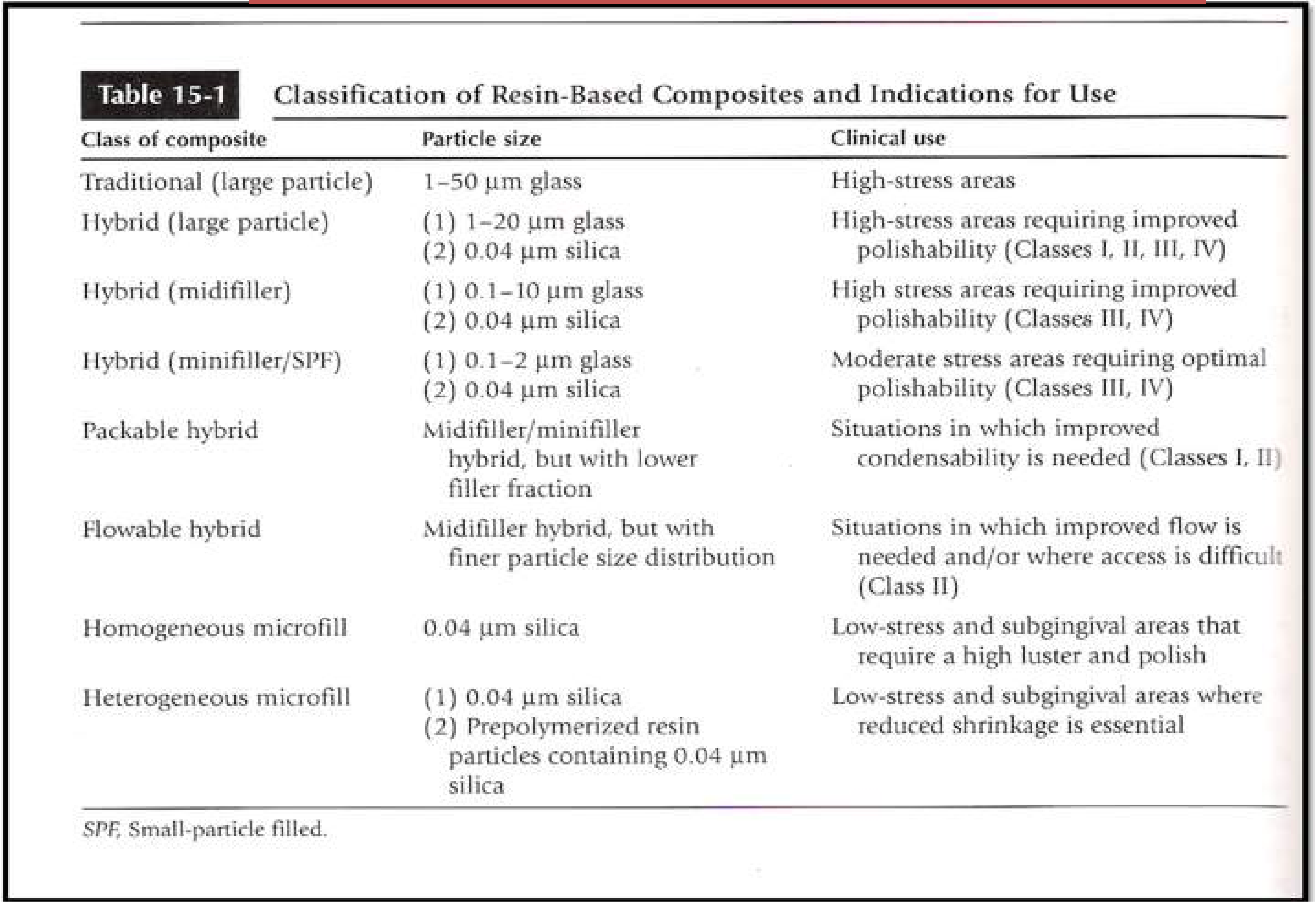


Table 15-1 Classification of Resin-Based Composites and Indications for Use

Class of composite	Particle size	Clinical use
Traditional (large particle)	1–50 µm glass	High-stress areas
Hybrid (large particle)	(1) 1–20 µm glass (2) 0.04 µm silica	High-stress areas requiring improved polishability (Classes I, II, III, IV)
Hybrid (midifiller)	(1) 0.1–10 µm glass (2) 0.04 µm silica	High stress areas requiring improved polishability (Classes III, IV)
Hybrid (minifiller/SPF)	(1) 0.1–2 µm glass (2) 0.04 µm silica	Moderate stress areas requiring optimal polishability (Classes III, IV)
Packable hybrid	Midifiller/minifiller hybrid, but with lower filler fraction	Situations in which improved condensability is needed (Classes I, II)
Flowable hybrid	Midifiller hybrid, but with finer particle size distribution	Situations in which improved flow is needed and/or where access is difficult (Class II)
Homogeneous microfill	0.04 µm silica	Low-stress and subgingival areas that require a high luster and polish
Heterogeneous microfill	(1) 0.04 µm silica (2) Prepolymerized resin particles containing 0.04 µm silica	Low-stress and subgingival areas where reduced shrinkage is essential

SPF, Small-particle filled.

ACCORDING TO STURDEVANT
BASED ON FILLER CONTENT(WEIGHT/VOLUME%)

Based on range of filler particle size

Mega fill-β quartz , large size

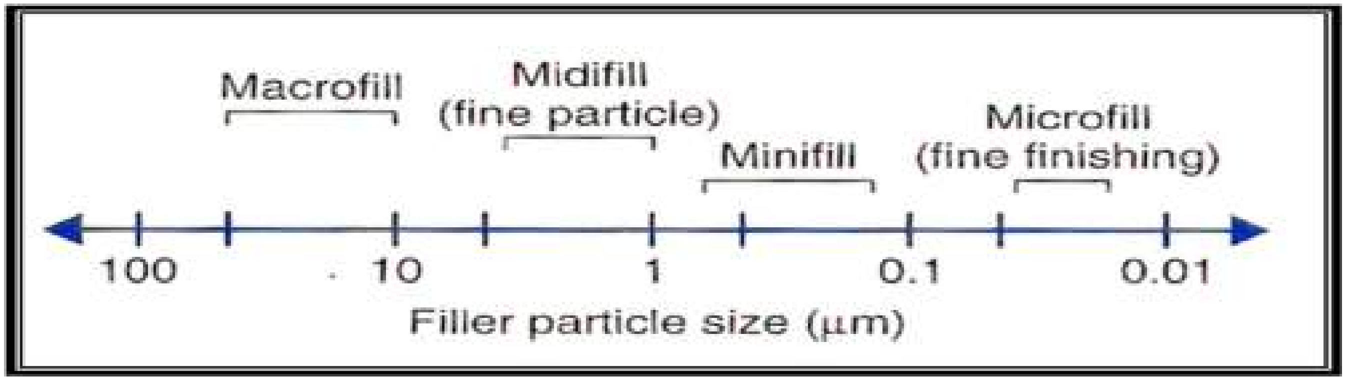
Macro fill – 10-100 micro meter

Midi fill – 1-10 micro meter

Mini fill – 0.1-1 micro meter

Micro fill – 0.01-0.1 micro meter

Nano fill – 0.005-0.01 nano meter



COMPOSITES WITH MIXED RANGE OF PARTICLES SIZES ARE CALLED HYBRID AND THE LARGEST PARTICLE SIZE RANGE IS USED TO DEFINE THE HYBRID TYPE

- ✓ Midifill hybrid
- ✓ Minifill hybrid

ACCORDING TO WHETHER COMPOSITE IS A HOMOGENOUS MIXTURE OF RESIN AND FILLER OR INCLUDES THE PRE-CURED COMPOSITE

- ✓ Homogeneous – if composite consists of filler and uncured matrix material
- ✓ Heterogeneous – if it includes pre-cured composites or other unusual filler

BASED ON AREA OF APPLICATION

Anterior
Posterior composites

BASED ON METHOD OF CURING

Chemical curing
Light curing
- ✓ UV light
- ✓ Visible light
- ✓ Plasma arc
- ✓ Laser curing

Dual cure

BASED ON CONSISTENCY

Light body – Flowable composite
Medium body – Homogeneous microfills, macrofills and midifills
Heavy body – Packable hybrid minifills

ACCORDING TO MARZOUCK

Generation	Fillers	Size of fillers
First Generation	Macro ceramics Silica / silicate based fillers Quartz fused silica Silicate glasses Crystalline lithium	1-5 □m 80% volume
Second Generation	Colloidal silica Pyrogenic silica	0.04 □m 0.05-0.1 □m 50% volume
Third Generation	Hybrid composite with macro and micro colloidal ceramics in 75:25% ratio	
Fourth Generation	Hybrid contains reinforced composite contain heat cured irregularly shaped highly reinforced composite with composite particles with reinforcing phase of micro ceramics	
Fifth Generation	Continuous phase reinforced with micro ceramics and heat cure spherical highly reinforced composite particles	
Sixth Generation	Continuous phase reinforced with micro ceramics and agglomerates of sintered micro ceramics	

POLYMERIZATION REACTIONS

- **POLYMERIZATION OF METHACRYLATE COMPOSITES**
- Methacrylate composites form the workhorse of direct restorative materials.
- The polymer network of these composites are formed by a process called *free-radical addition polymerization of the corresponding methacrylate monomers.*
- *The polymerization reaction* takes place in three stages:

