
Trust in God!

Bonding to Enamel and Dentin Bonding to Enamel and Dentin

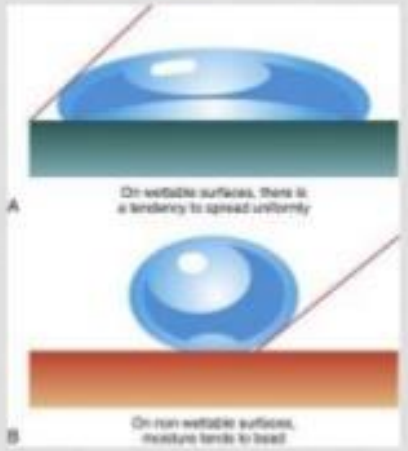
DEFINITION

- **Adhesion** is derived from Latin meaning "a state in which two surfaces are held together by interfacial forces like valence forces or interlocking forces or both".

(The American Society for Testing and Materials)

REQUIREMENTS FOR GOOD ADHESION

- The surface of the substrate should be clean
- The adhesive should wet the substrate well, have a low contact angle, and spread onto the surface.
- There should be intimate adaptation between the adhesive and the adherent.
- The bond strength between the adhesive and the adherent should be strong enough to resist debonding.
- The adhesive should be well cured.



ENAMEL BONDING

Development of phosphoric acid gels

- Gels provide the clinician a greater control and precision in the placement of etching agents (Fig. 16.9
- Earlier most gel etchants used to contain silica as a thickening agent
- recently available gels employ polymeric thickening agents which have better wetting abilities and rinse off more easily than silica containing gels

Percentage of etchants used:

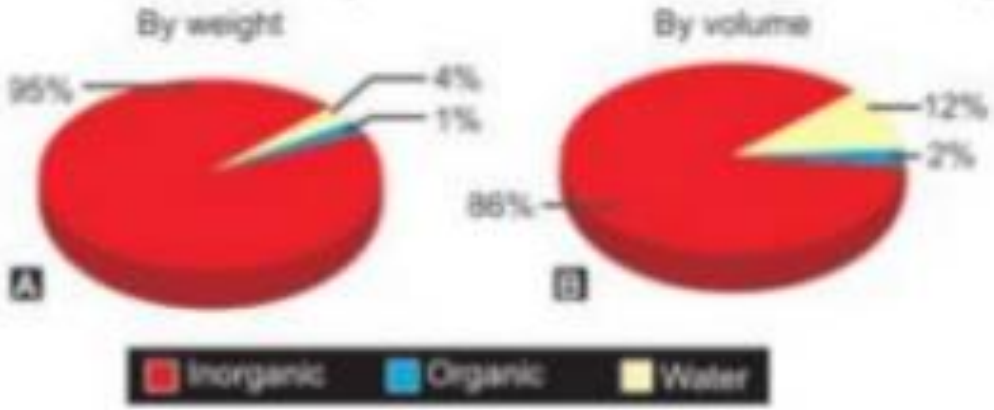
- Currently used etchants employ the concentrations of phosphoric acid that ranges from 10 to 50%.
- Use of lower concentrations of phosphoric acid and reduced etching time has shown to give an adequate etch of the enamel while avoiding excessive demineralization of the dentin

Decrease in the acid application time

- The standard treatment protocol for the etching of enamel has been application of 37% phosphoric acid for 60 seconds
- studies show that enamel should not be etched for more than 15-20 seconds
- This may result in secondary caries or discoloration of the margins

Fig. 16.9: Etching gel provides greater control and precision in the etchant placement

Fig. 16.8: Etchant



Figs 16.7A and B: Composition of enamel (A) By weight (B) By volume

Steps for Enamel Bonding

- Perform oral prophylaxis procedure using nonfluoridated and oil less prophylaxis pastes.
- Clean and wash the teeth with water. Isolate to prevent any contamination from saliva or gingival crevicular fluid
- Apply acid etchant in the form of liquid or gel for 10 to 15 seconds
- Wash the etchant continuously for 10 to 15 seconds.
- Note the appearance of a properly etched surface. It should give a frosty white appearance on drying.
- If any sort of contamination occurs, repeat the procedure
- Now apply bonding agent and low viscosity monomers over the etched enamel surface
  - Generally, enamel bonding agents contain BISGMA or UDMA with TEGDMA which is added to lower the viscosity of the bonding agent. The bonding agents due to their low viscosity, rapidly wet and penetrate the clean, dried, conditioned enamel into the microspaces forming resin tags. The resin tags which form between enamel prisms are known as Macrotags (Fig. 16.10)
- The finer network of numerous small tags are formed across the end of each rod where individual hydroxyapatite crystals were dissolved and are known as microtags


DENTIN BONDING
AGENTS


CONCEPT OF A DENTIN BONDING AGENT:
DENTIN
Dentin Bonding Agent
COMPOSITE
HYDROPHILIC
HYDROPHOBIC

EVOLUTION OF DENTIN BONDING AGENTS:

- First Generation.
- Second Generation.
- Third Generation.
- Fourth Generation.
- Fifth Generation.
- Sixth Generation.
- Seventh Generation.

FIRST GENERATION DBA

- Ignored the smear layer.
- Achieved deeper penetration in D' tubules
- These bonded to the enamel and dentin by chelation with calcium on the tooth surface.
- They included **NPG-GMA** (N- Phenylglycine Glycidyl methacrylate), the polyurethanes and the cyanoacrylates.
- NPG-GMA is a bifunctional molecule or coupling agent.
- This means that one end of this molecule bonds to dentin while the other bonds (polymerizes) to composite resin.

- An example of an NPG-GMA bonding agent was S.S.White's Cervident which became available in 1965.
- Bond strengths of first generation DBA'S was 2-3 MPa.

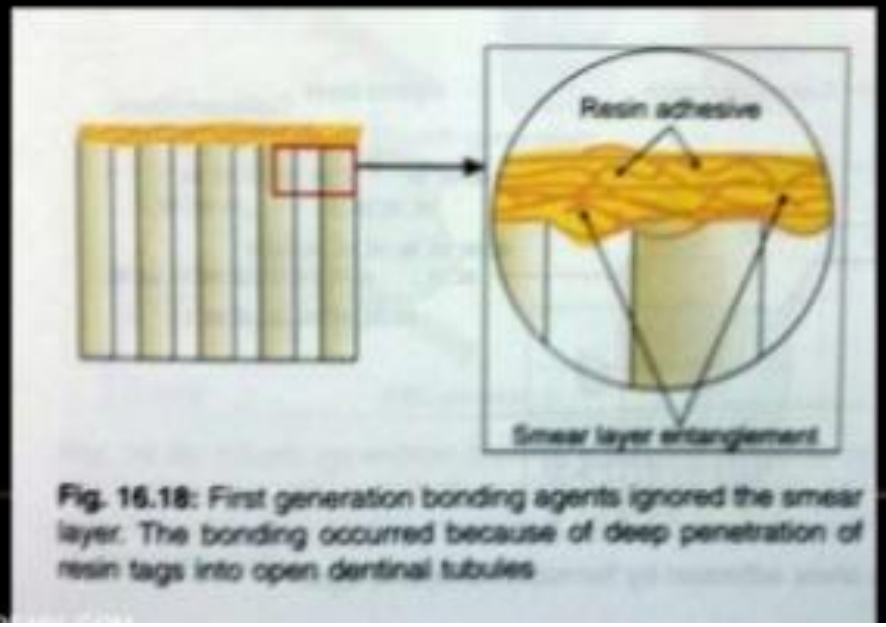


Fig. 16.18: First generation bonding agents ignored the smear layer. The bonding occurred because of deep penetration of resin tags into open dentinal tubules

Limitations:-

- Low bond strength of 2-3 MPa
- Loss in bond strength over time
- Lack of stability of individual components during storage
- Based on carbon-13 NMR analysis – No ionic bonding develops between NPG-GMA and hydroxyapatite

SECOND GENERATION DBA

- These products depended upon **smear layer** for bonding.
- The majority of these incorporated halophosphorous esters of unfilled resins such as bisphenol- A glycidyl methacrylate, or bis-GMA, or hydroxyethyl methacrylate, or HEMA.
- The mechanism by which these bonded to dentin were postulated to be through an ionic bond to calcium by chlorophosphate groups.
- Clearfil Bond system F (Kuraray) introduced in 1978, was the first product.
- Bond strength range from 4.5-6 MPa.

- Limitations :-

  - Primary bonding was to the smear layer which prevented intimate resin-dentin contact, which is a pre-requisite for a chemical reaction.

  - Low Bond Strength 4.5 to 6 Mpa Only

THIRD GENERATION DBA

- Three step systems.
  - Dentin etching was introduced by Fusuyama.
  - Followed by a primer application.
  - Application of an unfilled resin.
- These systems alter or **remove the smear layer** prior to bonding.
- Bond strength range between 12-15 MPa.
- Three component system consisting of –
  - Conditioner
  - Primer
  - Adhesive

Conditioner (Cleanser, Etchant)- Is usually

- a weak organic acid (maleic acid),
- a low concentration of a stronger inorganic acid (phosphoric or nitric acid), or
- a chelating agent (EDTA).

- *Actions:*-Heavily alters or removes the smear layer.
  - Demineralizes peritubular and intertubular dentin and thereby exposes collagen fibrils
  - Increases dentin permeability by 4-9 times.

Actions:- Links the hydrophilic dentin to the hydrophobic adhesive resin.

Promotes infiltration of demineralized peritubular and intertubular dentin by its own monomers and those of the adhesive resin.

- Increase wettability of the conditioned dentin .

- *Adhesive (Bonding resin, sealing resin):-* Is an unfilled or partially filled resin, may contain some component of the primer (e.g- HEMA) in an attempt to promote increased bond strength.
- *Actions:-*

  - Combines with the primer monomers to form a resin- reinforced *hybrid layer (resin-dentin interdiffusion zone)* 1-5 microns thick.
  - Forms resin tags to seal the dentin tubules.
  - Provide methacrylate groups to bond with the subsequently placed resin composite.

Representative brands:-

- Scotch bond 2
- Universal bond
- Syntac
- Tenure

FOURTH GENERATION DBA EARLY 990'S

- 3- component system.
- Fusayama and colleagues tried bonding to enamel and dentin by total etching the preparation with 40 percent phosphoric acid.
- The mineralized tissues of the peritubular and intertubular dentin are dissolved by the acidic action; the initial surface penetration exposes the collagen fibers.
- In this area, for a depth of 2 to 4 micrometers, hybridization takes place, and resin tags can seal the tubule orifices firmly.

