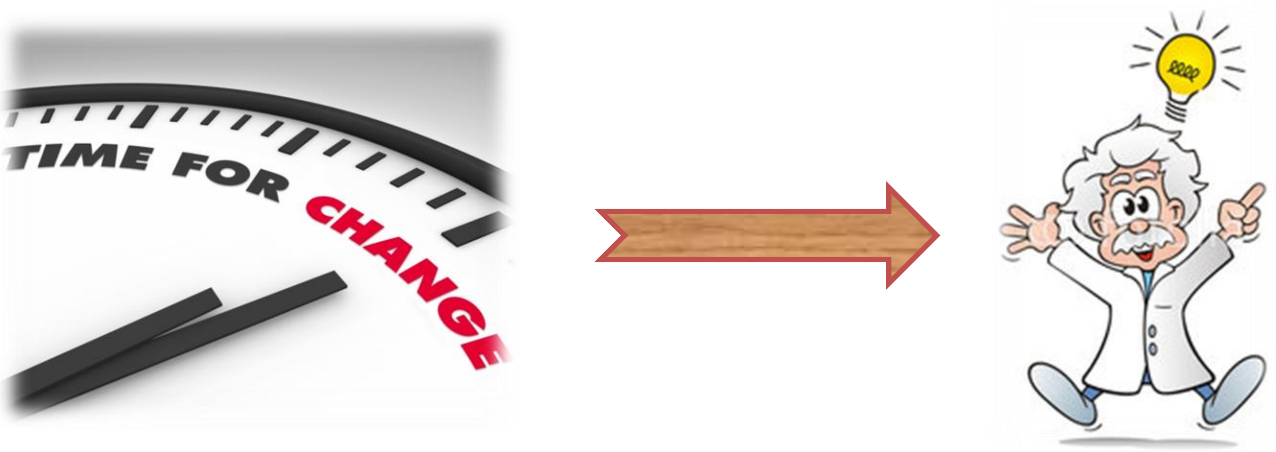
Good Morning

DENTIN BONDING AGENTS

CONTENTS

INTRODUCTION



The production of a stable long term bond to the tooth substance is an ideal requirement for the success of all restorations.

INTRODUCTION

- An adhesion permits the placement of a more conservative restoration, reduces micro leakage and dentin sensitivity.
- A solid understanding of biological, chemical and physical aspects of these adhesives is very essential for their proper use in field of dentistry.
- *Dentin Bonding Agents are di or multi-functional organic molecules that contain reactive group, which interacts with dentin and the monomer of the restorative resin.*