  1.initiation,

  2.propagation, and

  3.termination

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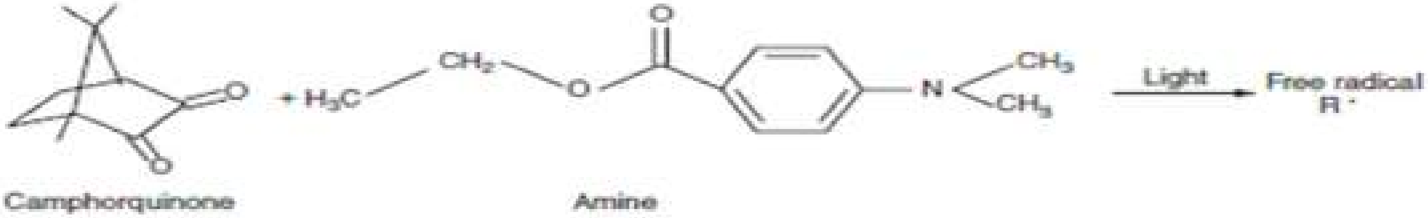
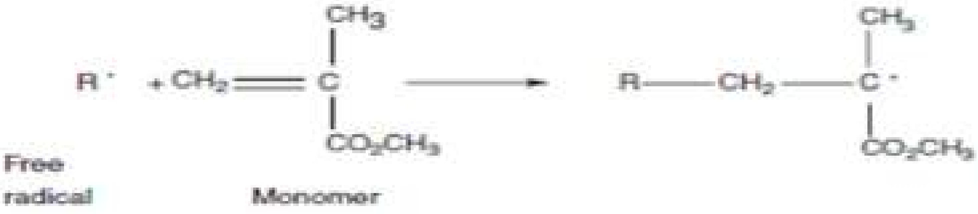
Initiation Stage

$$\text{Initiator} \xrightarrow[\text{or chemical reaction}]{\text{light, heat}} \text{Free radical } R^{\cdot}$$

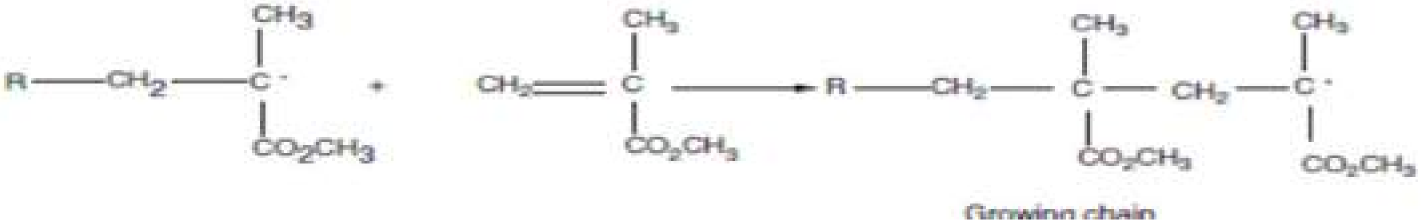
Example:





$$R^{\cdot} + CH_2{=}C(CH_3)CO_2CH_3 \longrightarrow R{-}CH_2{-}\dot{C}(CH_3)CO_2CH_3$$

Propagation Stage



$$R{-}CH_2{-}\dot{C}(CH_3)CO_2CH_3 + CH_2{=}C(CH_3)CO_2CH_3 \longrightarrow R{-}CH_2{-}C(CH_3)(CO_2CH_3){-}CH_2{-}\dot{C}(CH_3)CO_2CH_3$$

- The initiation stage is followed by the propagation stage during which rapid addition of other monomers molecules to the active center occurs to provide the growing polymer chain.
- The propagation reaction continues to build molecular weight and cross-link density until the growing free radical is terminated.
- During polymerization, molecules have to approach their “neighbors” to form chemical bonds with them.

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- Reduction of volume, or shrinkage, is generally observed during polymerization because two factors are reduced:
- the Van der Waals volume
- and the free volume.
- The Van der Waals volume is the volume of molecule itself derived from the atoms and bond lengths.
- Reduction in the Van der Waals volume takes place during polymerization because of a change in the bond lengths (conversion of double bonds to single bonds).

CRAIGS RESTORATIVE DENTAL MATERIALS -14TH EDITION

- When monomers are converted to polymers, reduction of the free volume occurs because the rotation of the polymer chain is more restricted than in unpolymerized monomer.
- several steps to minimize the polymerization contraction in methacrylate composites by one or more of the following methods:

1. Filling the monomer resins with prepolymerized resins

CRAIGS RESTORATIVE DENTAL MATERIALS -14TH EDITION

2.Maximizing the amount of inorganic filler

3. Using high molecular mass methacrylate monomers

4.In addition, incremental placement of methacrylate composites in the tooth cavity, necessitated by their limited depth of cure, controls shrinkage stress so that clinical success of the modern-day methacrylate composite is quite excellent

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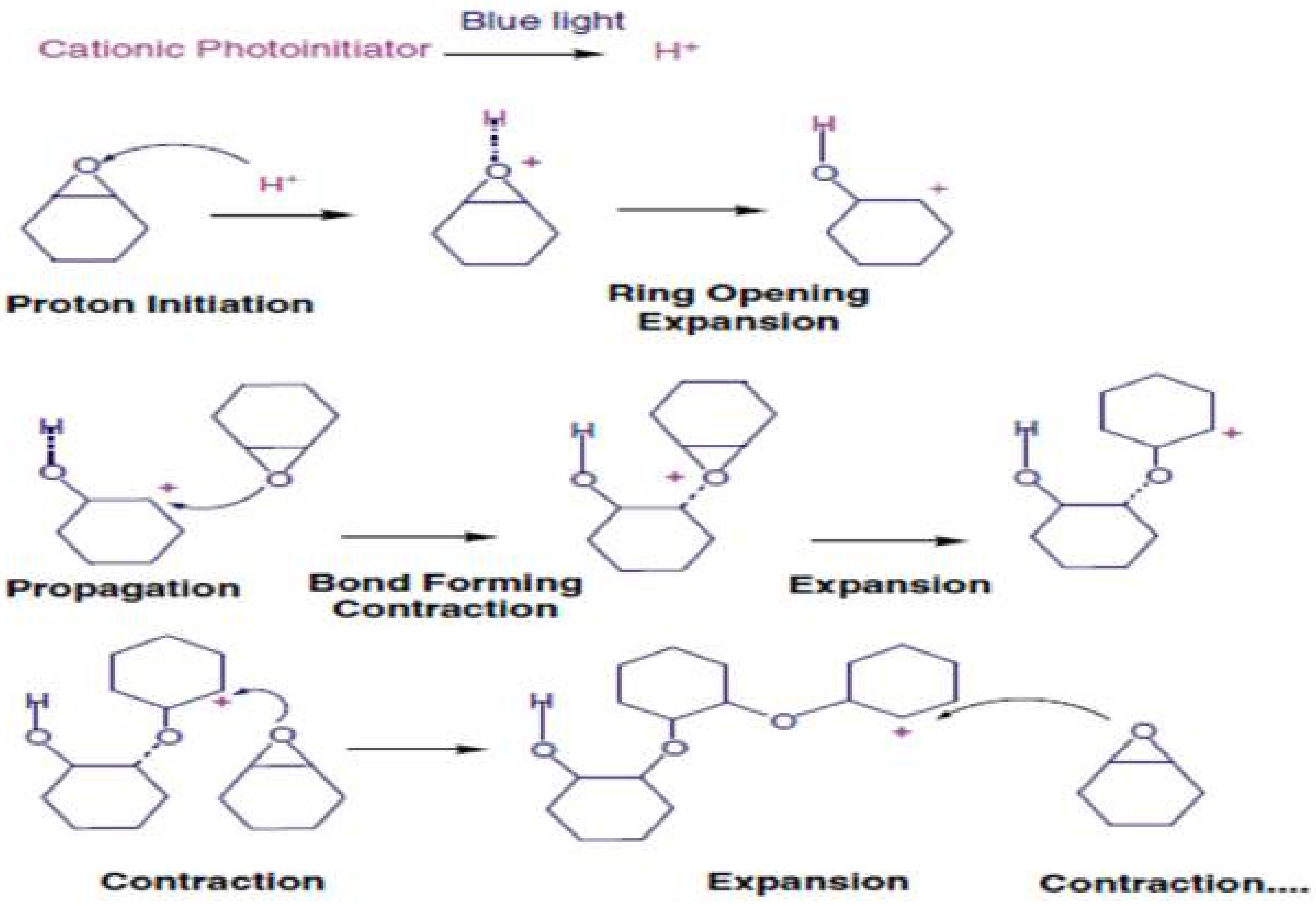
POLYMERIZATION OF SILORANE COMPOSITES



- This process gains space and counteracts some of the reduction in volume when chemical bonds are established to form the polymer.
- The silorane composites generate lower volume shrinkage and stress upon polymerization.
- It is still important to place these composites in increments because of limited depth of cure. In addition, special adhesives are needed

CRAIGS RESTORATIVE DENTAL MATERIALS -14TH EDITION

CURING LIGHTS

- Most curing lamps are hand held devices that contain the light source and are equipped with relatively short, rigid light guide made up of fused optical fibers.
- Most commonly used light source quartz bulb with tungsten filament in halogen environment.
- There are 4 types of curing lamps which available for curing of composite resin.
  - Light emitting diode (LED)
  - Plasma arc curing (PAC)
  - Quartz tungsten halogen (QTH)
  - Argon laser lamps (ALL)

UV-LIGHT CURING SYSTEM

Came into existence in the early 1970s - as Nuva light.