FOURTH GENERATION DBA'S EARLY 990'S

- Ability to bond as strongly to dentin as to enamel.
- *"Wet bonding"* (Ability to bond strongly to moist dentin and technique insensitivity).
- *"Multi purpose bonding"* (Ability to bond to many different substrates, e.g.- enamel, dentin, porcelain, base and noble metals, amalgam).
- Bond strength ranges between 17-24 MPa.

Etchant → First step

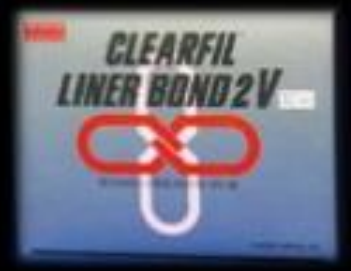
Primer → Second step

Adhesive → Third step

Representative brands:-

All Bond 2

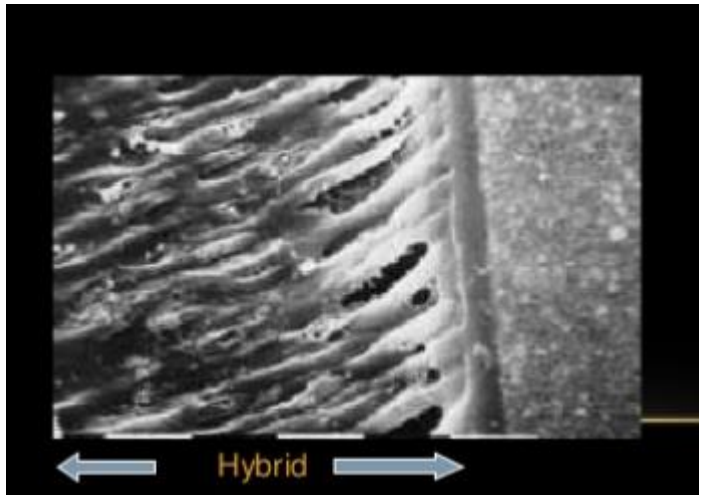
Pro-Bond



Liner Bond 2

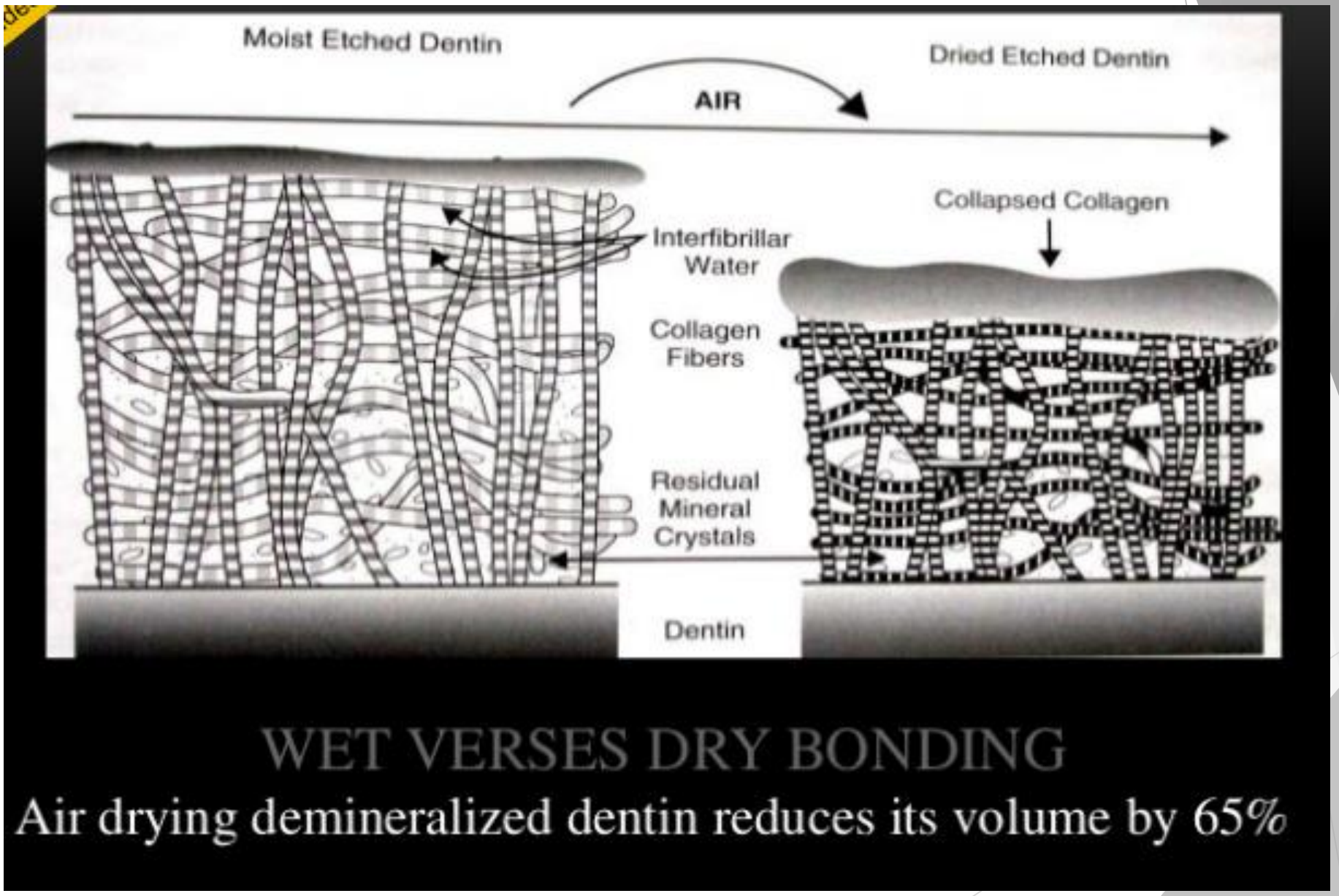
The hybrid layer is defined as "the structure formed in dental hard tissues (enamel, dentin, cementum) by demineralization of the surface and subsurface, followed by infiltration of monomers and subsequent polymerization."

Nakabayashi et al (1982)



Wet bonding

- Introduced by Kanca and Gwinnett in 1992.
- After conditioning, the enamel and dentin surfaces should be properly treated to allow full penetration of adhesive monomers.
- On the enamel surface – A dry condition is preferred.
- On the **Dentin** surface – A certain amount of moisture is needed to avoid collapse of exposed collagen scaffold, which impedes **effective penetration** of adhesive monomers.
- Consequently it is difficult to achieve the optimal environment for both substrates.


Moist Etched Dentin
Dried Etched Dentin
AIR
Collapsed Collagen
Interfibrillar Water
Collagen Fibers
Residual Mineral Crystals
Dentin
WET VERSES DRY BONDING
Air drying demineralized dentin reduces its volume by 65%

Box 9-1 **Clinical application steps, advantages, disadvantages, and common errors for three-step etch-and-rinse adhesives**

Etching

1. Apply 35% to 37% phosphoric acid to enamel for 15 to 30 s and to dentin for 15 s.
2. Rinse the etched surface for 15 s with an air-water spray.
3. Gently air dry to remove excess moisture.
4. Apply 0.2% to 2% aqueous chlorhexidine solution.
5. Remove excess chlorhexidine solution with a moist cotton pellet.

Priming

1. Perform active application of primer for at least 30 s (gently agitated or rubbed onto the dentin surface with a small brush).
2. Apply water-free, acetone-based primers generously in multiple layers.
3. The primed surface should appear glossy after air drying; if it appears chalky, the primer must be reapplied.
4. Primers must be adequately air dried to evaporate all of the solvent; usually 30 to 40 s are needed for proper solvent evaporation.

Bonding

1. Generously apply the adhesive resin with a microbrush.
2. Use a bristle brush to thin and create a homogenous layer.
3. Cure for manufacturer recommended time, which is typically about 10 to 20 s.

Advantages	Disadvantages	Common clinical errors
• Phosphoric acid etch provides the best bond to enamel. • Several research reports support their use on different substrates, including metals and porcelain. • The highest dentin bond strengths among all dentin adhesives. • Generally contain a dual-curing option for indirect restorations and bonded amalgams. • Can be used with chlorhexidine rewetting for bond preservation.	• Multiple bottles make their use more cumbersome. • Possibility of running out of one component before another. • Because primer and adhesive resin are dispensed into separate wells in the same plastic container, their sequential application may be reversed. • Thick adhesives may pool easily around preparation line angles and margins.	• Overetching dentin. • Suboptimal rinsing of the etching gel. • Overwet/overdry dentin surface. • Insufficient primer application/penetration. • Insufficient primer solvent evaporation. • Overthinning bonding component. • Suboptimal polymerization of the bonding component.

