Light -activation sources:

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1. Ultraviolet light source:

The introduction of photopolymerization to dentistry began in the late 1960s. Initially, ultraviolet cured pit and fissure sealant were put into clinical practice, UV radiation cause possible eye problems that might develop in office personnel and the possibility of selectively altering the oral flora of the patient's mouth through exposure to ionizing radiation.

2. Visible light sources:

A- Quartz-Tungsten-halogen (QTH) light source:

A modified light source delivery was introduced in the form of the handheld dental curing light.

Visible radiation passed through the infrared filter, is then further filtered by a band pass filter, providing energy restricted to a narrow visible light region where the absorbance of the photoinitiator is maximum, so that, only blue light is emitted. However, only the wavelengths around 470 nm are strongly absorbed by the Composite.

B- Argon laser lights

When laser technology provided sources that emitted high-intensity light within the energy band required by the photoinitiator in light-activated dental materials, the dental industry developed this type of curing source for the practitioner. The argon-ion laser provides high output energy at 488 nm for rapid polymerization of commercially available dental restorative

C. Short-Arc Xenon Sources (Plasma-Arc Curing lights (PAC)):

In the mid 1990s, Xenon arc light units were introduced in restorative dentistry as alternative for rapid light curing. Manufacturers claimed that these sources can effectively reduce clinical exposure duration to only 1 to 10-seconds or some manufacturers claimed that composites could be adequately polymerized in less than 1 second.

D. Blue light- emitting diode curing units (LED) s

The blue LED has become available in output wavelengths that fell within the spectral absorbance of a common dental photoinitiator (CQ). The intensity of these devices has increased at a rapid rate, and now commercial devices are available for the photopolymerization of dental composites. Instead of the hot filaments used in halogen bulbs, LED, use junction of doped semiconductors for generation light.

Polymerization:

Resin composite restoratives solidify by means of the chemical process termed polymerization. The polymerization of the resin matrix produces a gelation in which the restorative material is transformed from a viscous-plastic into a rigid-elastic phase. During the early stages of polymerization, monomers are mainly converted into polymeric chains.

After a certain degree of conversion has been attained, the predominant reaction is the cross-linking of the polymeric chains, resulting in a strong polymeric network.

Factors affecting polymerization shrinkage stress:

1-Factors related to the cavity design:

Stress developed during curing can be minimized by consideration of the ratio between the bonded and unbonded surface area (c- factor). When this ratio increases, as in Class I and Class V situations, increase the shrinkage stress loading on the tooth- resin interface leading to de bonding.

2-Factors related to the placement technique:

The second factor that might reduce polymerization shrinkage is to insert resin composites in increments to reduce the volume of the resin that is shrinking during polymerization.

3-Factors related to the composite formulation:

Nonbonded microfiller particles have been found to produce significant decreases in polymerization stress by acting as stress-relieving sites within the composite.

Acid Etching:

- A physical process that creates a microscopically rough enamel surface (enamel tags)
- first successful technique developed to bond dental materials to tooth structure
- acid used is 37% ortho-phosphoric acid
- sometimes referred to as conditioner

Smear Layer: When a rotary or handheld instrument is used on dentin it creates a special surface texture called a smear or smear layer that closes off the dentinal tubules. This layer is lightly adhered to the dentin surface and contains tooth cuttings, saliva, bacteria, and other surface debris

Enamel Etching

Enamel consists of organic and inorganic components. Application of 37% phosphoric acid removes about 10 microns of enamel to expose prisms of enamel rods and create the classic honeycomb effect. Acid also increases surface energy for better wetting of the enamel. Resins flow into micromechanical retentive areas. Resin tags fill microscopic holes to provide retention. Retention is about 30 MPa.

Acid etching is done for a minimum of 15 to 30 seconds. Thorough rinsing for 10 seconds removes acid and dissolved calcium phosphates.

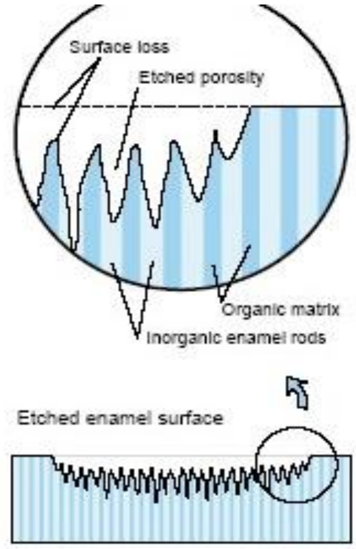


Figure 8–3. Schematic diagram depicting how acid etching produces microporosities in enamel.

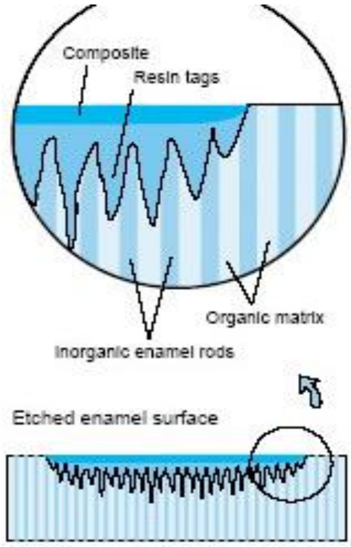


Figure 8–4. Schematic diagram depicting how resin tags penetrate the microporosities produced by acid etching of enamel.

- Over-etching results to formation of crystals (precipitates) that inhibits bonding
- Built-in quality control check – if properly etched it appears frosty or chalky white.