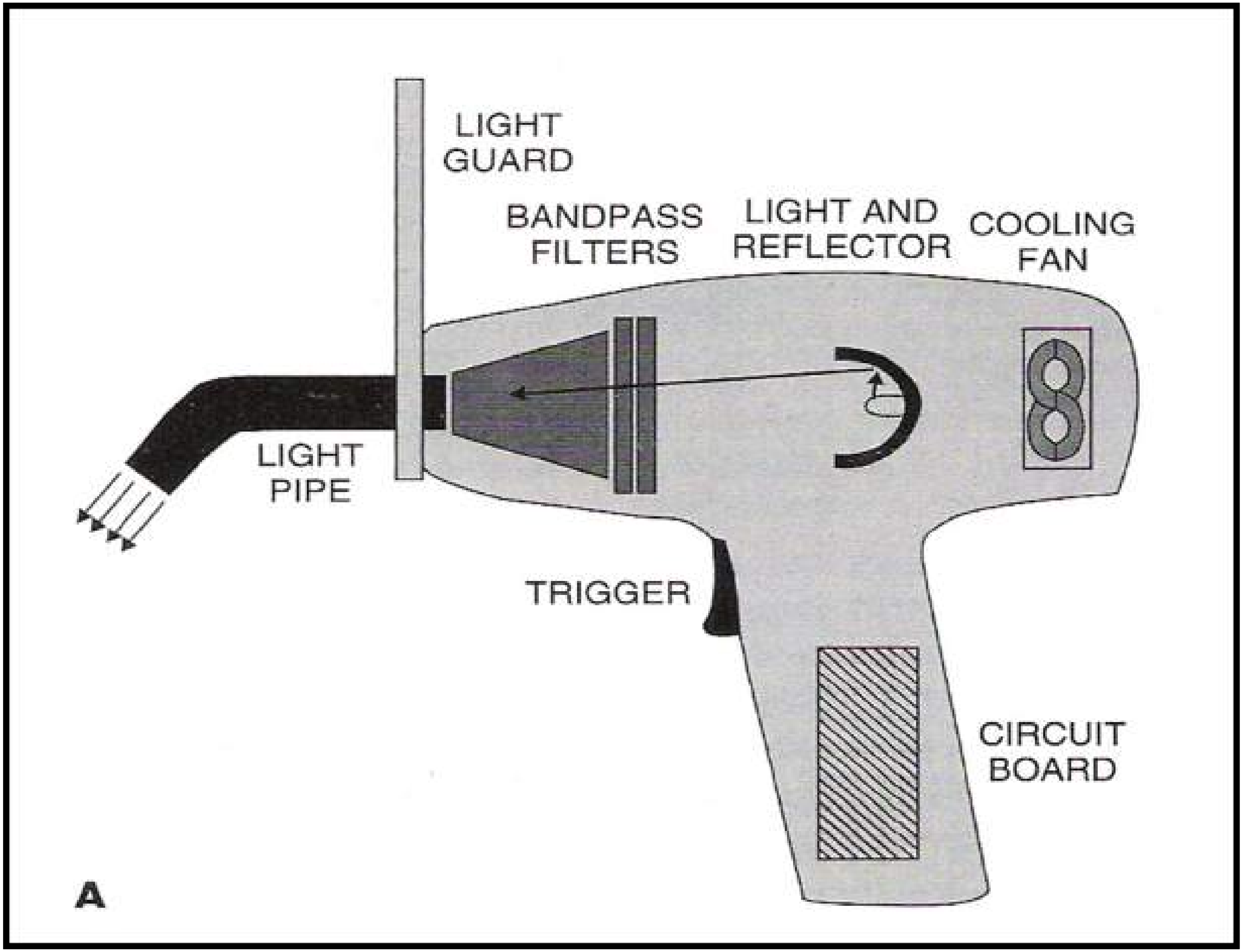
Works at 360 to 400nm range

Disadvantages:

- Because of spectral distribution of UV light, it may cause damage to eye and soft tissue burns
- Depth of cure achieved was less
- Lack of penetration through tooth structure
- Possibility of selectively altering the oral flora of the patient’s mouth.
- Intensity of light source decreased rapidly with use

QUARTZ TUNGSTEN HALOGEN

- Have a quartz bulb with a tungsten filament that irradiates both UV and white light that must be filtered to remove heat and all wavelengths except those in the violet-blue range (~400 to 500 nm)
- Minimum output should never drop below 300mW/cm^2
- Wavelength varies among the units from 450 to 490nm
- A typical resin composite requires an energy density of 16J cm^2 (400 mW/cm^2 *X* 40 seconds =16,000mWs/ cm^2) for polymerization.


LIGHT GUARD
BANDPASS FILTERS
LIGHT AND REFLECTOR
COOLING FAN
LIGHT PIPE
TRIGGER
CIRCUIT BOARD
A

Factors causing decrease in intensity of light from QTH light using units and maintenance hints

Factors	Maintenance hints
Dust or deterioration of reflector	Clean or replace reflector
Burn out of bulb filament	
Darkening/ frosting of bulb	Replace bulb
Age of components	Monitor intensity, replace units.
Chipping in line voltage	Replace light tip
Resin deposit on light tip	Clean or replace light tip.
Change in line voltage	Get built in voltage regulator
Lack of uniformity across light tip	Overlap curing on larger surface
Increased distance of the tip from material to be cured	Keep light tip close to material

ENHANCED HALOGEN LIGHT

- Provide greater curing intensity and faster cure
- Accomplished is by the use of light guides that diminish in size as they exit from the curing light
- The turbo tip decreases the time necessary to cure by about 50%
- Tip cause an increase in heat, and also the cost is more than that of the standard curing light.

PLASMA-ARC CURING UNITS

- (NASA) developed the original plasma arc technology
- Two electrodes with a large voltage potential ionize a gas (Xenon gas) that emits light.
- The PAC light produces a high intensity limited spectrum light that is filtered to blue light in the range of 460 – 490 nm.

10 seconds from a PAC light Use of 2 mm increments is still required.

ADVANTAGES -

- Shorter polymerization time (3-5 seconds)
- Shorter curing times makes overall procedures shorter and more integrated

DISADVANTAGES –

- Heat production
- Expensive.
- Although lamps last many hours, when a lamp wears out or is broken, replacement of lamp is costly.
- Most of the devices are large, heavy and bulky.
- Very low efficiency.
- Continuous spectrum must be narrowed by filter systems.
- PAC lights can burn soft tissue if the tissue is left exposed to it for standard curing times recommended by adhesive manufactures, so caution must be exercised.

ARGON LASER CURING UNITS

- The first laser, a pulsed ruby laser, was developed by Theodore H. Maiman in 1960
- Argon laser emit a monochromatic coherent light in wavelength (488nm) that cover the blue light region of the visible light spectrum.
- Does not employ filters.
- Five seconds argon laser exposure results in a resin composite cure at 2mm depth

ADVANTAGES -

- The thoroughness and depth of composite resin polymerization
- Less un polymerized monomer is found
- Thoroughness in curing results in enhancement of certain physical properties of the laser-cured composite resin
- Laser-cured bond strengths did not decrease with increasing distance, whereas there was a significant decrease in VLC bond strengths at distance greater than 0.5 mm

- Laser requires less time to achieve equivalent or greater polymerization of the restorative material.
- No refractory period,
- In cases where it is impossible to place the light wand in close proximity to the restoration, the laser beam offers the advantage of no loss of power over the distance, as is suffered by the VLC units
- Can cure thicker increments satisfactorily

DISADVANTAGES –

- Cumbersome and occupies considerably more space.
- Generate a substantial amount of heat.
- Expensive.
- From in vitro and in vivo studies, there is a temperature rise in the dentinal roof of the pulp chamber as well as within the pulp itself .
- Increased shrinkage and brittleness of some small-particle filled resins have been reported when they have been cured with a laser especially class V restorations

LIGHT-EMITTING DIODE

- ❑ In 1995, Mills et al proposed using solid state light emitting diode technology.
- ❑ Use junction of doped semiconductors (p-n junction) for the generation of a monochromatic light.

GENERATIONS OF LED’S –

- **FIRST GENERATION** - relatively low-powered chips offering a comparative low output and poor curing performance compared with conventional QTH lights

- **SECOND GENERATION** - have a single high-powered diode with multiple emission areas E.g. Elipar Freelight 2

- **THIRD GENERATION** - they have two or more diode frequencies and emit light in different ranges to activate CQ and alternative photo-initiators. E.g. – UltraLume 5

ADVANTAGES -

- Consistent output, with no bulbs to change
- No need for filter systems
- High efficiency leads to:
- Low temperature development (no ventilation fan required
- Low power consumption (battery-operation is possible)
- Frame can be easily cleaned, since no slots for a ventilation fan are needed
- Long service life of LED'S
- Quiet
- Cordless, light weight

DISADVANTAGES

- Due to the narrow emission spectrum LEDs can only polymerize materials with an absorption maximum between 430 and 480 nm (camphorquinone as photoinitiator)
- New technology.
- Slower than PAC
- Batteries must be recharged
- Cost more than halogen lamps

Dissipation of heat produced during LEDs use -

- Critical for the durability of the LED based system
- The heat is dissipated by use of heat sink or cooling fan
- With heat sink; it uses a highly thermally conductive aluminum integrated in the housing

Pulsed output in LED technology –

Periodic level shifting (PLS) or “Micro-pulsing

CURING SYSTEMS

AUTOCURED SYSTEMS

Autocured (ie, chemically activated) systems, usually consisting of two pastes.