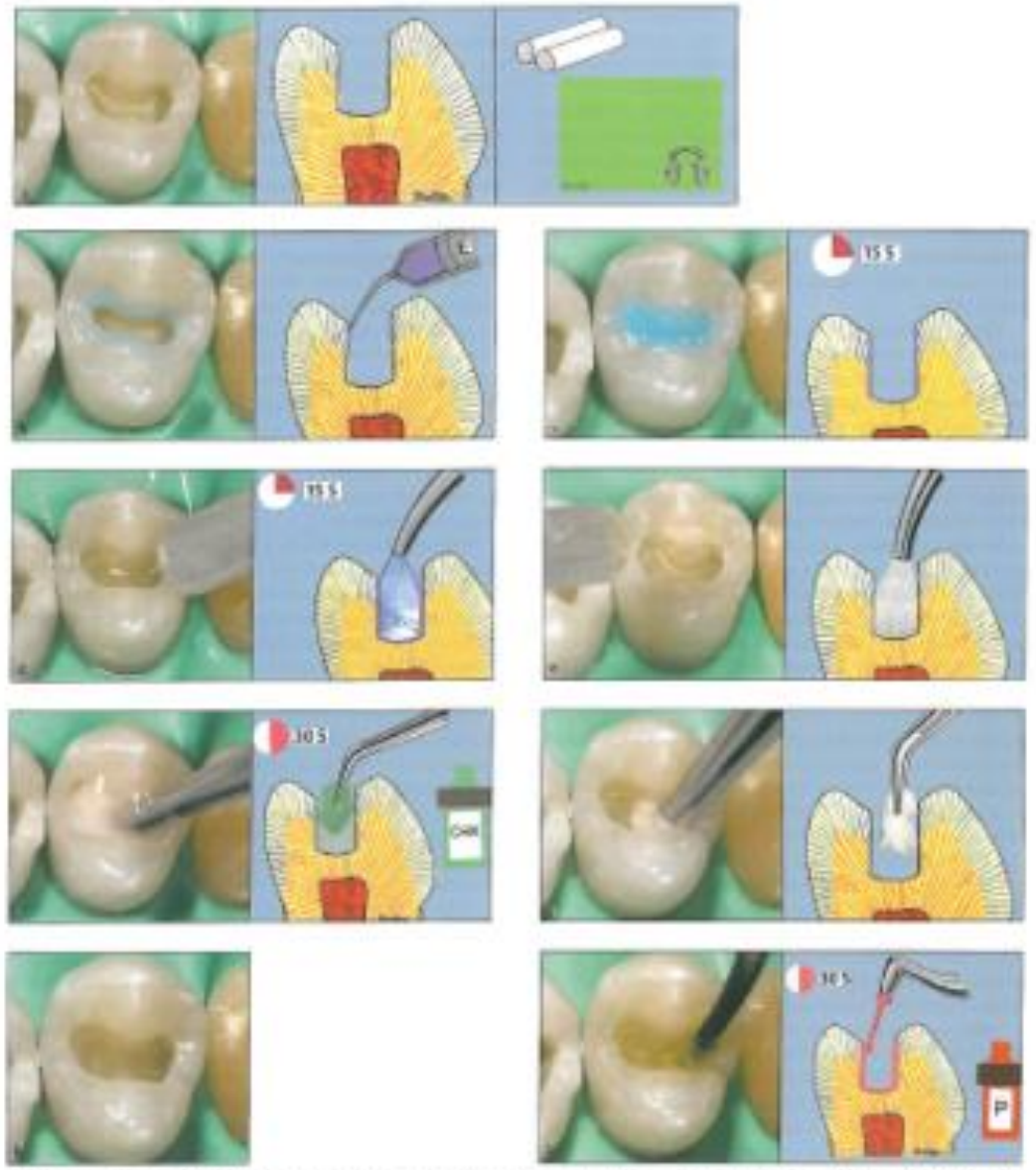


Fig 9-8 (Step-by-step application of the three-step etch-and-rinse adhesive. (a) Preparation complete, ready for adhesive application. Appropriate isolation must be provided. (b) Phosphoric acid etchant gel is initially applied to the enamel margins only. (c) Phosphoric acid etchant gel is applied to the remaining prepared tooth surfaces and allowed to remain for 15 seconds. (d) Etchant gel is thoroughly rinsed with air-water spray for 15 seconds. (e) Preparation is dried. Frosty appearance of enamel confirms adequacy of etch. (f) The preparation is revealed with an aqueous chlorhexidine solution for 30 seconds. (g) A damp cotton pellet is used to absorb excess chlorhexidine solution. (h) The glistening appearance of the dentin indicates the appropriate dentin moistness prior to applying the primer. (i) The primer component is actively applied for at least 30 seconds.

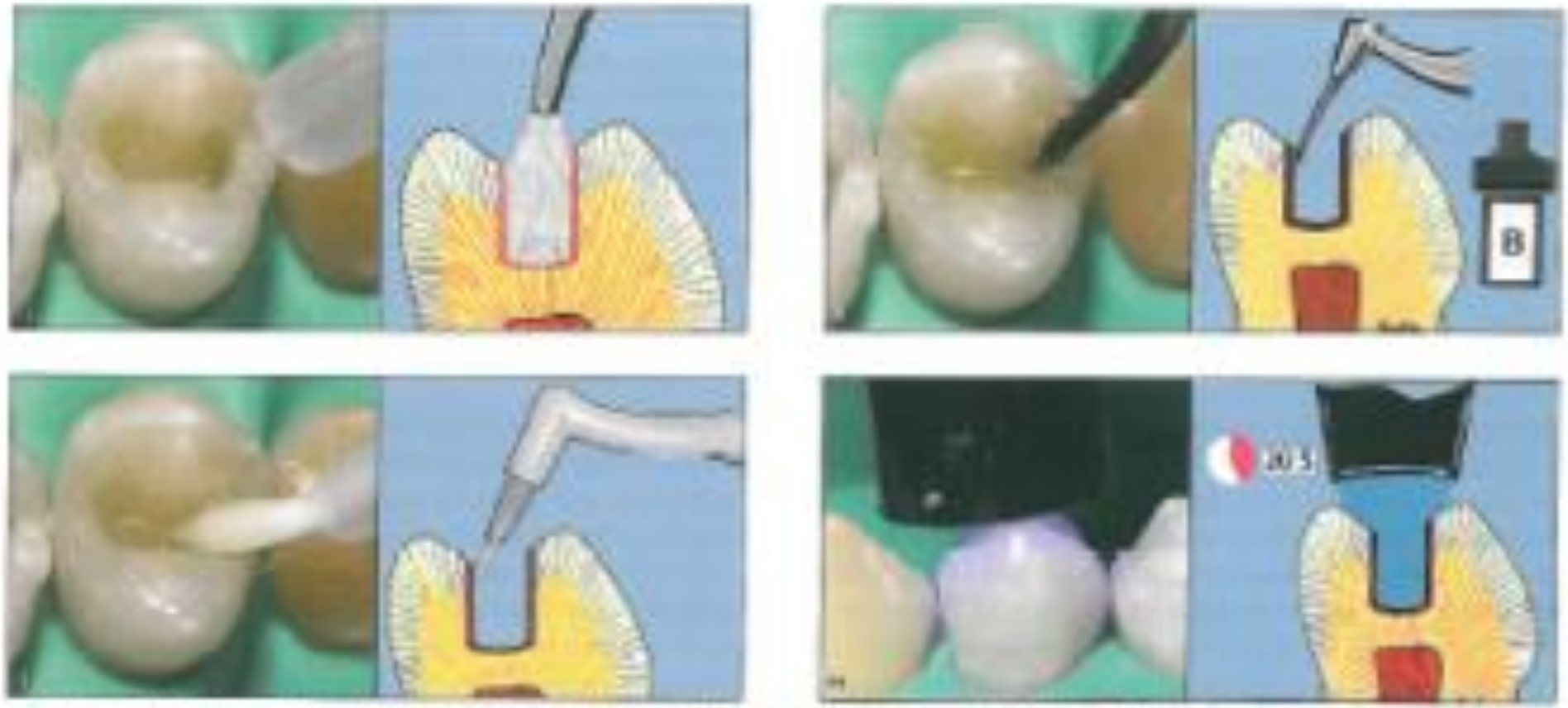


Fig 5-8 (cont'd) (j) The primer component is air dried for 30 to 45 seconds to ensure thorough evaporation of solvents. (k) The adhesive component is actively applied to the entire preparation. (l) A briskly brush is used to **absorb excess adhesive**, avoid pooling, and **distribute** the adhesive evenly on all cavity walls. (m) The adhesive is light cured for 10 to 20 seconds prior to inserting the resin composite.

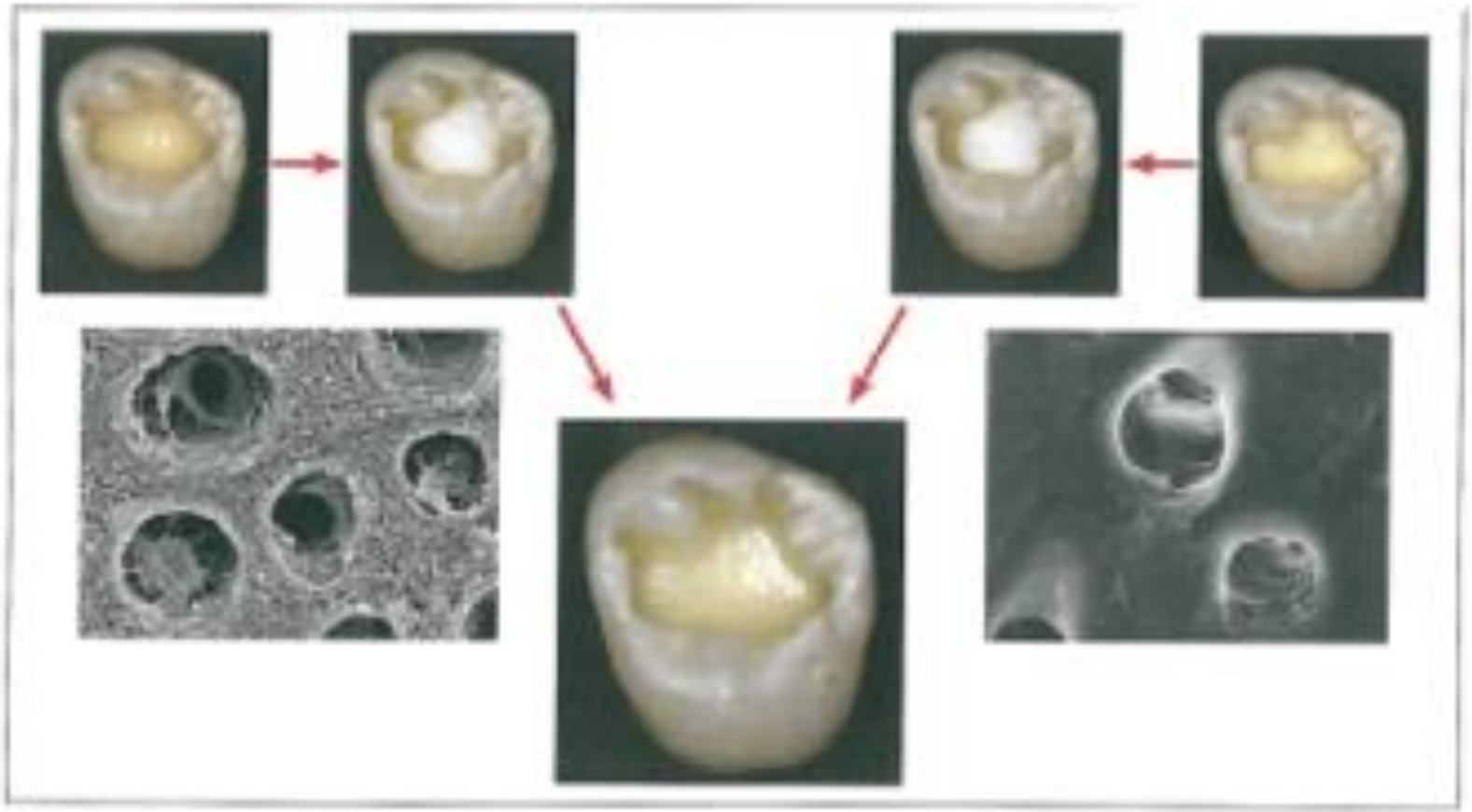


Fig 9-8 Wet bonding for the etch-and-rinse adhesive technique. The ultimate goal is to have a moist, glistening surface, as seen in the center photograph. If, after etching and rinsing, the surface is too wet, a moistened cotton pellet can be used to remove excess moisture (upper left). The SEM image on the left side shows large interfibrillar spaces in the intertubular dentin available for adhesive infiltration if the dentin surface remains moist. (Courtesy of Gilles Duarte, Los Angeles, California.) Conversely, if the dentin is overdried, a moist cotton pellet can be applied to the dried dentin for 30 seconds to rerewet the dentin surface (upper right). The SEM on the right side shows a compact intertubular surface due to collagen collapse. Under this condition, adhesive penetration is difficult to achieve due to the reduced intrinsic porosity of the collapsed collagen layer. (Reprinted from Breschi et al[29] with permission.)