HISTORY

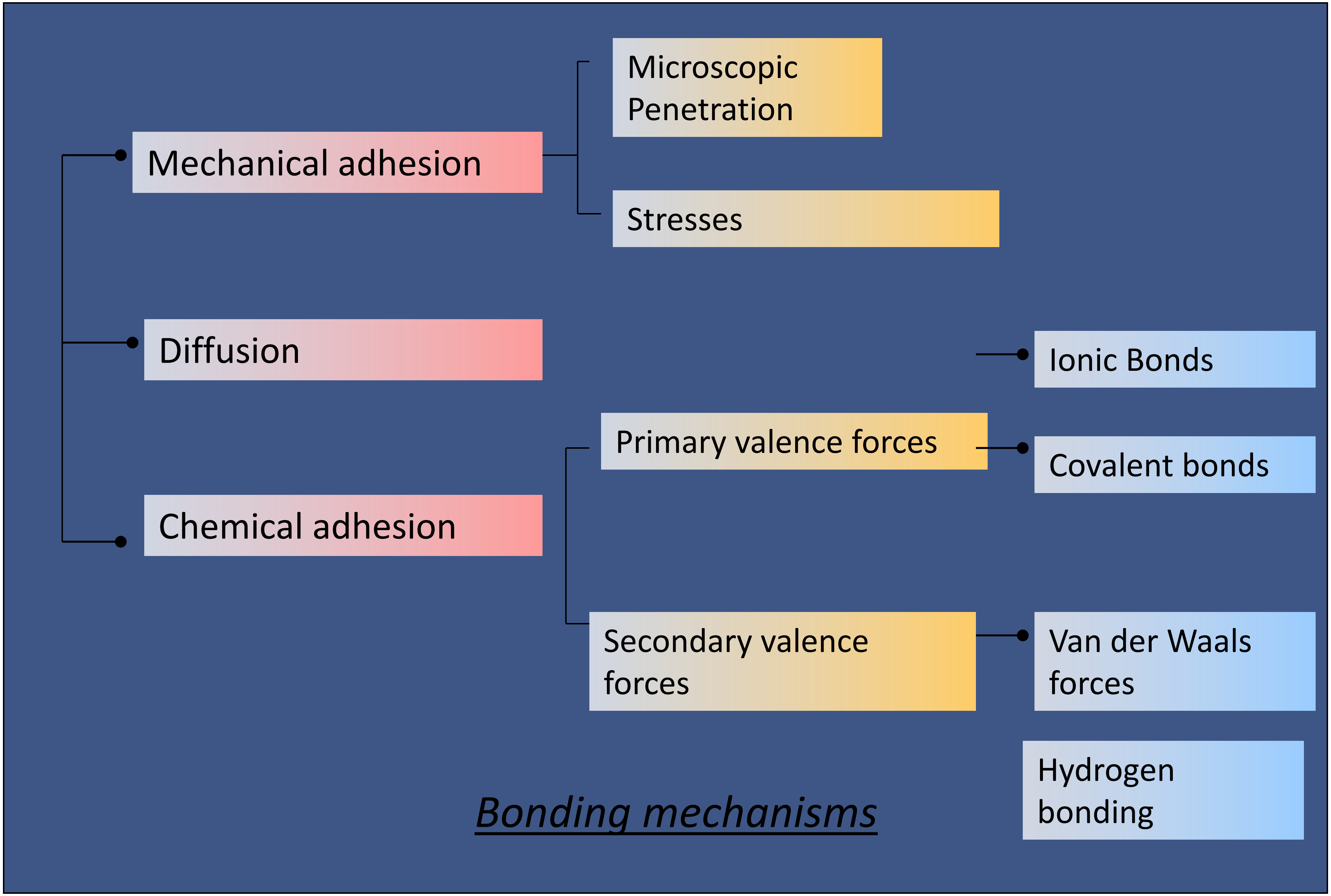
1938	Development of epoxy molecule by *Castan*
1951	Glycerophosphoric acid dimethacrylate developed by *Dr. Oscar Haggart*
1952	Glycerophosphoric acid dimethacrylate used by *Kramer & Mc Lean*
1955	*Buonocore* acid etching with phosphoric acid
1956	*Buonocore* developed the first dentin bonding agents
1957	*Bowen gave* BISGMA *resin system*
1965	*Causto* described how primers work
1975	*Gwinnet and Silverstone* three patterns of etching of enamel
1982	*Bowen, Cobb and Rapson* developed multilayer adhesive system
1987	*Fusayama* -concept of total etching and bonding
1990s	*Kanca*-concept of wet bonding
1997	*Ferrari*-bonding mechanism of one bottle adhesive system
2000	*Ferrari* -evaluated bonding ability of 6th gen bonding systems
2003	*Ferrari*-seventh generation bonding agents

BASIC CONCEPTS OF ADHESION

- Adhesion: The state in which two surfaces are held together by interfacial forces, which may consists of valence forces or interlocking forces or both. (The American Society for Testing and Materials; specification D 907)
- Adherend: The surface or substrate that is adhered .

- Adhesive/adherent: A material that can join substances together, resist separation and transmit loads across the bond.
- Adhesive failure: The bond that fails at the interface between the two substrates.
- Cohesive failure: The bond fails within one of the substrates, but not at the interface.

BASIC CONCEPTS OF ADHESION



Mechanical adhesion

- Microscopic Penetration
- Stresses

Diffusion

Chemical adhesion

- Primary valence forces
  - Ionic Bonds
  - Covalent bonds
- Secondary valence forces
  - Van der Waals forces
  - Hydrogen bonding