Disadvantages:

(1) a long setting time,

(2) voids in the final restorative (voids caused by mixing typically account for 3 to 10% of the volume, inhibiting polymerization and increasing surface roughness), and

(3) a higher probability of longterm discoloration after placement.

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- **ULTRAVIOLET LIGHT-ACTIVATED SYSTEMS**
- The first light-activated systems, introduced in 1970, used UV light.
- **ADVANTAGES**: rapid cure; indefinite working time, because no setting occurs until the light source is applied and less composite waste.
- **DISADVANTAGES**

(1) curing units require a 5-minute warm-up period,

(2) depth of light penetration is 1 to 2 mm

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(3) maintaining the light at 100% efficiency is difficult,

(4) UV radiation can cause corneal burns.

Another difficulty is that the loss of UV efficiency Cannot be determined by looking at the unit.

- Thus, a dentist cannot determine if a composite has adequately cured. EX:Nuva

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VISIBLE LIGHT-ACTIVATED SYSTEMS

Advantages of visible light-activated composites are:

1. materials can be manipulated longer and still have a shorter curing time (20–40 seconds or less vs. minutes for autocured composites),
2. earlier finishing, and
3. better color stability.
4. no lamp warm-up time;
5. less chance of voids and air bubble incorporation;
6. less waste of materials; and use of halogen bulbs, which maintain constant blue light efficiency

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- **DISADVANTAGES:**

(1) possible eye damage (retinal burns with visible light systems),

(2) a maximum depth of light penetration of about 3 mm,

(3) heat generation that could harm the pulp, and

(4) the high purchase and maintenance costs of curing lights.

- In systems using flexible fiber-optic bundles, it is difficult to maintain the efficiency of the light cord, which can result in a less effective depth of cure.
- The mechanism of visible light-curing uses a diketone, most commonly, camphoroquinone. When this photoinitiator absorbs blue light, the molecule forms a free radical and starts the polymerization process.

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CURING TECHNIQUES

- Two categories of technique are commonly used in curing polymers:

1.continuous and

2.discontinuous.

- The continuous cure refers to a lightcure sequence in which the light is on continuously
- There are four types of continuous curing:
  1. uniform continuous cure,
  2. step cure,
  3. ramp cure, and
  4. high-energy pulse.
- Continuous curing is conducted with halogen, arc, and laser lamps.

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UNIFORM CONTINUOUS CURE

- In the uniform continuous cure technique, a light of constant intensity is applied to a composite for a specific period of time.
- This is the most familiar method of curing currently used.

STEP CURE

- In the step cure technique, the composite is first cured at low energy, then stepped up to high energy, each for a set duration.
- The purpose is to reduce polymerization stress by inducing the composite to flow in the gel state during the first application

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- In addition, this technique results in an uneven cure, since the top layer is more saturated with light and thus more highly cured.
- Step curing is possible only with halogen lamps; arc lamps and lasers cannot be used because they work by applying large amounts of energy over short periods of time.

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RAMP CURE

- In the ramp cure, light is initially applied at low intensity and gradually increased over time to high intensity.
- This allows the composite to cure slowly, thereby reducing initial stress, because the composite can flow during polymerization
- It is possible to ramp cure manually by holding a conventional curing lamp at a distance from a tooth and slowly bringing it closer to increase intensity

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HIGH-ENERGY PULSE CURE: High-energy pulse cure technique uses a brief (10 second) pulse of extremely high energy (1000–2800 mW per cm2), which is three to six times the normal power density.

There are 3 areas of potential concern:

(1) the rapid application of energy might result in a weaker resin restoration owing to the formation of shorter polymers;

(2) it is possible that rapid applications of energy could reduce diametral tensile strength; and

(3) there may be a threshold level at which a resin has good properties, and thus, higher energies would result in more brittle resins

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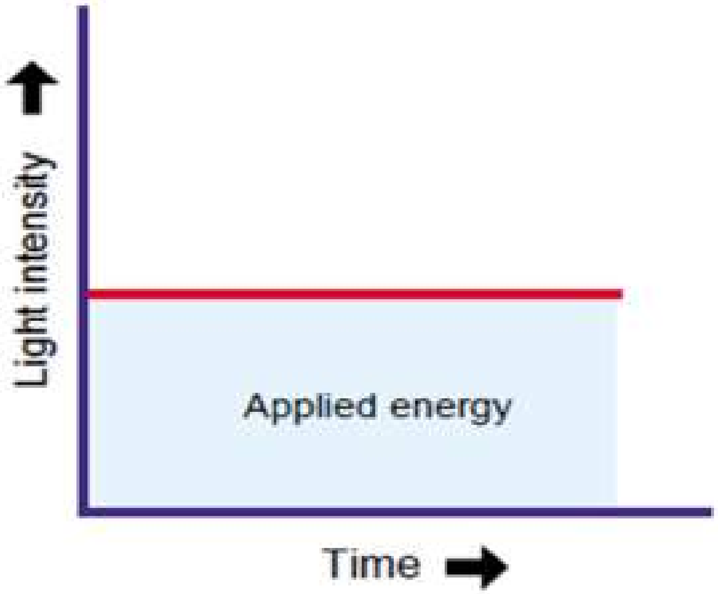
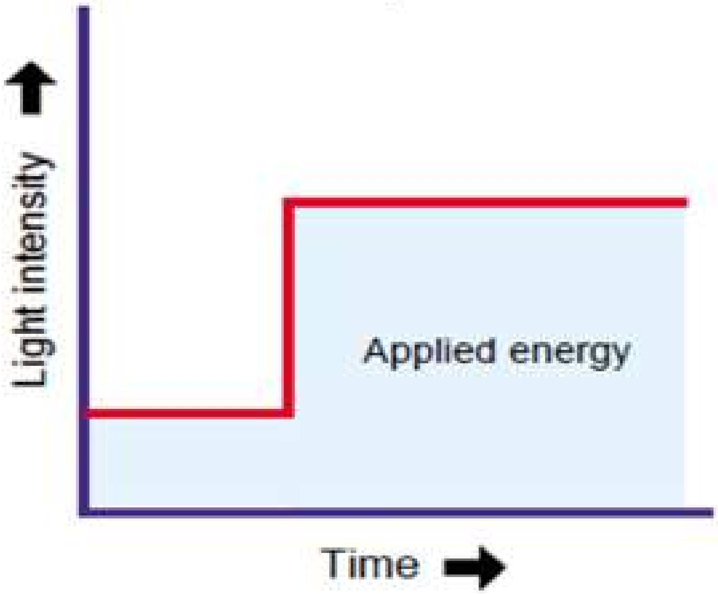
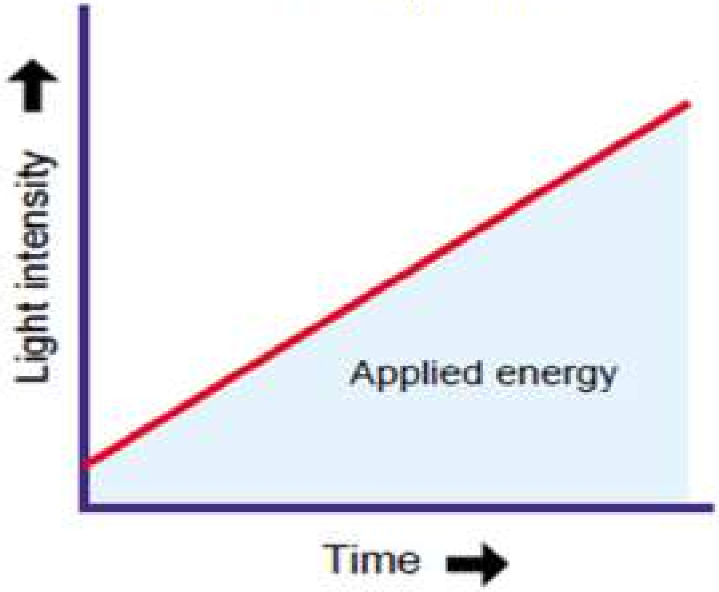


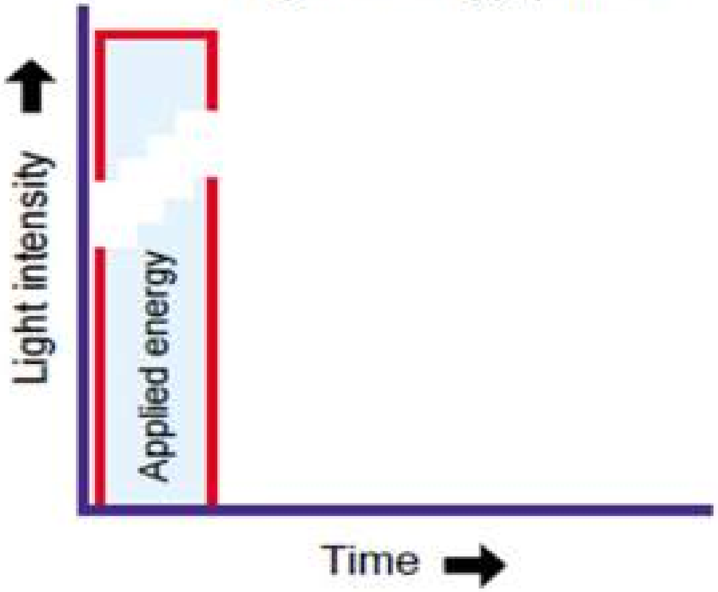
Uniform continuous cure



Step cure



Ramp cure



High-energy pulse

DISCONTINOUS CURING:

- The discontinuous cure is also called soft cure, which commonly uses a pulse delay.
- In the discontinuous or soft-cure technique, a lowintensity or soft light is used to initiate a slow polymerization that allows a composite resin to flow from the free (unbound) restoration surface toward the (bound) tooth structure.
- To complete the polymerization process, the intensity of the next curing cycle is greatly increased, to produce the needed energy for optimal polymerization.