FIFTH GENERATION DBA'S

- Unique feature is the combination of the priming and bond resin application steps, resulting in a one component formula.
- Also rely heavily on wet bonding.
- Most commonly used and probably the most successful system.
- These bonding systems create a mechanical interlocking with etched dentin by means of resin tags, adhesive lateral branches and hybrid layer formation..

- Bond strength - > 20MPa
- ***Representative brands***:-
  - Prime and bond
  - Prime and bond 2.1
  - One step
  - Optibond solo
  - Single bond

Prime & Bond- NT

Adper Single Bond

Gluma Comfort Bond

Optibond Solo

INTER-COMPARISON OF V GENERATION:

Adhesive	Mean Shear Bond Strength (MPa)
Single Bond	30.0±5.5
Opti Bond Solo	23.4±3.4
One-Step	22.5±3.8
Prime & Bond 2.1	21.1±5.0

Box 9-2 Clinical application steps, advantages, disadvantages, and common errors for two-step etch-and-rinse adhesives

Etching

1. Apply 35% to 37% phosphoric acid to enamel for 15 to 30 s and to dentin for 15 s.
2. Rinse the etched surface for 15 s with an air-water spray.
3. Gently air dry to remove excess moisture.
4. Apply 0.2% to 2% aqueous chlorhexidine solution.
5. Remove excess chlorhexidine solution with a moist cotton pellet.

Priming and bonding

1. Apply primer/bonding solution generously, producing a shiny appearance, then vigorously rub at least 30 s.
2. Air dry to evaporate solvent for 30 to 40 s.
3. Actively reapply the primer/bonding solution and air dry.
4. Cure for manufacturer recommended time, which is typically about 10 to 20 s.

Advantages	Disadvantages	Common clinical errors
• Phosphoric acid etch provides the best bond to enamel. • Laboratory research supports their use on enamel and dentin. • High immediate bond strength. • The combined primer/bond bottle concept makes them extremely user friendly. • Can be used with chlorhexidine for bond preservation.	• Most two-step adhesives showed lower bond strengths than their three-step counterparts (produced by the same manufacturer). • Acetone-based adhesives may lose their efficacy with constant utilization due to rapid evaporation of volatile components. • More coats than those recommended by the manufacturer often needed to maximize bond strength. • Thick adhesives may pool easily around preparation line angles and margins. • Some adhesives are not compatible with self-curing or dual-curing composites (core buildup composites and resin luting cements). • Inclusion of hydrophilic components in bonding resin can cause increased hydrolytic degradation.	• Overetching dentin. • Suboptimal rinsing of the etching gel. • Overwet/overdry dentin surface. • Reduced impregnation of the primer adhesive agent. • Inadequate solvent evaporation. • Overthinning adhesive when air drying to remove solvent; failure to use multiple coats. • Suboptimal primer/bonding polymerization.

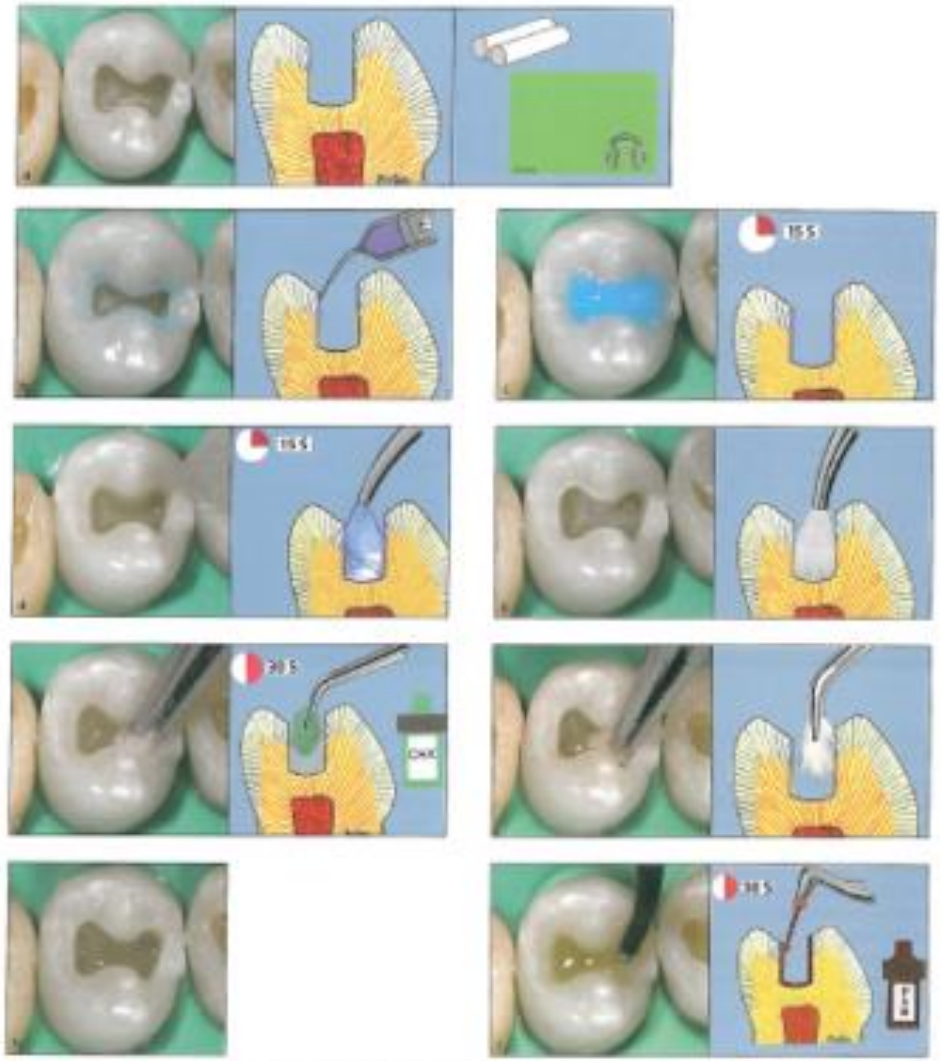


Fig 9-10 Step-by-step application of the two-step etch-and-rinse adhesive. (a) Preparation complete, ready for adhesive application. Appropriate isolation must be provided. (b) Phosphoric etchant gel is initially applied to the enamel margins only. (c) Phosphoric etchant gel is applied to the remaining prepared dentin surfaces and allowed to remain for 15 seconds. (d) Etchant gel is thoroughly rinsed with air-water spray for 15 seconds. (e) Preparation is dried. Frosty appearance of enamel confirms adequacy of etch. (f) The preparation is rewetted with an aqueous chlorhexidine solution for 30 seconds. (g) A damp cotton pellet is used to absorb excess chlorhexidine solution. (h) The glistening appearance of the dentin indicates the appropriate dentin moistness prior to applying the primer. (i) The combined primer-adhesive component is actively applied for 30 seconds.