Bonding mechanisms

BASIC CONCEPTS OF ADHESION

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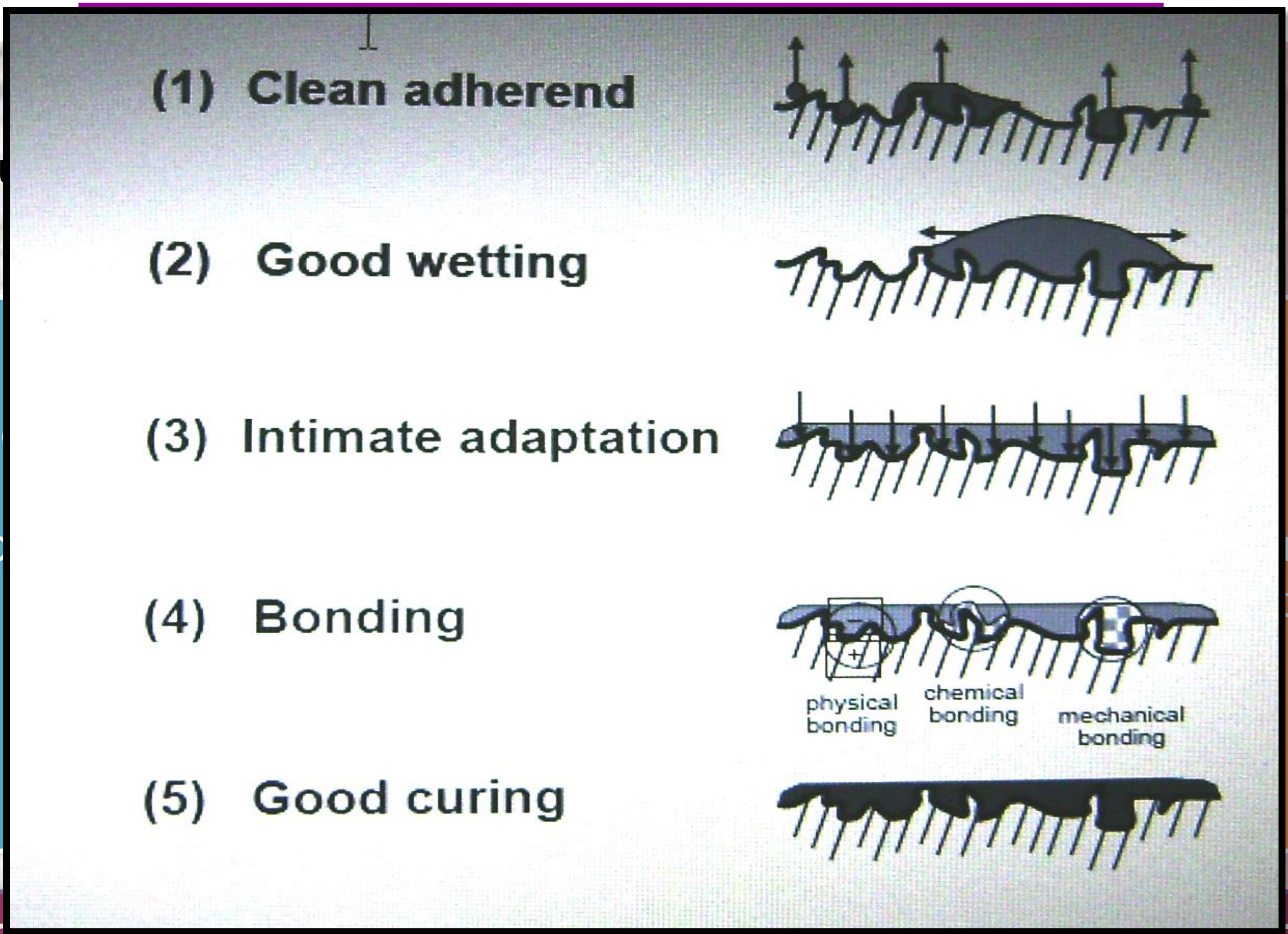


(1) Clean adherend

(2) Good wetting

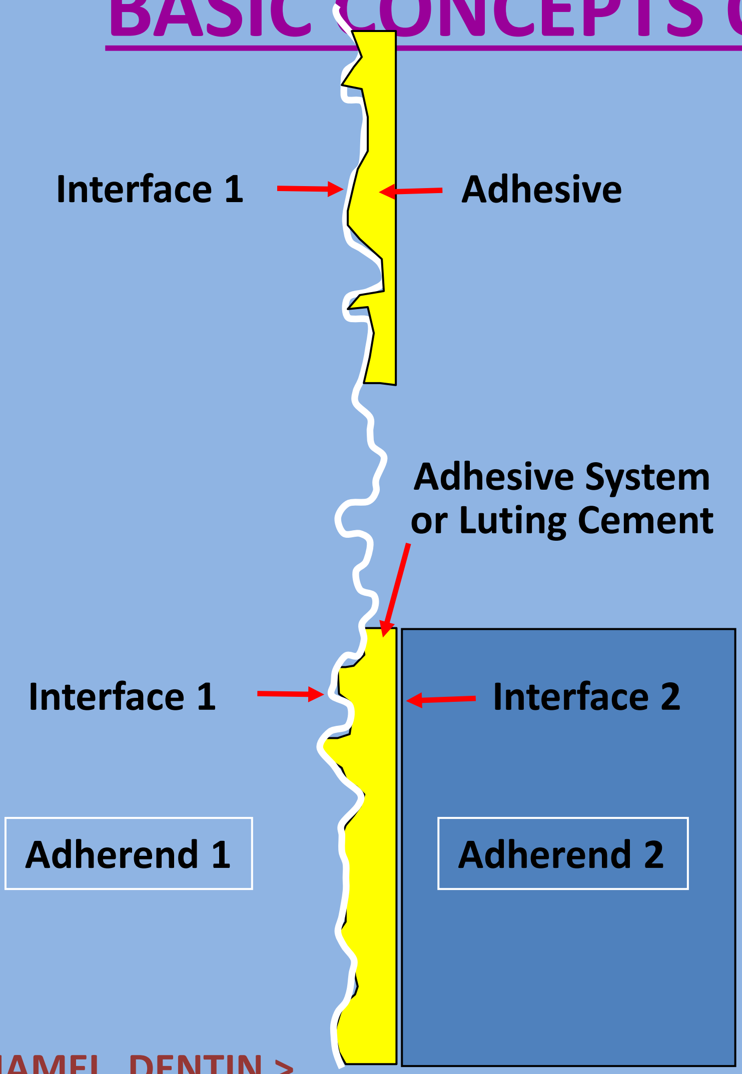
(3) Intimate adaptation

(4) Bonding

(5) Good curing

Therefore an adhesive with low surface tension low contact angle and low viscocity is preferred