PULSE-DELAY CURE

- In pulse-delay curing, a single pulse of light is applied to a restoration, followed by a pause and then by a second pulse cure of greater intensity and longer duration.
- It is best thought of as an interrupted step increase
- The lower-intensity light slows the rate of polymerization, which allows shrinkage to occur until the material becomes rigid, and is purported to result in fewer problems at the margins .

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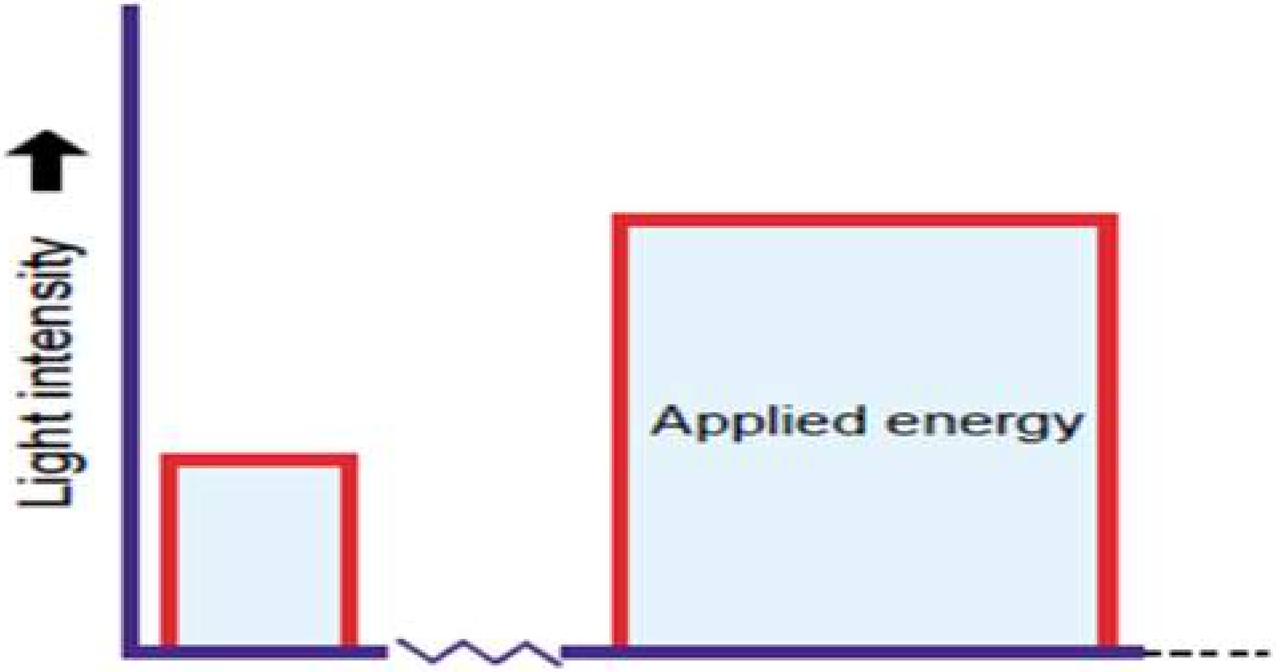
- The second, more intense pulse brings the composite to the final state of polymerization.
- Pulse curing is usually done with halogen lamps



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FACTORS THAT AFFECT LIGHTCURING OF COMPOSITE

- Some of the most important factors to consider in using and maintaining a light-curing system are

1.time,

2.intensity,

- temperature,
- light distance,
- resin thickness,
- air inhibition,
- tooth structure,
- Composite shade,
- filler type,
- accelerator quantity, heat,

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- **EXPOSURE**
- Light-cured composites polymerize both during and after visible light-activation.
- These two curing reactions are known as the “light” and “dark” reactions.
- The dark reaction, also called post-irradiation polymerization, begins immediately after the curing light goes off and continues for up to 24 hours, even in total darkness, but most of it occurs within 10 to 15 minutes post cure
- Regardless of how a composite is cured, the dark reaction takes time and greatly contributes to the overall strength of the material.

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- Generally, waiting 10 to 15 minutes after curing before finishing a composite improves the hardness by 20 to 30%
- A waiting period prior to finishing can improve wear properties significantly, because the finishing process damages the margins of a restoration.
- Damage to the margins is greatest when a composite is finished before it is fully polymerized.
- A good way to minimize finishing damage is to reetch and reseal the margins with a glaze after finishing.

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- **INTENSITY**
- The curing intensity of a 468 ± 20 nm blue light has been about 400 mW/cm2 for many years.
- This is the output of most curing units and is referred
- to as the "power density."
- Problems occur when the minimum intensity is not achieved. There are four common causes of decreased intensity:
- (1) as the bulbs in curing lamps age, the intensity of blue light can decrease,
- (2) voltage drops can affect blue light production,
- (3) sterilization of curing tips can reduce light transmission, and (4) filters to increase blue light transmission can degrade

- Curing units should be checked every month with a radiometer to ensure production of adequate blue light intensity.
- When the intensity is low, replacing the bulb, filter, or curing tip usually returns the intensity to acceptable levels.
- Many curing lamps have radiometers built in. Newer curing units with a higher power density (600 to 1200 mW/cm2) maintain acceptable output levels for a longer time

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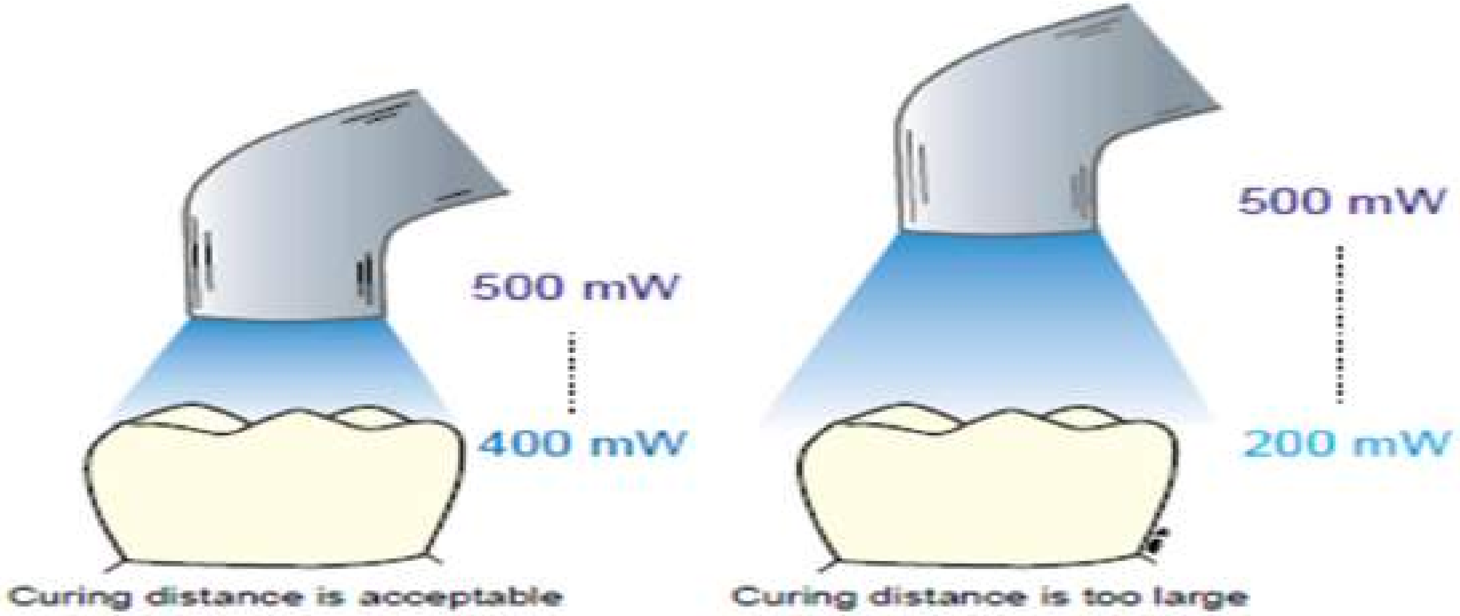

Figure 6–15. In deep restorations and those with poor access, the distance between the light guide and the composite can increase, which generally reduces the power density at the surface by over 70%.