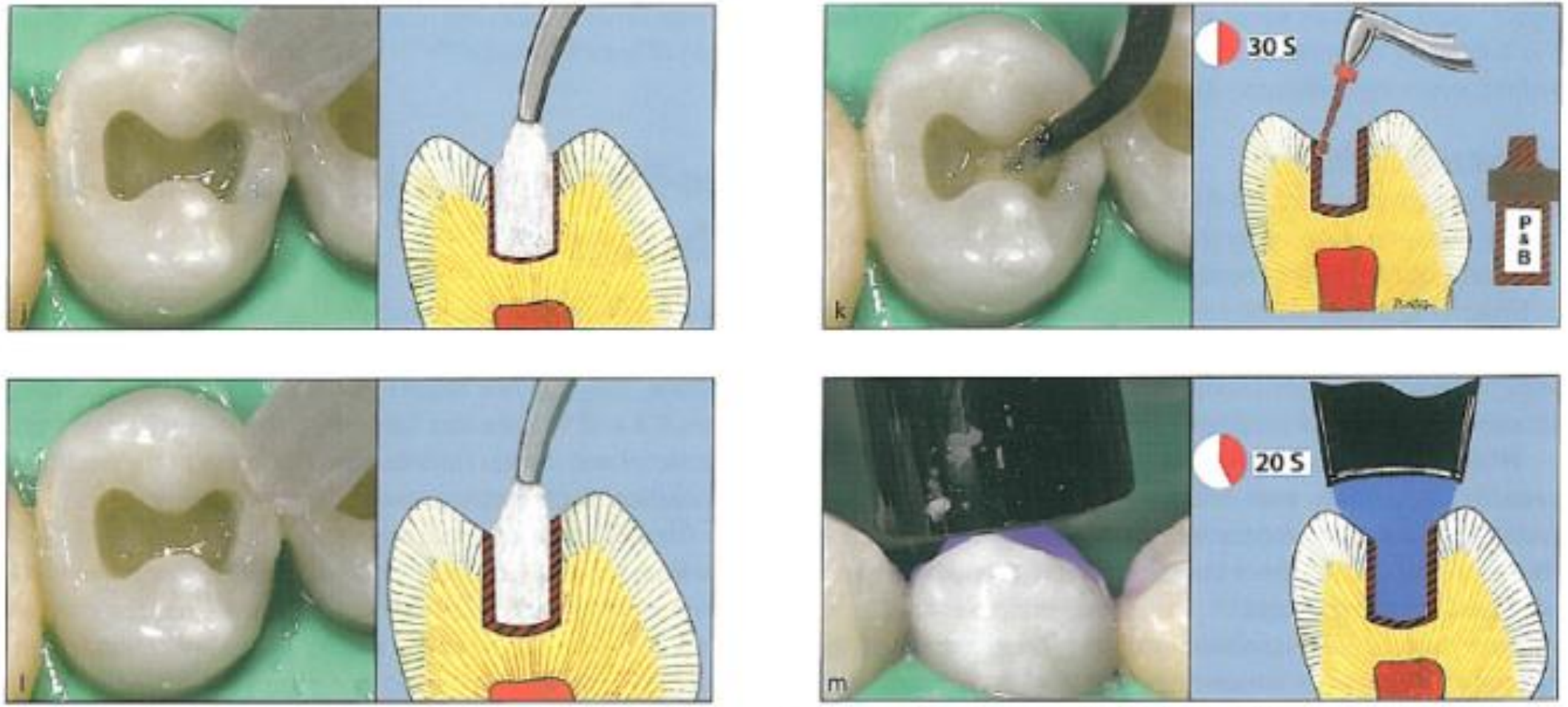


Fig 9-10 *(cont) (j)* The primer-adhesive component is air dried for 30 to 40 seconds to ensure thorough evaporation of solvents. *(k)* The combined primer-adhesive component is actively reapplied for 30 seconds. *(l)* The primer-adhesive component is air dried for 30 to 40 seconds to ensure thorough evaporation of solvents. *(m)* The adhesive is light cured for 10 to 20 seconds prior to inserting the resin composite.

The following are some of the fifth generation systems in the market.

1. Prime and Bond (Dentsply)
2. OptiBond Solo (Kerr)
3. Single Bond (3M) (Fig. 16.23)

Fig. 16.23: Fifth generation bonding agent

SIXTH GENERATION DBA'S

- They are self etching adhesives (Etch & prime simultaneously).
- They involve a somewhat different mechanism in that, as soon as the decalcification process is initiated, the infusion of the evacuated spaces by dentin bonding agent is begun.
- As a result, the potential for residual vacancies amongst the collagenous fibers is dramatically reduced or eliminated altogether.

DISADVANTAGES OF SELF-ETCHING ADHESIVES

Advantages :-

- Simultaneous demineralization and resin infiltration.
- No post conditioning rinsing.
- Not sensitive to diverse dentin-wetness conditions.
- Time saving application procedure.
- Consistent and stable composition.
- Hygienic application (Unidose).
- Effective dentin desensitizer.

- *Disadvantages :-*

  - Insufficient long term clinical research.

  - Adhesion potential to enamel yet to be clinically proven.

Clearfil SE Bond

Prompt L Pop

Xeno III

Box 9-3 Clinical application steps, advantages, disadvantages, and common errors for two-step self-etching or etch-and-dry adhesives

Etching and priming

1. Selectively etch enamel with 35% to 37% phosphoric acid for 15 s.
2. Air-water rinse for 15 s, trying to minimize rinsing over the dentin. Dry gently.
3. Actively apply the self-etching primer agent on etched enamel and unetched smear layer–covered dentin for the time recommended by the manufacturer (typically 20 s).
4. Air dry to remove any excess solution and solvent and terminate the etching reaction.

Bonding

1. Generously apply the adhesive resin with a microbrush.
2. Use a bristle brush to thin and create a homogenous layer.
3. Cure for manufacturer recommended time, which is typically about 10 to 20 s.

Advantages	Disadvantages	Common clinical errors
• No rinsing; quick application. No risk of overwet or overdry dentin. • Results of several studies support their use on dentin. • Additional chemical bonding is claimed to stabilize the hybrid layer for some adhesives. • Bonds well to enamel etched with phosphoric acid.	• If phosphoric acid etch not done first, enamel microleakage may result due to deficient enamel etch. • Prior etching of dentin surface with phosphoric acid may compromise bond to dentin. • Unknown effect of incorporating smear layer into adhesive zone. • Thick adhesives may pool easily around preparation line angles and margins.	• Insufficient etching on the enamel if selective preliminary enamel etch is not performed. • Inadvertent application of separate enamel etching agent to dentin.

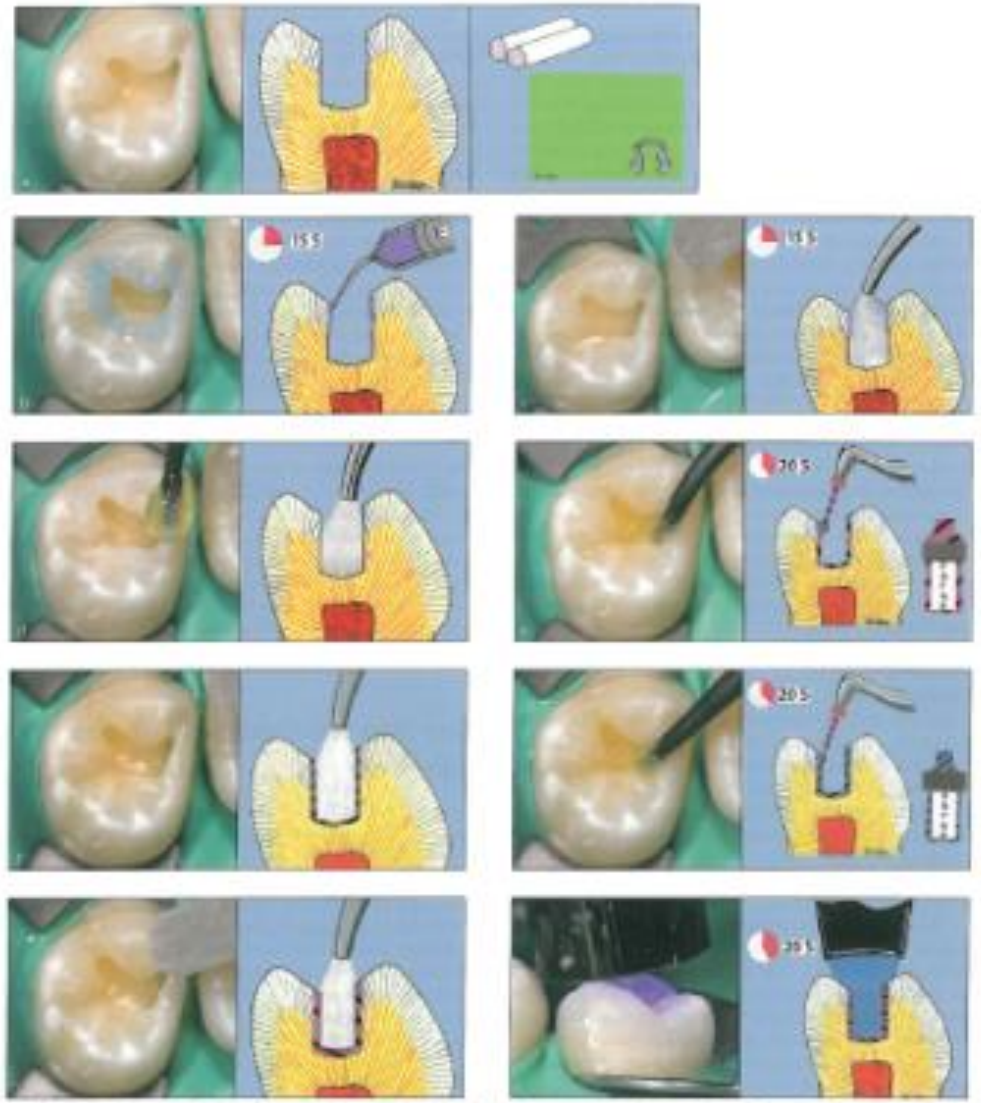


Fig 9-E2 Step-by-step application of the one-step self-etching adhesive. (a) Preparation complete; ready for adhesive application. Appropriate isolation must be provided. (b) Phosphoric etchant gel is used to selectively etch the enamel margins of the preparation. (c) Etchant gel is thoroughly rinsed with air-water spray for 15 seconds and then air dried. (d) Preparation is dried. Frosty appearance of enamel confirms adequacy of etch. Applicator brush with combined etchant-primer-adhesive component is ready for application. (e) The combined etchant-primer-adhesive component is actively applied for the recommended time. (f) The etchant-primer-adhesive component is air dried for 30 to 40 seconds to terminate the etching reaction and ensure thorough evaporation of solvents. (g) The combined etchant-primer-adhesive component is actively reapplied. (h) The etchant-primer-adhesive component is air dried for 30 to 40 seconds to terminate the etching reaction and ensure thorough evaporation of solvents. (i) The adhesive is light cured for 10 to 20 seconds prior to inserting the resin composite.