BASIC CONCEPTS OF ADHESION



Interface 1

Adhesive

Adhesive System
or Luting Cement

Interface 1

Interface 2

Adherend 1

Adherend 2

ADHESION

ADHESIVE JOINT

ENAMEL, DENTIN >
Liner, Base, Cement >
Post and Core >
Dental Amalgam >
Implant >

< Pit and fissure sealant
<Composite, Amalgam
< Cast Inlay, Onlay, or Crown
< All-Ceramic Inlay, Onlay, or Crown
< Veneers, Maryland Bridges
< Orthodontic Brackets

CLINICAL FACTORS AFFECTING ADHESION

Flow of Saliva and /Or Blood Contamination	Moisture contamination	Oil contamination
•Although dentin is a wet substrate, saliva and blood can destroy good dentin bonding. •The use of rubber dam or other dry field methods.	•Water leakage from air-rotor hand piece •Air-water syringe can effect bonding.	•Lack of maintenance of dental equipments •Prevented by using effective oil filters

CLINICAL FACTORS AFFECTING ADHESION

Flow of Saliva and /Or Blood Contamination

Moisture contaminatio n

Oil contamination

Tooth structure

Location and Size of Dentinal Tubules

Presence of Plaque, Calculus, Extrinsic Stains or Debris

- Altered tooth resi etching.
- For effective etchi the normal etchin

- If tubules are attachment is if tubules are attachment is enhanced.

Impair effective bonding. Cleaned with scalers, abrasive prophy pastes using rubber cups or with abrasive rotary instruments.

CLINICAL FACTORS AFFECTING ADHESION

Flow of Saliva and /Or Blood Contamination

Moisture contamination

Oil contamination

Tooth structure :

Location and Size of Dentinal Tubules :

Presence of Plaque, Calculus, Extrinsic Stains or Debris :

- Cause collapse of exposed collagen and may prevent resin infiltration and impair bonding.

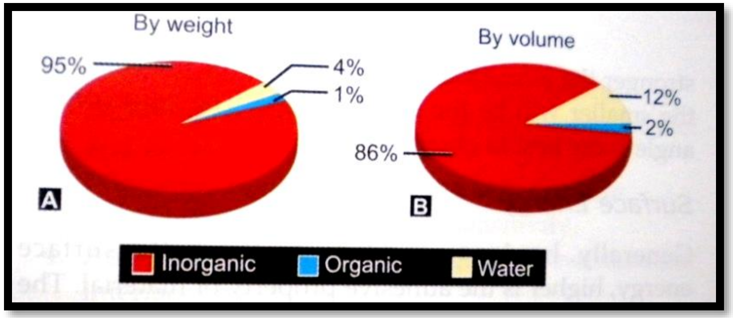
Presence of Bases or Liners on Prepared Teeth

Tooth dehydration

ENAMEL ADHESION

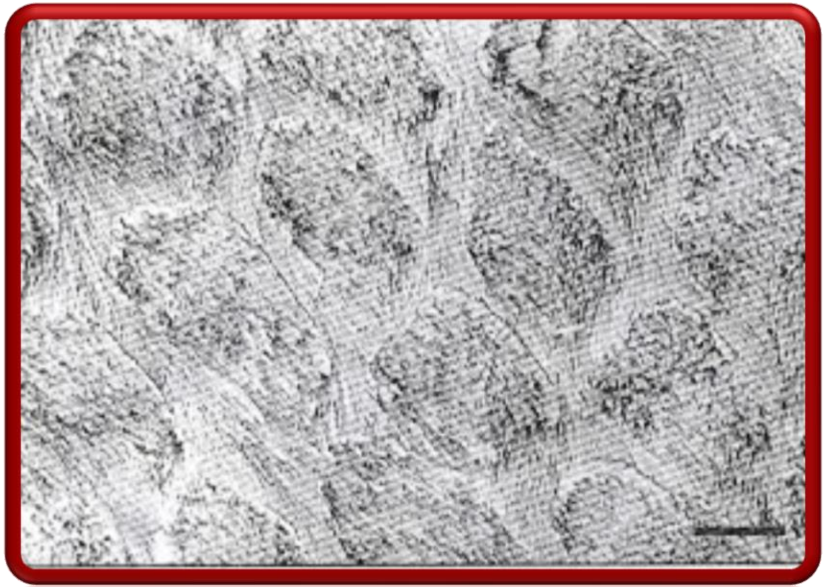
Composition of enamel

- Primary component – hydroxyapetite
- Inorganic content – higher
- Homogenous in structure and composition



Inorganic fraction - prism.