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- **TEMPERATURE**
- Light-cured composites cure less effectively if they are cold during application (eg, just taken out of the refrigerator).
- Composites at room temperature cure more completely and rapidly.
- Composites should be held at room temperature at least 1 hour prior to use

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DISTANCE AND ANGLE BETWEEN LIGHT AND RESIN

- The ideal distance of the light source from the composite is 1 mm, with the light source positioned 90 degrees from the composite surface.
- Light intensity drops off rapidly as the distance from the light rod to the composite increases .
- To compensate for the loss of intensity, cure for longer periods of time the layers of composite that are at a greater distance from the light rod.
- Further polymerization can be achieved by curing from the proximal surfaces after finishing.

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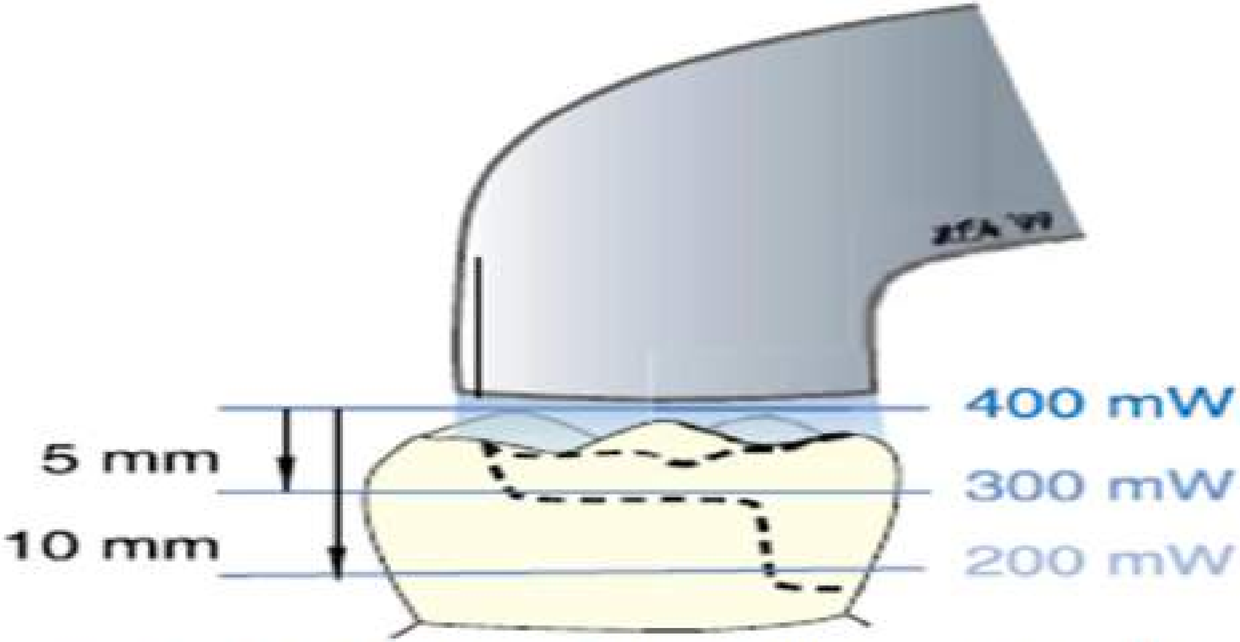

Curing power density at different depths

Figure 6–16. Schematic representation of a 50% reduction in light intensity in deeper areas of a preparation.

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ANGLE AND PATH OF THE LIGHT

- As the angle diverges from 90 degrees to the composite surface, the light energy is reflected away and penetration is greatly reduced.

- In molar preparations, the marginal ridge of the adjacent tooth blocks light when placed at an angle

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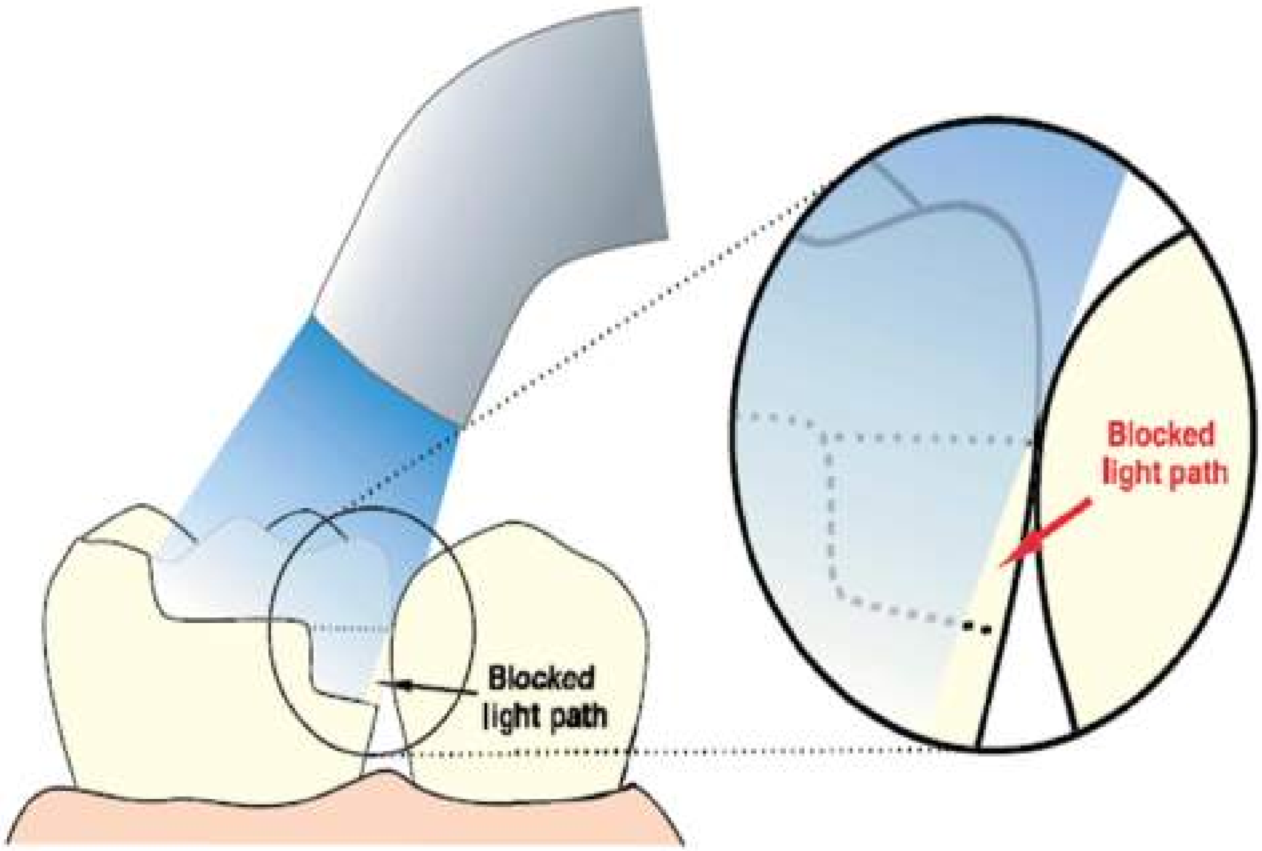

Figure 6–17. In deep restorations, particularly in posterior sites, a direct path of light to the entire restoration can be blocked. The critical area of the gingival margin is most commonly affected. Some light guides are not curved enough to allow a 90-degree angle of exposure on a molar tooth.

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THICKNESS OF RESIN

- Resin thickness greatly affects resin curing
- Optimum polymerization occurs at depths of just 0.5 to 1.0 mm, owing to the inhibition of air at the surface and the difficulty with which light penetrates a resin.
- One classic study showed that 7 days after a 40- second curing cycle, a 1-mm deep composite (of light shade) is cured to 68 to 84% of optimum hardness, as measured by surface hardness.19
- At 2 mm, this same composite has only 40 to 60% of the desired hardness.

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- At 3 mm, it has only 34% of the hardness. Thus, composites should be cured in increments of not more than 1 to 2 mm.
- This assumes an optimum light source and a composite that is light in shade
- In some studies, increasing the curing time to 2 minutes increased the depth of cure; however, additional curing time has limited effects on depth of cure

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- **AIR INHIBITION**
- Oxygen in the air competes with polymerization and inhibits setting of the resin.
- The extent of surface inhibition is inversely related to filler loading.
- The undercured layer can vary from 50 to 500 µm (or more), depending on the reactivity of the photointiators used.
- Unfilled resins should be cured, then covered with an air-inhibiting gel, such as a thin layer of petroleum jelly, glycerin and then re-cured.
- Some glazes have photoinitiators that are sufficiently reactive to make this unnecessary.
- In addition, curing through a matrix increases surface polymerization because the matrix reduces air inhibition.

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CURING THROUGH TOOTH STRUCTURE

- It is possible to light-cure resin through enamel, but this technique is just one- to two-thirds as effective as direct curing and is appropriate only when there is no alternative.
- Such curing is possible through up to 3 mm of enamel or 0.5 mm of dentin,
- But the clinician should double or triple exposure times.
- When light-curing through tooth structure, porcelain veneers, and other barriers, it is advisable to use a high-intensity light.