SEVENTH GENERATION DBA'S

I- Bond

G Bond

GC

Xeno IV

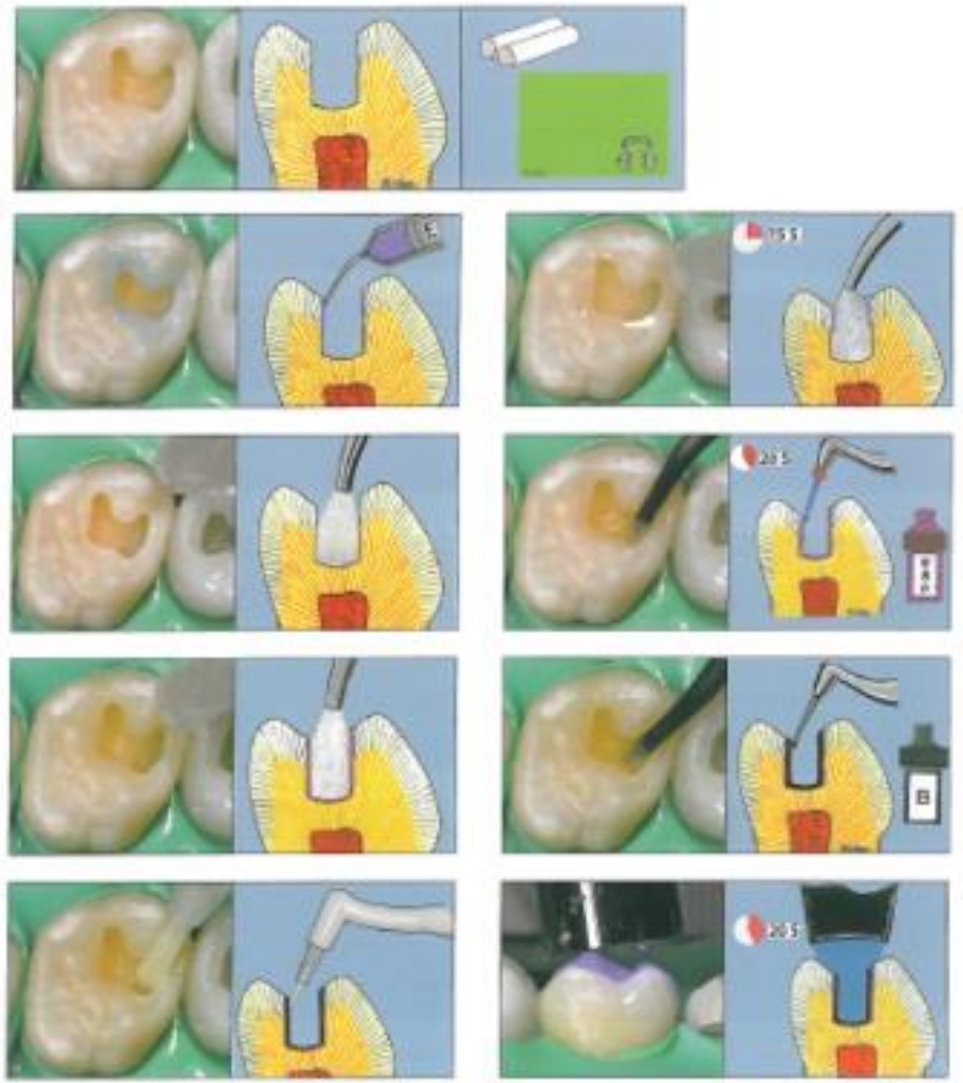
Dentsply

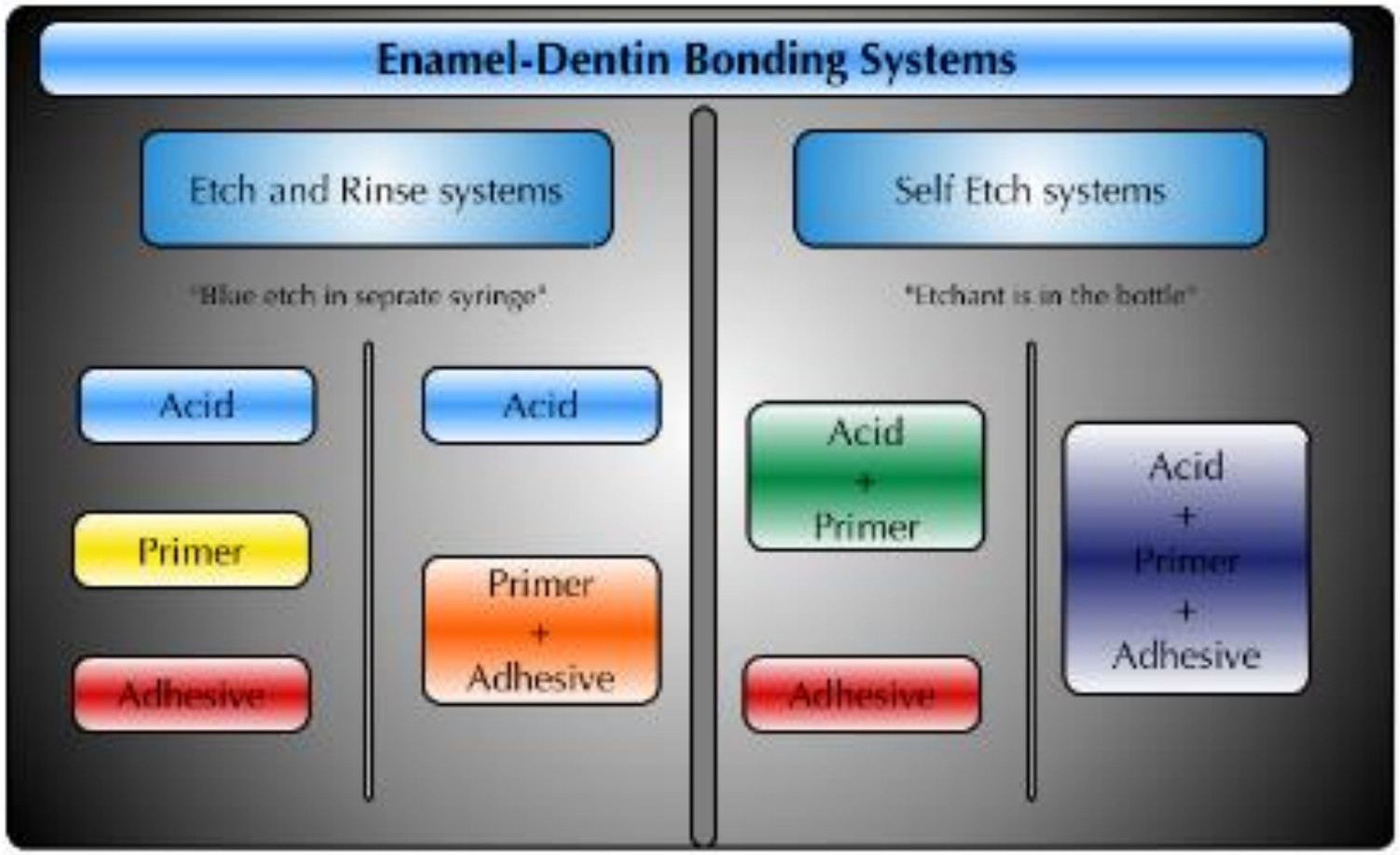
Box 9-4 **Clinical application steps, advantage, disadvantages, and common errors for one-step self-etching or etch-and-dry adhesives**

Etching, priming, and bonding

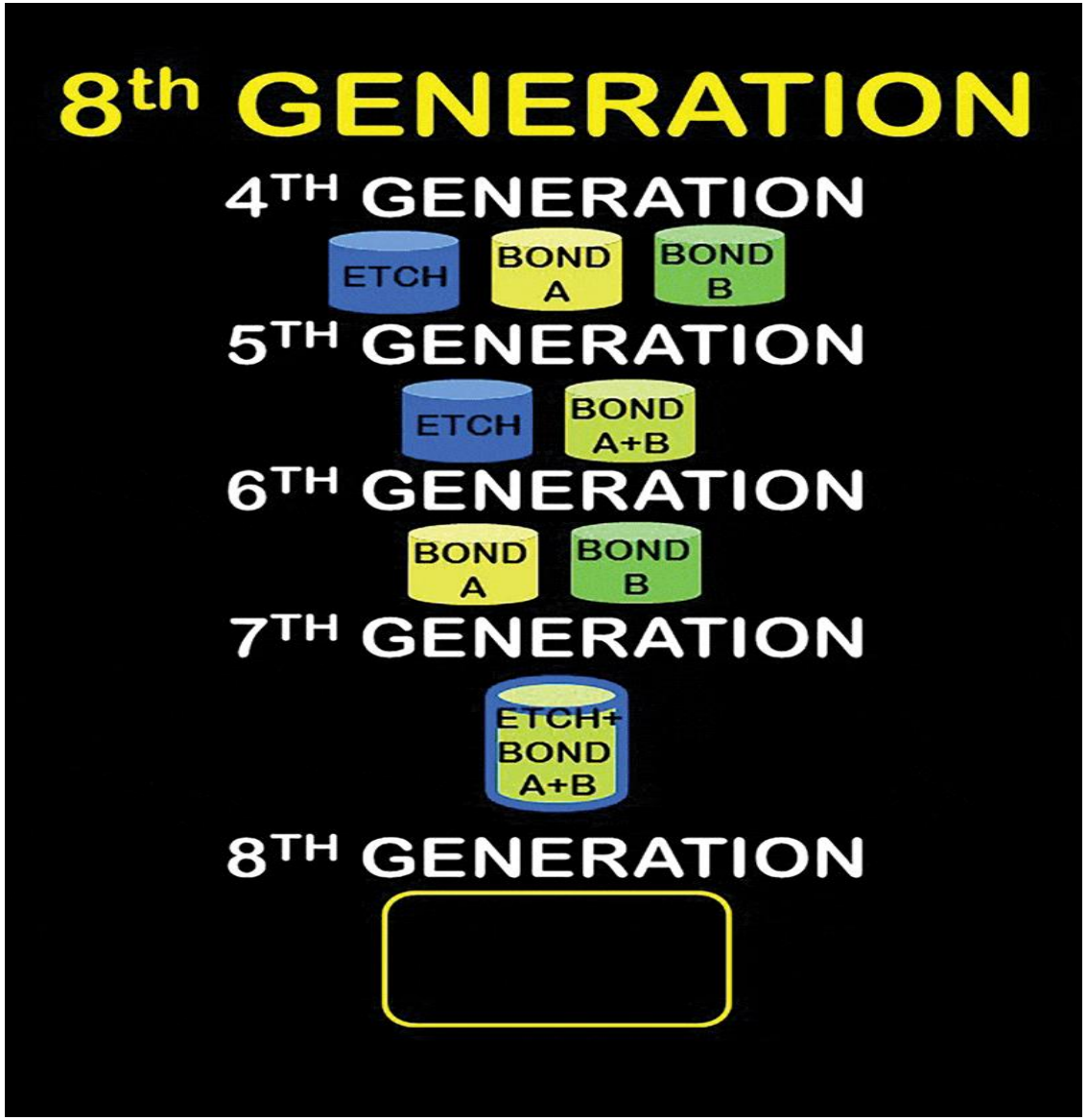
1. Selectively etch enamel with 35% to 37% phosphoric acid for 15 s.
2. Air-water rinse for 15 s, trying to minimize rinsing over the dentin. Dry gently.
3. Actively apply the one-step adhesive on etched enamel and unetched smear layer–covered dentin for the time recommended by the manufacturer.
4. Air dry to remove any excess solution and solvent and terminate the etching reaction.
5. Reapply the adhesive in multiple layers using an active rubbing motion.
6. Air dry to remove any excess solution and solvent and terminate the etching reaction.
7. Cure for manufacturer recommended time, which is typically about 10 to 20 s.