Normal enamel rods - key-hole pattern.



Natural surface -smooth

Operatively prepared surface expose rods in tangential, oblique, and longitudinal planes

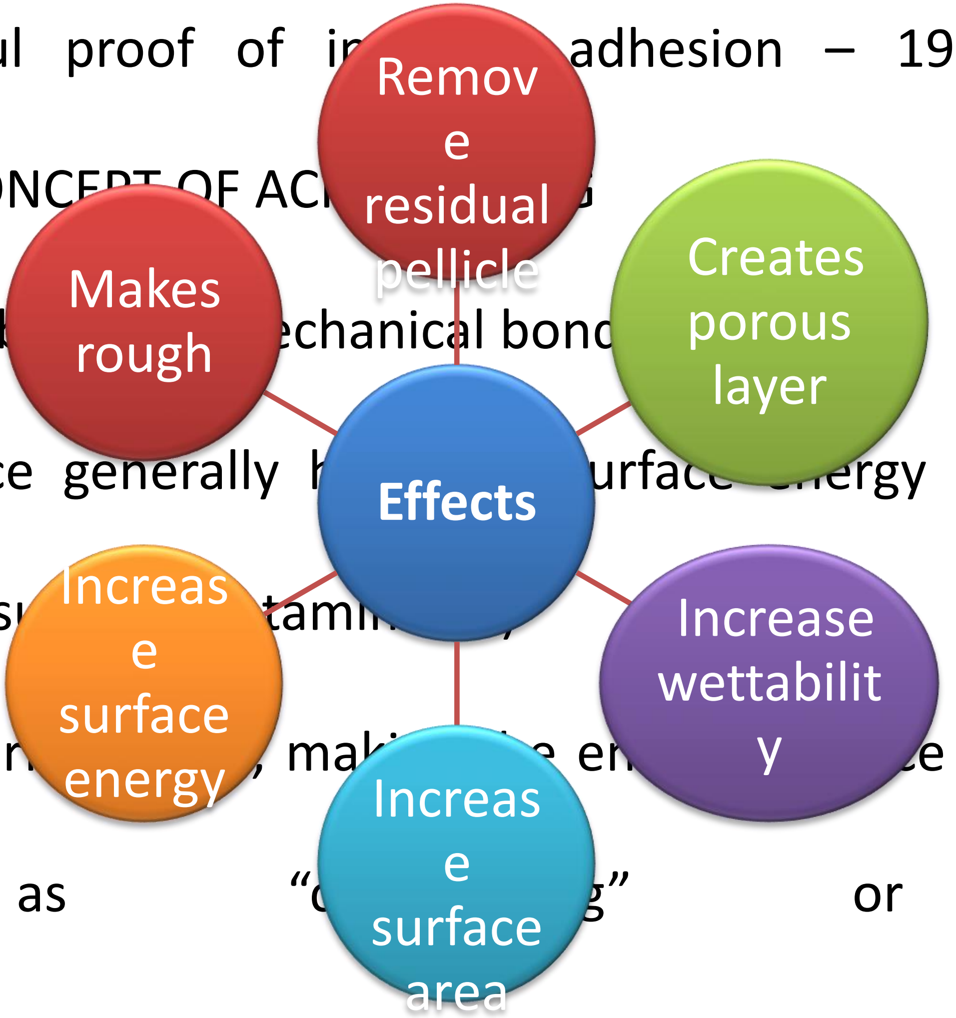
ENAMEL ADHESION

•1st meaningful proof of in adhesion – 1955, by Michael Bunocore- CONCEPT OF AC G

•Etching to enab echanical bond

•Enamel surface generally h urface energy (organic pellicle, smear layer as s tami),

•Removal of sur , mak e en e more reactive is known as “c g” or “etching”.