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- **SHADE OF RESIN**
- Darker composite shades cure more slowly and less deeply than lighter shades.
- At a depth of 1 mm, a dark composite shade achieves just twothirds of optimum depth of cure achieved in translucent shades).
- A brighter light reduces the amount of time it takes to cure darker shades.
- Hence, when esthetics is not critical, the lightest shade should be used.

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- **TYPE OF FILLER**
- Microfilled composites are more difficult to cure than macrofilled composites, which have larger
- quartz and glass fillers.
- Generally, the more heavily loaded a composite is with larger inorganic fillers, the more easily the resin cures

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- **AMOUNT OF PHOTOINITIATOR**
- Composites differ in the amount of photoinitiator they contain.
- All photoinitiators deteriorate over time.
- However, light-cured composites are more stable than chemically cured composites..
- The maximum usable life span of a lightcured composite is generally 3 to 4 years or more from the date of manufacture, if stored at room temperature.
- The major cause of decreased shelf life for light-cured composite is evaporation of critical monomers from unidose containers

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- **HEAT GENERATED BY LIGHT-CURING UNITS**
- The heat given off by a curing light increases the rate of photochemical initiation and polymerization reaction and increases the amount of resin cured.
- Excessive curing heat is thought to cause no photochemical damage to either the tooth or the composite.
- However, the heat generated in the tooth during light-curing results in higher intrapulpal temperatures, which could be harmful.
- Deep layers of resin should be cured thoroughly; cooling with a dry air syringe may be helpful.

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- **ROOM-LIGHT POLYMERIZATION**
- The working time of light-cured composites depends on the operatory light and the ambient room light to which the composites are exposed.
- Differences in these light sources can dramatically affect working time.
- Newer, faster-setting composites are even more sensitive.

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SELECTION OF CURING LIGHTS

- There is no one best visible light-curing unit, since different units work better for specific applications.
- The diameter of cure, for example, is not critical in the placing of only Class III, Class V, and Class IV restorations;
- whereas, a unit with a larger diameter of cure saves chair time by curing larger portions of composites and veneers during each curing cycle.

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- Dentists placing indirect veneers should have both a wide curing tip and a highintensity light (as measured by a radiometer).
- The minimum intensity for light-cured cementing of l indirect veneers is usually 400 mW/cm2 over the entire diameter of the curing tip

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MAINTENANCE OF CURING LIGHTS

- Curing tip
- Fiber-optic cords
- Light guides
- Filters
- Fans

These have to be checked periodically

TOOTH-COLORED RESTORATIVES PRINCIPLES AND TECHNIQUES-9TH EDITION -HARRY F. ALBERS,

PROPERTIES OF COMPOSITES

- Of all the tooth colored materials composite resins possess the highest tensile and compressive strengths.
- The modulus of elasticity is high.
- The modulus of resilience is very low which may explain some of the crazing, cracking and wear failures of composite resins.
- The co-efficient of thermal expansion of composite resin is close to that for amalgam (25-35 PPM/1^0C).

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- Composite resins show less resistance to abrasion. The abrading forces dislodge the particles.
- The interfacial failure is precipitated first by exposure of resin matrix and further by deterioration of coupling agents by environmental factors
- Solubility of resins is influenced by the residual monomer and discontinuity or weakness in the bond between the dispersed and dispersion phase in composite and filled resin.

CRAIGS RESTORATIVE DENTAL MATERIALS -14TH EDITION

PROPERTIES

- PHYSICAL
- MECHANICAL
- CLINICAL

- Working, setting time
- Polymerization shrinkage
- Thermal properties
- Water sorption
- Solubility
- Colour stability

- Flexural strength
- Compressive strength
- Knoop hardness
- Bond strength
- Rigidity
- Fracture toughness
- creep

- Wear
- Depth of cure
- Radiopacity
- Biocompatibility
- Staining
- Secondary caries
- Marginal integrity
- Post-op sensitivity

WORKING & SETTING TIME

- Light cure: surface hardens in 60-90 sec
- Chemical cure: 3-5 min

THERMAL PROPERTIES –

- The thermal conductivity of composites with fine particles (25 to 30×10^{-4} cal/sec/cm^{2}[^{0}C/cm]) is greater than that of composites with microfine particles (12 to 15×10^{-4} cal/sec/cm^{2}[^{0}C/cm]).

CRAIGS RESTORATIVE DENTAL MATERIALS -14TH EDITION

PROPERTIES	
HARDNESS	Of all the tooth coloured restorative materials, composite resins show greater Knoop Hardness Number (KHN) of 30-100 as compared to 300 of enamel.
SURFACE ROUGHNESS	Of all tooth coloured restorative materials composite resins in general have the highest and deepest scratches after all finishing and polishing procedures.
DISINTEGRATION	Composite resins undergo disintegration due to failure at interphase between dispersed and dispersion phases
PLASTICITY	Composite resins & unfilled resins are viscoelastic in nature and show limited degree of plasticity that may lead to a change in shape under loading

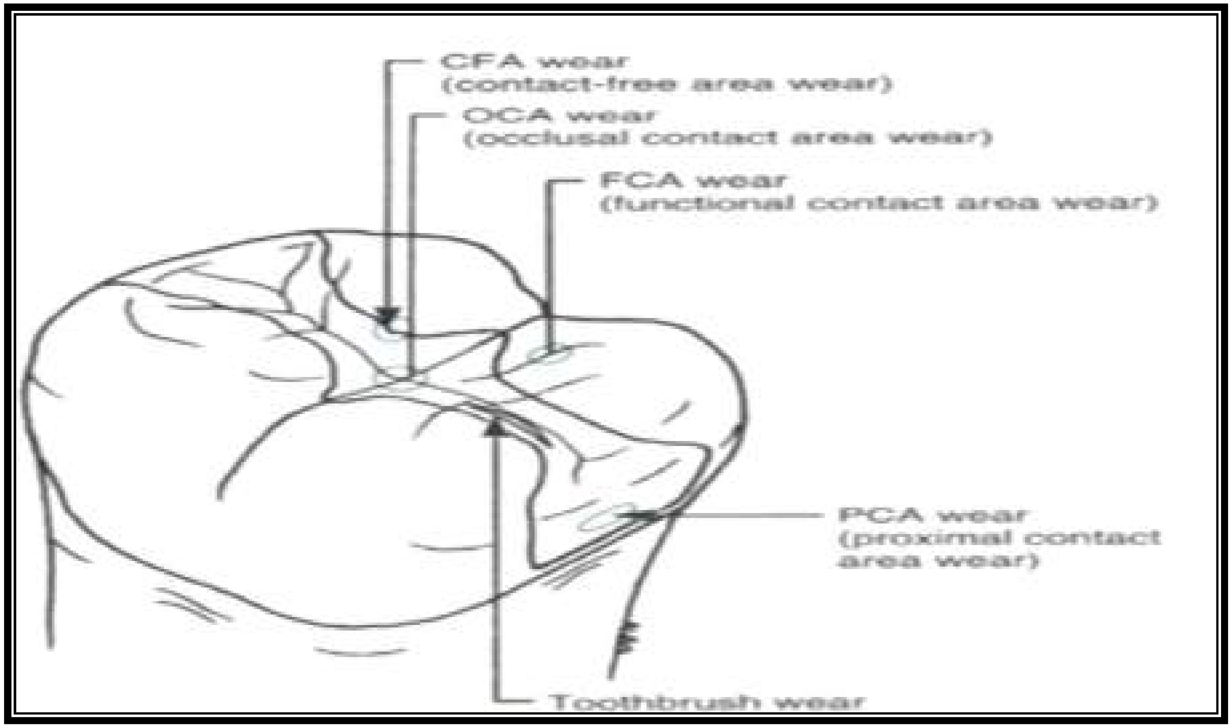
WATER SORPTION	Water sorption swells the polymer portions of the dental composite and promotes diffusion and desorption of any unbound monomer. degrade the matrix disruption of adhesive bonds, , susceptibility to discoloration
MICROLEKAGE	The unfilled resins and II generation composites show greatest micro leakage, especially when inserted with a bulk-pack technique. The use of acid – etched technique reduced the micro leakage

OPTICAL PROPERTES	Translucency to that of tooth enamel. Translucency depends mainly on the type and nature of unreacted particles of fillers.
COLOUR STABILITY	Composite resins may undergo discoloration may be intrinsic or extrinsic .
BIOCOMPATABILTY OF COMPOSITES	Relates to Two aspects. a) Inherent chemical toxicity of the material and b) Marginal leakage
RATE OF HARDENING	Composite resins gain most of their mechanical properties within 15 minutes; and can usually be finished and polished after 5-8 minutes**.**

WEAR:

The second most frequent clinical problem apart form polymerization shrinkage of composite is Occlusal wear.

The wear rate of posterior composite is 0.1 to 0.2 mm/year more than that of enamel.