Advantage	Disadvantages	Common clinical errors
• Extremely simplified application procedure.	• Requires multiple layers. • Need for preliminary etching on enamel. • Lower bond strength than unsimplified counterparts (two-step systems). • Most of the adhesives are not compatible with self-curing or dual-curing composites (core buildup composites and resin luting cements). • Inclusion of hydrophilic components in bonding resin can cause increased hydrolytic degradation.	• Suboptimal polymerization. • Inadequate solvent evaporation. • Overthinning adhesive when air drying to remove solvent.





Classic categories	4th Gen	5th Gen	6th Gen	7th Gen
Examples	Optibond	Prime & Bond	Clearfil SE	Prompt L Pop


8th GENERATION
4TH GENERATION
ETCH
BOND A
BOND B
5TH GENERATION
ETCH
BOND A+B
6TH GENERATION
BOND A
BOND B
7TH GENERATION
ETCH+ BOND A+B
8TH GENERATION


Universal Adhesives
(enhancement of durable bond to dentine)
Dr.F.Ezoji


DIRECT adhesive protocols
KU Leuven biomat.
UNIVERSAL adhesives
3 ADHESIVE MODES
ETCH&RINSE mode
2
Conditioner
Acidic UNIVERSAL adhesive
SELF-ETCH mode
1
Acidic UNIVERSAL adhesive
COMBINED mode
2
Conditioner (enamel selectively)
Acidic UNIVERSAL adhesive

RECENT ADVANCES :

UNIVERSAL ADHESIVE

- In 2012, the term "universal adhesive" has been given several definitions which are:

a)Can be used in total-etch, self-etch, and selective etch techniques;

b)Can be used with light-cure, self-cure, and dual-cure materials (without the separate activators);

c)Can be used for both direct and indirect substrates;

d)Can bond to all dental substrates, such as dentin, enamel, metal, ceramic, porcelain, and zirconia.

- In November 2011, a new "ScotchBond Universal" was discovered.

  Which needs a separate self-cure activator or a special amine-free dual-cure cement when in use with dual-cure or self-cure materials, hence not a truly "universal" adhesive.

- In March 2012, a "All-Bond Universal" was discovered, which can be used in:

  i.total-etch, self-etch and selective etch techniques,

  ii.can be used with any dual-cure, self-cure and light-cure materials without the need of a separate activator,

  iii.can also be used for both direct and indirect substrates, and can bond with any dental substrates.

- All-Bond Universal is the first truly "universal adhesive".

Name of Material	Scotchbond Universal (3M)	Clearfil Universal (Kuraray)	Futurabond U (VOCO)	All Bond Universal (Bisco)	Premio Bond (GC)	Adhese Universal (Ivoclar)	One Coat 7 Universal (Coltene)
Components	BisGMA, 10-MDP, Vitrebond Copolymer, HEMA, Ethanol, Water, Filler, Silane, Initiators	10-MDP Bis-GMA, 2-HEMA, Hydrophilic aliphatic dimethacrylate, Colloidal silica, Silane, Camphorquinone, Ethanol, Water	Liquid 1: BisGMA, HDDMA, UDMA, HEMA, fumed silica, CQ, 10 MDP Liquid 2: Ethanol, water, catalyst	10-MDP, Phosphate monomer, HEMA, BisGMA, Ethanol, Water, Initiators	4-META, 10-MDP, 10-Methacroyldecyl dihydrogen thiophospate, Methacrylate ester, Acetone, Distilled water, Photoinitiators, Silica fine powder	10-MDP, Methacrylated carboxylic acid polymer, HEMA, Bis-GMA, D3MA,	10-MDP, Methacrylated polyacid, HEMA, Urethane di-methacrylate, Photoinitiators, Filler, Ethanol, Water

Table 1. Components of some Universal Bonding Agents.


Thank
you!

CLINICAL FACTORS AFFECTING ADHESION

- Flow of saliva and/or blood contamination
- Moisture contamination from handpiece or air water syringe
- Oil contamination of handpieces or air-water syringes
- Fluoride content of teeth
- Location and size of dentinal tubules
- Presence of plaque,calculus,extrinsic stains or debris
- Presence of bases or liners on prepared teeth
- Tooth dehydration
- Presence of residual intermediary cements

CRITICAL STEPS IN BONDING:-

- Proper isolation:- by using rubberdam , saliva contamination can block mechanical bonding.
- Pulp protection:- by using calcium hydroxide liner.
- Acid etching of enamel and dentin:- by using 37% phosphoric acid for 15 sec. then wash
- Dentin surface must be kept moist. If dentin is over dried it would result in collapse of exposed collagen fibers.
- Careful application and curing of bonding agents.
- Placing the composite resin.

BONDING TO AMALGAM

- Bonding of amalgam restoration to tooth is still a debatable topic.
- The use of adhesive systems beneath amalgam restoration reduces or prevents microleakage, makes cavosurface angle less susceptible to demineralization when compared to varnish.
- There is reduction in sensitivity and more conservative cavity preparation can be achieved when amalgam is bonded to tooth.

- Staninec M (1989) showed that retention with amalgam bonding is equal to or superior to traditional means of mechanical retention.

- Tig IA, Fodor O, Moldovan M et al (2005) noticed that at higher magnification, teeth restored with unbonded amalgam had more spaces and artifacts at the amalgam-tooth structure interface when compared with those

Failures can occur at various levels:

- ✓ between mineralised and demineralised dentin
- ✓ between demineralised dentin and bonding agent
- ✓ within layer of bonding agent
- ✓ between bonding agent and composite resin.

Affected by –

- ➢ dentin wetness
- ➢ tooth flexure
- ➢ arch
- ➢ size of lesion
- ➢ substrate
- ➢ material factors

RECENT ADVANCES

NEWEST PRODUCT

- *Nanofilled :-*

  - Recently, bonding agents have been marketed that contain extremely small filler particles. These are called *nanofilled DBA's.*

E.g.- Prime and bond NT (7nm fillers)

- Excite (12nm fillers)

Advantages- Make DBA stronger and tougher

- Able to cover adequately with a single coat
- Improved marginal integrity.

- *Newer Antibacterial Dentin Bonding Agents:-*

  - Recently, bonding agents have been marketed that contain methacryloyloxy dodecyl pyridinium bromide (MDPB), has been developed (Imazato et al., 1994).. And also Nano-silver!

E.g.- Clearfil Protect Bond and Prime

Bond NT

Advantages- The incorporation of MDPB is considered to be a potential method of providing dentin adhesive systems with antibacterial activity before and after curing.

Eradication of residual bacteria that invade the tooth-adhesive interface by microleakage.

NANOFILLED BONDING AGENTS

- These bonding agents contain extremely small filler particles.
- Bonding agents under this type are Prime and Bond NT (Dentsply/Caulk) (Fig. 16.25).
- Prime and Bond NT contains 7-nanometer fillers, greater concentration of resin and a smaller molecular weight resin.

Advantages of Using Small Fillers

- ✓ Small fillers make the bonding agent tougher and stronger.
- ✓ Covers dentin in one application
- ✓ It has shown that they penetrate dentin better
- ✓ Provide improved marginal integrity
- ✓ A low film thickness
- ✓ Satisfactory bonding to sclerotic and aged dentin

Fig. 16.25: Nanofilled bonding agent

Futurabond DC- 8th Generation

- It is dual-cured and works with all light, self or dual-cured resins .
- Nanosized cross linking agents with fused silica particles

- It works in a self-cured mode without any light – great for endo

- It takes only 35 sec. from start to finish.

- It needs only one coat.


1
2
3
Simply press and bond!
20s
4
5
5s
10s
"The easiest self-etch bond ever"


FUTURABOND NANO REINFORCED
stress-breaking area
hybrid layer

Surpass: A Universal Eighth Generation Bonding System

Has the best attributes of the fourth generation and the ease of the sixth-generation bonding systems

Consists of three bottles: an etchant/conditioner, a primer, and a separate hydrophobic bond resin

Etchant/conditioner is not rinsed from the t

Bond Strength: 50 Mpa

Fluoride releasing bonding agents

- Anti-cariogenic
- Increase dentin bond strength
- Increase the local concentration of fluoro-apatite in the mineralized dentin just beneath the hybrid layer
- Prevent the release of hydrolytic enzymes from the matrix.
- Reduce the solubility of intrinsic calcium phosphate within the hybrid layer.

Examples:

- **CLEAR FIL SE BOND PLUS**
- **ONE UP BOND F**
- **G BOND**

FL BOND II

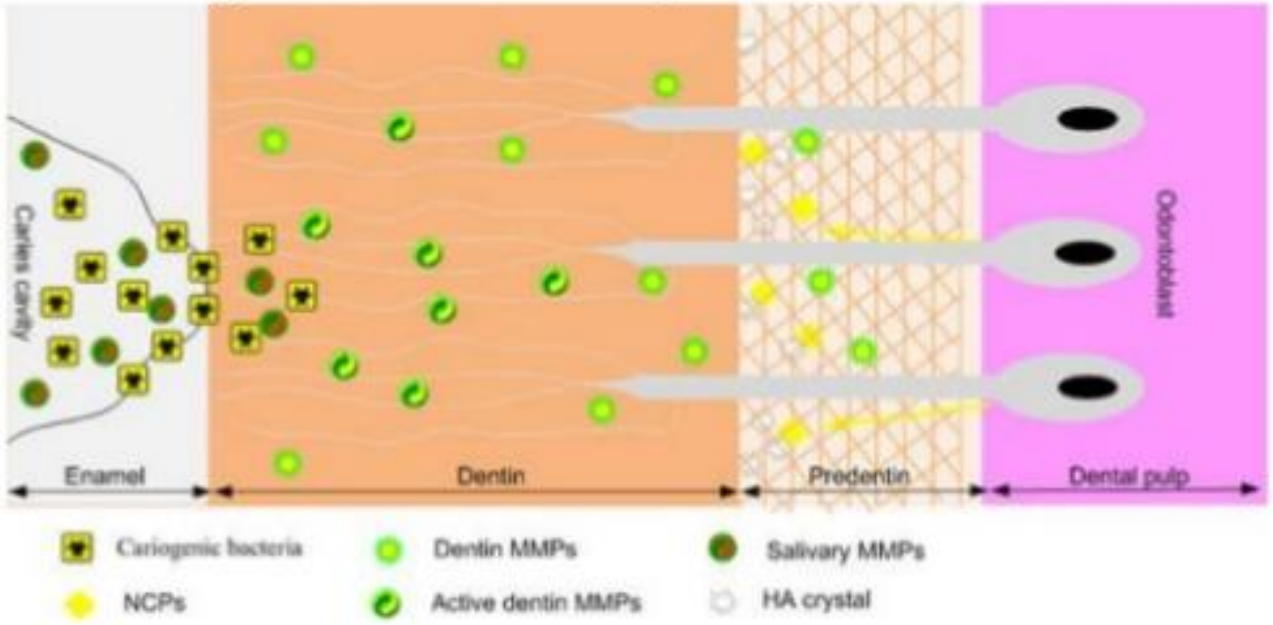
FL-Bond is a self-etching fluoride releasing two-step adhesive system which features an excellent bond to both enamel and dentin and provides a secure marginal seal.