Effects

Remove residual pellicle

Creates porous layer

Increase wettability

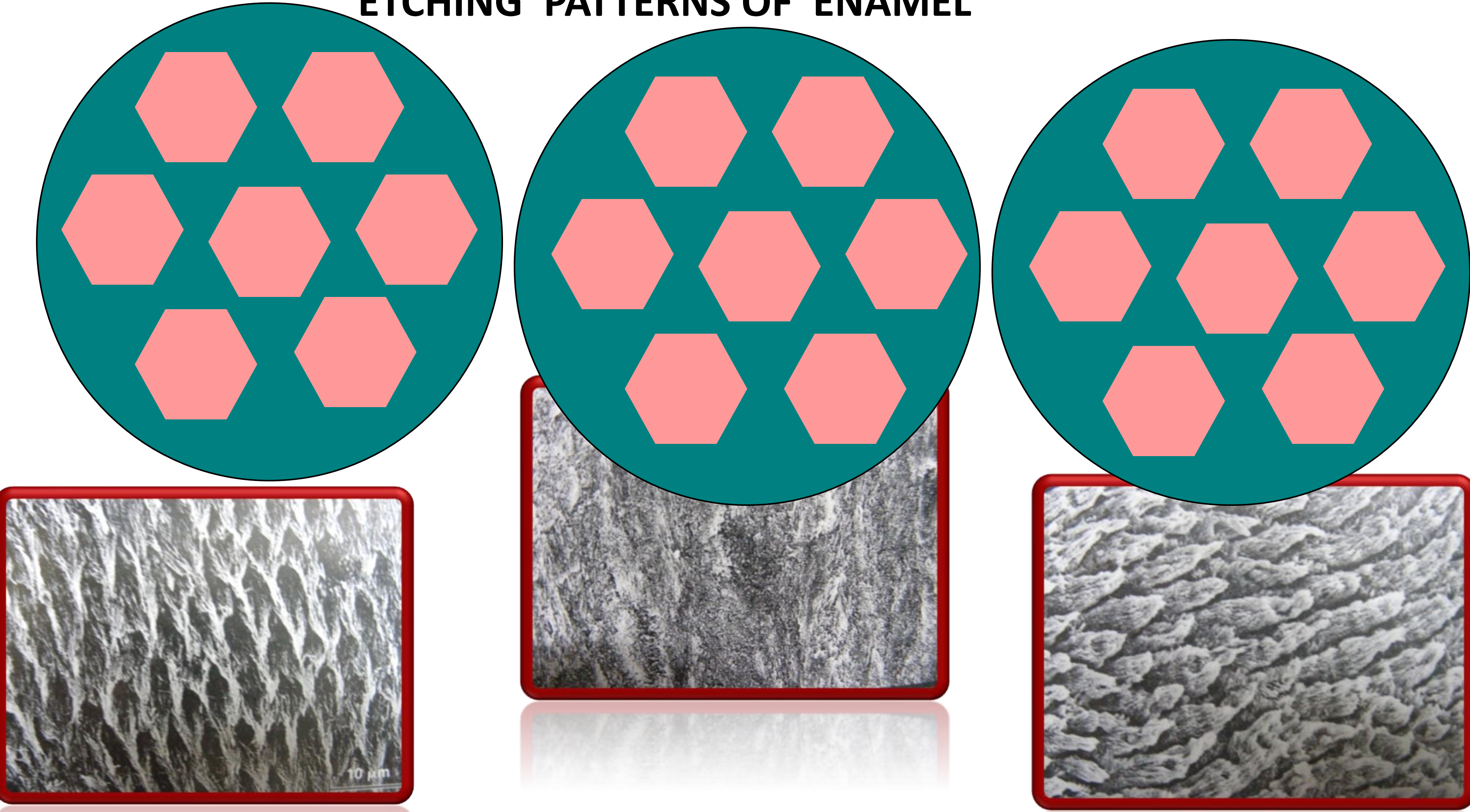
Increase surface area

Increase surface energy

Makes rough

ENAMEL ADHESION

ETCHING PATTERNS OF ENAMEL



Type II - Peripheral enamel is dissolved but cores are left intact.

ENAMEL ADHESION

Enamel acid etching – removes 10 micron of enamel

Creates microporous layer 5 to50 microns deep

Smooth surface – irregular surface

Unfilled liquid acrylic resin (enamel bonding agent)