THE PRINCIPAL MECHANISMS OF COMPOSITE WEAR ARE:

a) TWO BODY WEAR:

- **This is due to direct contact of restoration with an opposing cusp / adjacent proximal surfaces that result in high stresses in the contact area.**
- **Two body wear causes significant wear of composite rather than three body wear.**

b) THREE BODY WEAR:

- **Three body wear explains loss of composite material in non-contacting areas.**
- **This is due to the contact with food bolus as it is forced across occlusal surface.**

DEGREE OF CONVERSION:

- It is the percentage of Carbon – Carbon double bonds that have been converted to single bonds to form a polymeric resin. A 65% conversion is considered to be good.
- The higher is the degree of conversion, better will be the strength and wear resistance.
- Conversion of the monomer to polymer depends on resin composition, transmission of light through the material, concentration of sensitiser, initiator & inhibitor.
- Due to faster polymerization of Visible Light Cure resins there are chances of building up of residual stresses.

DEPTH OF CURE

- It is determined by the boundary between somewhat cured and uncured material.
- Most light curing requires minimum of 20 seconds under optimal conditions of access.
- The problems of light penetration can be slightly overcome by increasing curing times.
- Curing again after completion of recommended procedure (Post – curing) for 20 – 60 seconds may slightly improve the surface layer.

CRAIGS RESTORATIVE DENTAL MATERIALS -14TH EDITION

POLYMERIZATION SHRINKAGE

- All composites shrink while hardening in order of 2-3 % volume. This is referred to as Polymerization shrinkage .
- It usually does not cause significant problems with restorations cured in preparations having all- enamel margins.
- However when a tooth preparation extends on to the root surface polymerization shrinkage can cause gap formations at the junction of composite and root surface, as the force of polymerization of composites is greater than the initial bond strength of composites to tooth structure.

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1. C-factor
2. Monomer formulations
3. Elastic modulus
4. Filler content
5. Self curing or light-curing composite
6. Degree of conversion
7. Water sorption

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This problem though cannot be eliminated, can be minimized.

This polymerization contraction depends on two factors:

- The quality of bond
- The shape of the cavity preparation - C –Factor configuration.
    - Multipurpose composite – 0.7 to 1.4%
    - Microfill composite – 2 to 3%
    - Packable composite – 0.6 to 0.9%
    - Macrofilled composite – 1.2 to 1.3%
    - Small particle filled composite – 2 to 3%
    - Nanocomposite and other types – yet to be determined

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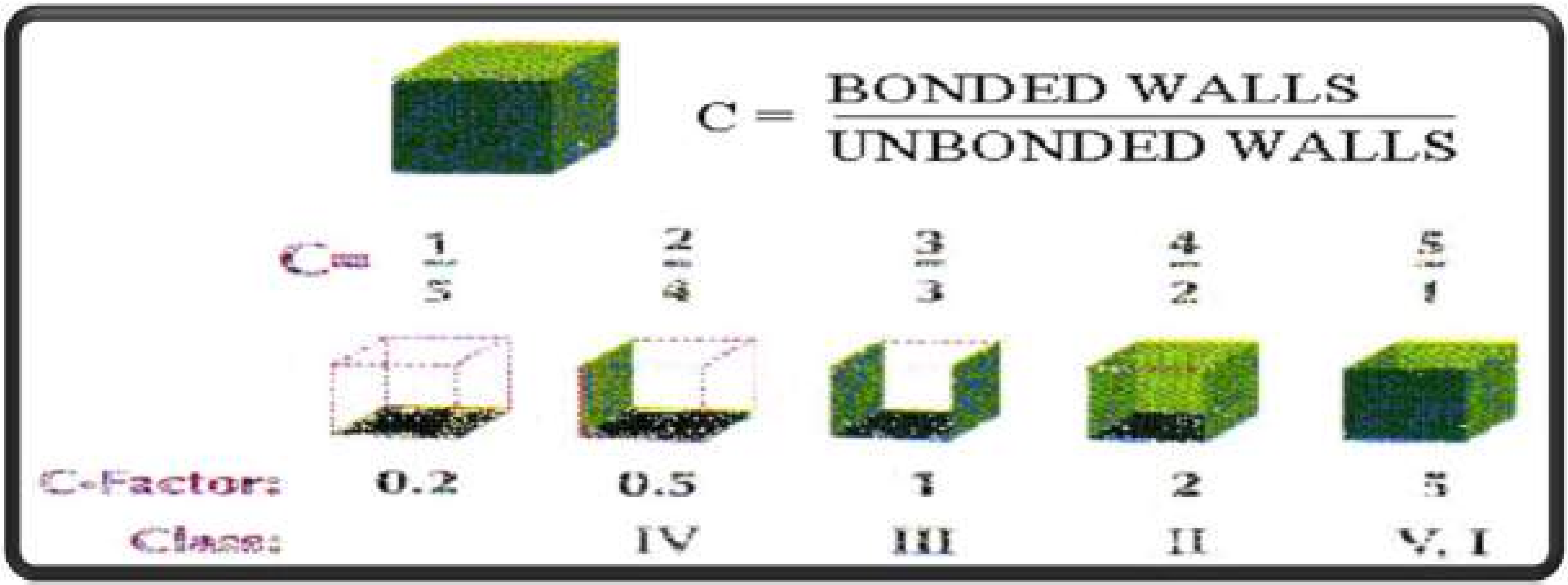
- It was first analyzed by Feilzer in 1987 and is described in terms of the **ratio of surface area of bonded surfaces to the surface area of unbonded surfaces**.
- The higher is the C –factor the greater is the potential for bond disruptions from polymerization effects.



- Most technique sensitive preparations to restore successfully are class V, and I both of which have five bounded and one free surface, thus resulting in the maximum stresses.
- A veneer on the other hand has five free and only one bounded surface.
- The magnitude of development of stresses is influenced by the rate at which the composite is cured .
- Light cured materials demonstrated twice the magnitude of stress compared to self-cured materials.
- Also heavily filled composites exhibited higher stress. Maximum stresses developed are at internal line angles and stress on lateral walls increases with depth of the cavity.

CLINICAL TECHNIQUES TO REDUCE C-FACTOR:

1.LAYERING TECHNIQUE:

- The restoration is built up in increments, curing one layer at a time. This reduces ‘C’ factor by reducing the surface area of bonded surfaces and increasing the non bonded surface areas.
- This is done in increments whereby problems of depth of cure and residual stress concentration are both eliminated

2. SECTIONING

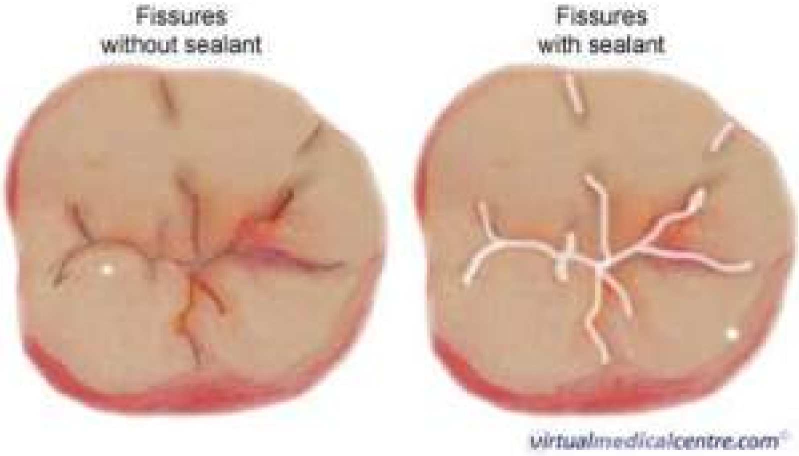
The composite is sectioned horizontally and vertically to reduce the stresses.

STRESS ABSORBING LAYERS WITH LOW ELASTIC MODULUS LINERS

- According to the “elastic cavity wall concept” the shrinkage stress generated by a subsequent layer of higher modulus resin composite can be absorbed by an elastic intermediary layer, thereby reducing the stress at the tooth-restoration interface.
- Flowable resin composites have shown shrinkage stress comparable to conventional resin composites, supporting the hypothesis that the use of flowable materials does not lead to marked stress reduction and the risk of debonding at the adhesive interface as a result of polymerization contraction is similar for both type of materials .

INDICATIONS

- Restoration of class I, II, III, IV, V, VI cavities.
- Foundations or core build-ups.
- Pit & fissure sealants.
- Conservative composite restorations or preventive resin restorations .



AESTHETIC ENHANCEMENTS SUCH AS:

- Full veneers
- Partial veneers
- Tooth colour modifications.
- Closure of Diastema

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- As luting cements

  Eg: Resin cements for indirect restoration

- Temporary restorations
- Periodontal splinting.

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CONTRAINDICATIONS

- The operating site cannot be properly isolated.
- When the occlusal contacts are in such a way that they are on the composite material.
- Heavy occlusal stresses such as bruxism
- Deep sub gingival areas that are difficult to prepare.
- Extension onto root surfaces may exhibit marginal gap formation.

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MERITS

- Aesthetics
- Conservation of tooth structure.
- Improved resistance to micro leakage
- Strengthening of remaining tooth structure
- Low thermal conductivity
- Completion of restoration in one appointment
- Economic – Less expensive compared to gold or porcelain restorations
- No corrosion

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DEMERITS

- Very technique sensitive
- High coefficient of thermal expansion than tooth structure
- Low modulus of elasticity
- Biocompatibility of Bis GMA and TEGDMA resins is not known
- Limited wear resistance in high stress areas
- Finishing procedures are prolonged and tedious
- Post operative sensitivity

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Thank

YOU