•The primer has new effective adhesive promoting monomer and new photo initiator and is **free of HEMA** and acetone to considerably minimize odour, post operative sensitivity

•The FL-BOND Bonding Agent incorporates fluoride containing **S-PRG filler** (Surface Pre-Reacted Glass-ionomer) which continuously provide fluoride to the tooth structure.

Matrix Metallo-Protineases

Host-derived matrix metalloproteinases (MMPs), found both in **saliva** and
in **etched dentin**, have been shown to be involved in the degradation of the
unprotected collagen fibrils within the hybrid layer.



Role Of MMP Inhibitors

- Dentin MMPs can be activated following the demineralization of the dentin surface by acids, resulting in collagenolytic and gelatinolytic activities.
- Effective synthetic MMP inhibitor must contain a functional group (e.g., carboxylic acid, hydroxamic acid, sulfhydryl) capable of **chelating the active-site zinc ion** in the MMP molecule.
- resulting in improved micromechanical retention of the adhesive within the collagen matrix, suggesting an auxiliary bonding mechanism.

Examples:

- CHX(0.2-2%), quaternary ammonium methacrylate resin

Monomers, Batimastat,Galardin

Desensitization

- precipitation of proteins in the tubule

- Penetrates the tube as far as 200um.
- Forms series of bridges across the tu
- Impermeable to odontoblastic fluids.

Examples : **GLUMA SYSTEM(5% GLUTARALDEHYDE+35% HEMA)**

ALL BOND 2

MULTIPURPOSE BONDING

- Scotchbond™ Universal Adhesive is a combined Total-Etch, Self-Etch and Selective-Etch adhesive.

1. Etchant: 35% phosphoric acid
2. Primer: water (40%), HEMA (47%) and poly-alkenoic acid copolymer (13%)
3. Adhesive: Bis-GMA (65%), HEMA (34%) and
4. Initiators/accelerators (1%)

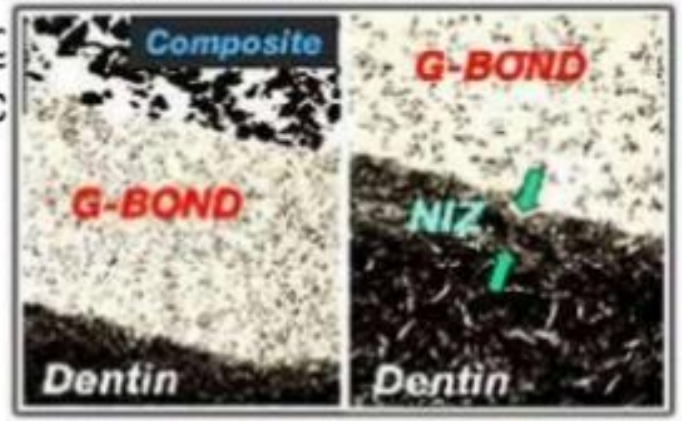
- It offers one simple adhesive application technique for both direct and indirect indications and bonds to all surfaces including enamel, dentin, glass ceramic, zirconia, noble and non-precious alloys, and composites - without additional primer.

G-Bond

- 4 MET monomer : Strong consistent bond to dentin
- Phosphoric acid ester monomer : Consistent bond to enamel.

Nanointeraction technology:

Non-conventional interface with the dentin – a “Nano Interaction Zone” (NIZ) with minimal decalcification and almost no collag hydroxyap struc



Nano filled adhesives

- These fillers were mainly silica or glass of varying sizes.
- Filled adhesives had greater film thickness, greater ability flex and can help dissipate the stress of composite polymerisation.
- Higher filled, larger particle filled adhesives yielded stronger physical properties .
- These nano fillers are generally Amorphous silica dioxide which are 100 times smaller than the fillers in hybrid composites which results in optimal optical properties.

Advantages

- Increased adhesive strength to both enamel and dentin
- Increased marginal integrity
- Sufficient film thickness for one-coat, one cure technique
- Deeper penetration into dentinal tubules
- The filled adhesives should be rubbed on the surface to lift the filler particles so that small spaces between collagen fibrils are not clogged, which could act as a barrier to permeation

Examples: **Prime and Bond NT (7nm)**
Excite (12 nm)

Antibacterial Agents

Clearfil™ SE Protect, an antibacterial self-etching adhesive.

SE Protect contains an antibacterial monomer, **MDPB** (methacryloyloxyl-dodecyl pyridinium bromide) which disinfects the tooth's surface duri

Go! One Component Self-Etching Light-Cure Adhesive

- Go! is a **super quick adhesive** saves valuable chair time
- **HEMA free**
- **No post-operative sensitivity**
- **High fluoride release**

Assists in strengthening the tooth &prever recurrent decay.

- **Quick color change**
  Initially, Go! is a dark yellow color, but upon curing, it changes to clear.

Frog Self-Etch Adhesive

- **Self etcher**
  Frog self-etching primer infiltrates cut tooth surfaces, effectively dissolving the smear layer formed during cavity preparation.

Does not require a separate etching step. Instead, the dentinal tubules are simultaneously plugged as they are etched.

- **Optimal pH**
  Frog's optimal pH of 2.0 allows the unblocking of dentin tubules without aggressively decalcifying the tooth surface.

- **The gripper**
  - Frog deeply penetrates to form a very strong bond enabling a perfect grip to the tooth surface.

  - maintains the hydroxyapatite in the collagen fibrils assisting in mechanically bonding the adhesive to the tooth surface.

- **Protecting the pulp**
  Post-operative sensitivity is prevented: no separate etching, washing and / or drying required, hence over drying cannot occur. Patient comfort is maximized

- **Nano**
  Frog's specially treated nanofillers improve the cohesive strength of the bond and ensure good adaptation to tooth structure when applied to both dentin and enamel. There will be complete marginal sealing to protect the restoration margins against the diffusion of oral fluids and microorganisms.

- **Low film thickness**
  Frog's low film thickness of **12 microns** ensures invisible margins.

AMALGAM BONDING

Must have Auto-polymerizing capability
First layer-light cure
Bond strength : 2-20 Mpa

ADVANTAGES

- Conservative preparation
- Increase fracture resistance of resto
- Seal margins better
- Decrease post operative sensitivity
- Prevent permeation of corrosion pro

Examples: ALL BOND 2
AMAGAM BOND PLUS
CLEARFIL LINER BOND

CERAMIC BONDING

CONVENTIONAL SILICA BASED

- Partly of mechanical interlocking & partly of chemical union.

- Mechanical retention is obtained by etching fitting surface of porcelain with dilute **Hydrofluoric acid(6-10%) or ammonium bifluoride** to increase surface roughness & allowing low viscosity resin to penetrate into pores by capillary action.

Chemical union occurs by interaction of silicate ceramic surface & silane coupling agent of composite-

Inert ceramics: Aluminium oxide and Zirconia based

- Air Abrasion
- Tribochemical SURFACE treatment
- phosphate based adhesive (panavia).10 MDP

CEMENTUM BONDING

One of the most frequent clinical problems associated with class-II and class-V cavities in adhesive resin restorations is the weak link of restorative material to root dental structures, when the cervical margin is located below the cementoenamel junction.

- Ferrari et al. reported that cementum treated with dentin bonding systems is infiltrated by the resin, but the predictability of the bond is unclear.

- The shear bond strength of a resin composite to EDTA conditioned sound cementum, after treatment with an aqueous primer composed of 5% glutaraldehyde and 35% hydroxyethyl methacrylate, was estimated as **6MPa**.

- It seems that after demineralization the increased intrinsic fibrial
content of intact cementum surface creates an organic network that lacks the cohesive strength of demineralized dentin collagen, and although it is reinforced by resin infiltration, results in low bond strength.

- Modification of intact cementum surfaces to improve adhesion may include a **eproteination step**, prior to any adhesive treatment, in order to remove the high organic content and expose the inorganic substrate, like conditioning with aqueous solutions of sodium hypochlorite (NaOCl)


THANKYOU

DENTIN BONDING AGENTS - SlideShare

https://www.slideshare.net/tadurivivek/dentin-bonding-agents-76772297

Jun 8, 2017 - ... *THE RECENT ADVANCES ARE INCLUDED IN THIS **PRESENTATION**. ... INTRODUCTION Today we are in the age of adhesive **dentistry**. ... Ideal requirements of dentin **bonding agents**: 1961 Phillips and Ryge: High bond strength to dentin . Provide ..... Prisma **Universal** Bond(Johnson and Johnson).

- Bonding to Enamel and Dentin Bonding to Enamel and ... - SlideShare
- https://www.slideshare.net/.../bonding-to-enamel-and-dentin-bonding-to-enamel-and-...
- Dec 15, 2017 - “INTRODUCTION **The** past decade has seen increased use **of bonding** agents in concurrence with traditional **dental** materials. **The** .

SELF ADHESIVE SYSTEM

Table 18.2. Use of individual component in self-etch adhesive systems

UDMA/HEMA	Conditioning of enamel and dentin Wetting agent, help in thin film formation Promote infiltration
4-META	Binding to calcium of apatite Binding to collagen
Glutaraldehyde	Disinfectant Desensitizing agent
Acetone	Helps in removing humidity Solvent for monomer
Water	Helps in etching process Solvent for monomer