Wets the surface

Enters into microporosities by capillary action

Two types of resin tags are formed

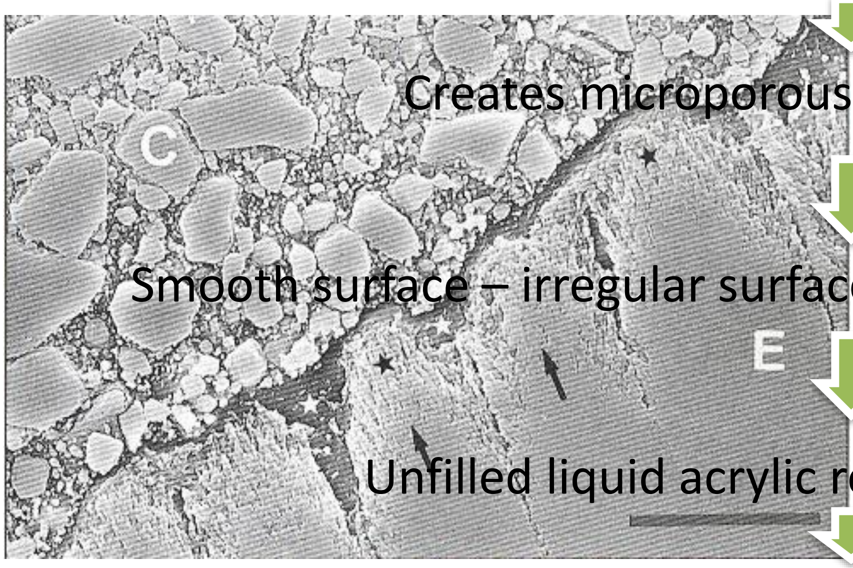
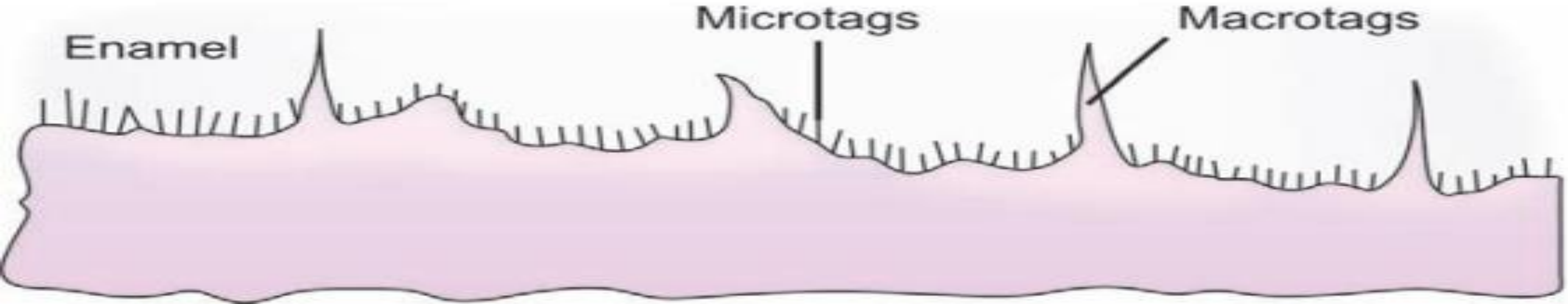


Fig 8-23 Field-emission scanning electron photomicrograph showing a resin-enamel interface subjected to an argon-ion–bombardment procedure when a "three-step total-etch" adhesive (Scotchbond Multi-Purpose Plus, 3M) was bonded to 35% phosphoric acid–etched enamel (E). Macrotags *(white stars)* are formed circularly between the longitudinally sectioned enamel prism *(black arrows)* peripheries. Microtags *(black stars)* are formed at the cores of the enamel prisms. C = luting composite; bar = 5 µm. (From Peumans et al.[246]



ENAMEL ADHESION

EDTA (24%; pH =7)

Citric acid

Tannic acid

Maleic acid

Polyacrylic acid

Nitric acid

Sulfuric acid

Hydro chloric acid

Pyruvic acid

Phosphoric acid

Concentration 30 – 40%

Etching time- not less than 15 sec

Washing times- 5-10 sec

0%

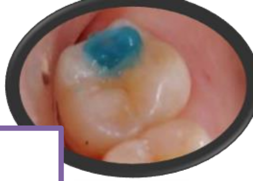
Acid applied for 60 sec- monocalcium phosphate monohydrate – rinsed off

Dicalcium phosphate dihydrate- couldn’t easily removed

Calcium dissolution and etching depth increases and then reverse effect seen

ETCHANTS

ENAMEL ADHESION



ETCHING TIME

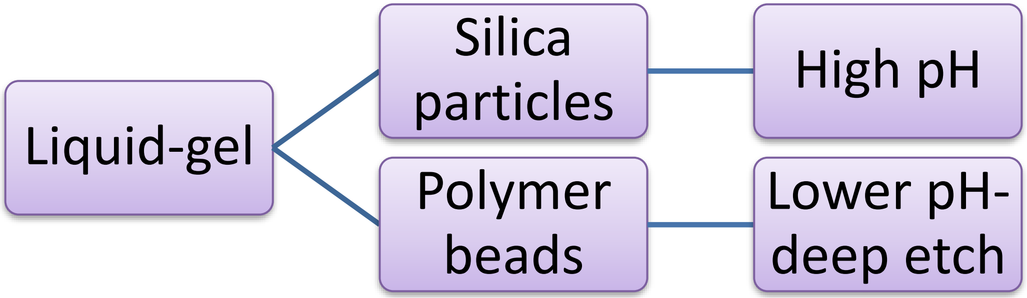
- Time for etching- traditionally, 60 sec
- But SEM studies have shown same surface roughness in 15 sec
- Similar shear bond strengths & marginal leakage values for 15 & 60 sec have been observed
- Current recommendations- permanent teeth, 15 to 20 sec
- Fluoridated enamel, primary teeth- require more time

Clinically, the most important measure of a properly etched tooth is the *frosty white appearance* of the surface

ENAMEL ADHESION

LIQUID/GEL

Liquid-gel



Liquid-gel

Silica particles

High pH

Polymer beads

Lower pH-deep etch

On smooth surfaces, etching liquids and gels result in similar etch patterns.

With deep grooves and fissures, a liquid etch is recommended, because it penetrates the irregularities of the occlusal surface.