Dentin Etching

- 37% ortho-phosphoric acid
- removes the smear layer from the surface of the of the dentin as well as the plugs of material forces into dentinal tubules during cavity preparation.
- decalcifies a layer of dentin several microns thick.Time:10-15 seconds

If the etched tooth surfaces are contaminated with saliva or blood, they need to be reetched. Such a reetching procedure requires only 5 seconds.

Adhesion to Dentin

Conditioning or Etchant (E):-dentin etching time 15 sec only

-Removes the smear layer.

- Exposes the intertubuler and peritubular collagen.

- Opens the tubules.

-Decreases the surface free energy.

Primer (P):-

- Includes bifunctional molecules hydrophilic and hydrophobic).

- Envelops the external surface of collagen fibrils.

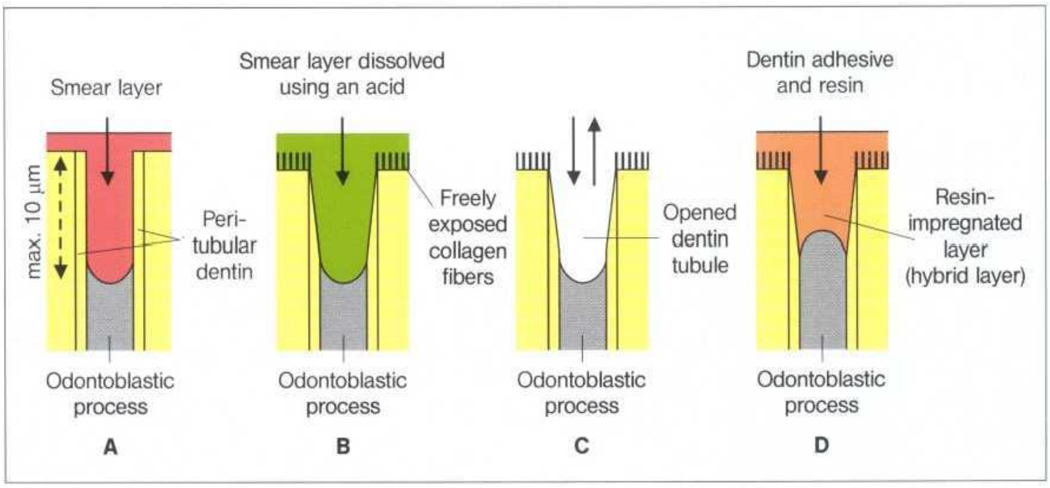
- Re-establishes surface free energy to levels compatible with more hydrophobic restorative materials

Bonding Agent (B): (Adhesive resin)

- Includes monomers that are mostly hydrophobic such as Bis-GMA

- Copolymerize with the primer molecules penetrates and polymerizes into interfibriller spaces to serve as a structural backbone to hybrid layer.

Adhesion to Dentin protects the pulp, because after removal of the smear layer with a mild acid (conditioner) the opened dentin wound was sealed with a hydrophilic resin, for example, HEMA (primer) and a bonding agent (adhesive). During this treatment a dentin surface impregnated with resin (hybrid layer) is formed that guarantees an optimal dentin wound closure which is acid resistant and prevents bacteria penetrating.



Effect of the total etch technique on the opening of the dentin canals

A- Prepared cavity
B -The smear layer is dissolved through treatment with phosphoric acid
C- The acid and the dissolved smear layer are washed away using a water-air spray
D- Forming the hybrid layer with a dentin adhesive

Current strategies for Adhesion of Resin to Dentin:

I-Total etch adhesive

A- Three step total etch adhesive:

Etchant (E) + Primer (P) + Bonding Agent (B)

B- One-bottle total –etch (two step total-etch adhesive):

Etchant (E) +Primer and Bonding agent (PB)

II-Self-etch adhesive:

A- Two –bottle self-etch:

Etchant and Primer (EP) + Bonding (B)

***B- All-in-one self-etch (EPB) we call it single application*:**

-it demineralises and penetrates dentin simultaneously leaving a precipitate on the hybrid layer.

- Forms a thin layer of adhesive.
- a multi-coat approach is recommended.

Adhesive strategies – principles:

1- Acid etch will remove smear layer with collagen fibers upright, tubules open, primer and adhesive penetrate.
2- Leave smear intact, tubules plugged, partially demineralize smear layer with self- etching primer and replaced with resin filler in to tubuler dentin.

Since their introduction in 1955, dental bonding agents have evolved from no-etch to total-etch (fourth- and fifth-generation) to the more recent, self-etch systems (sixth- and seventh-generation). The newest adhesive system, seventh-generation, combines the acid, primer, and bond in one bottle, which requires a single step with no mixing or etching.

Thirty-six primary anterior teeth were randomly divided into 3 groups of 5th generation (Single Bond 2), 6th generation (Clearfil SE) and 7th generation (Single Bond Universal) bonding agents.

Seventh-generation bonding agents have water as a solvent

Seventh-generation bonding agents offer good bond strengths to tooth structure and less technique sensitivity than etch-and-rinse (total-etch) and sixth-generation bonding agents. They may be excellent choices for bonding direct and indirect resin and all-ceramic posterior restorations.

6th-**generation bonding agents** are self-etching, which means that they do not need phosphoric acid to demineralize tooth structure. They contain a self-etching primer that demineralizes and primes the tooth structure simultaneously. They also utilize a hydophobic adhesive that bonds more readily to composites.

fifth generation bonding agents primer and adhesives are in same bottle.

4th generation 3-step system

5th generation 2-step system

Third generation attempted to deal with smear layer and dentinal fluid

The **third generation** bonding systems introduced a very important change: the acid etching of the dentin in an effort to modify or partially remove the smear layer