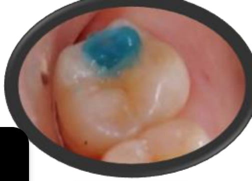
ENAMEL ADHESION

RINSING ETCHANT

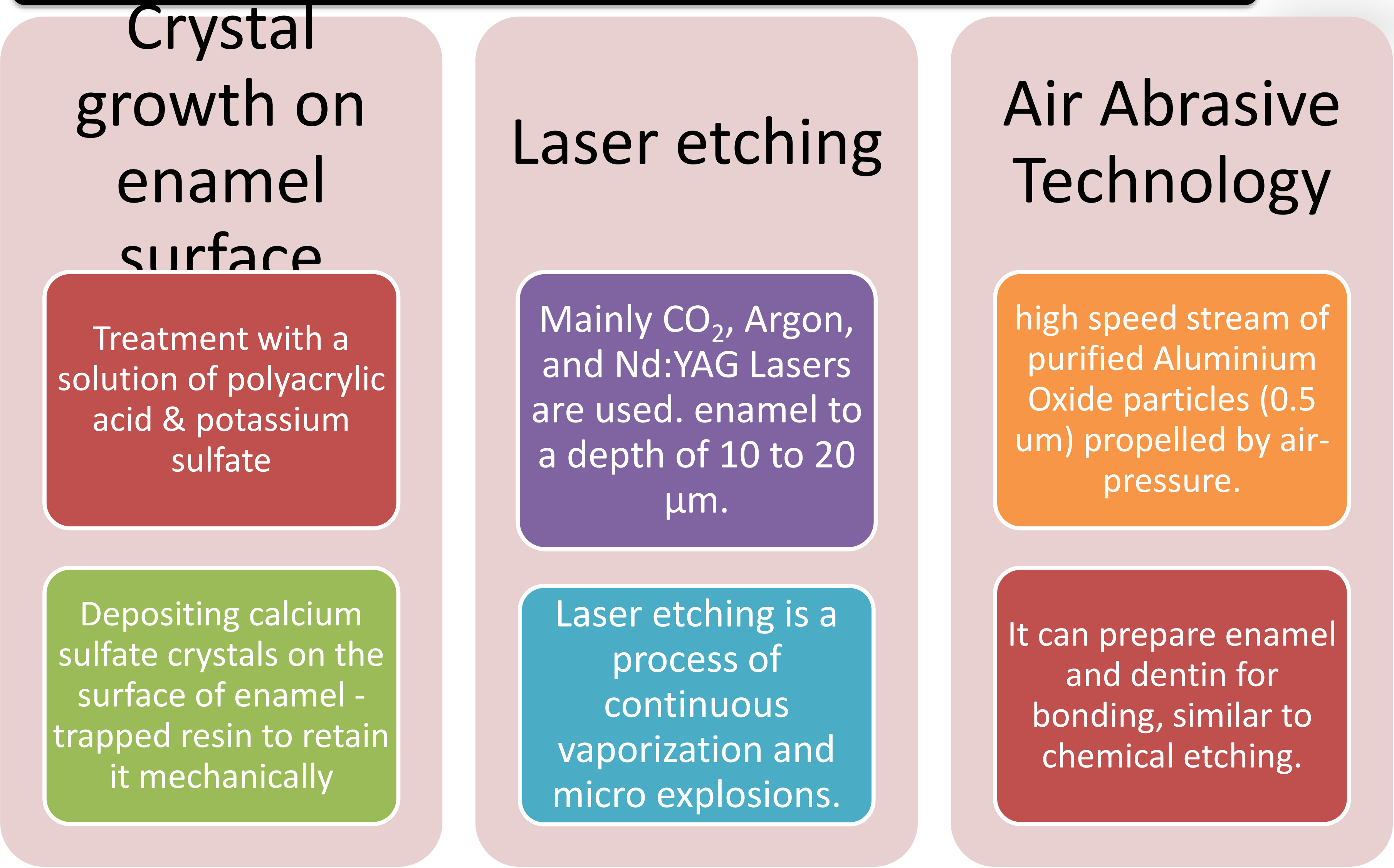
- Insufficient washing leaves debris that interferes with the flow of resin into the enamel channels.
- Acid-etched enamel must be washed for 10 seconds; gel etchants should be washed longer.
- Some studies have shown a 10- to 30-second wash time yields the same bond strength.

Time- 3-5 sec on flat surfaces –provide for adequate bond and seal
Complex preparations- 5 – 10 sec
Ethanol – remove residual water – enhance resin penetration

ENAMEL ADHESION



NEWER ALTERNATIVES TO ETCHING



Crystal growth on enamel surface

Treatment with a solution of polyacrylic acid & potassium sulfate

Depositing calcium sulfate crystals on the surface of enamel - trapped resin to retain it mechanically

Laser etching

Mainly CO_2, Argon, and Nd:YAG Lasers are used. enamel to a depth of 10 to 20 µm.

Laser etching is a process of continuous vaporization and micro explosions.

Air Abrasive Technology

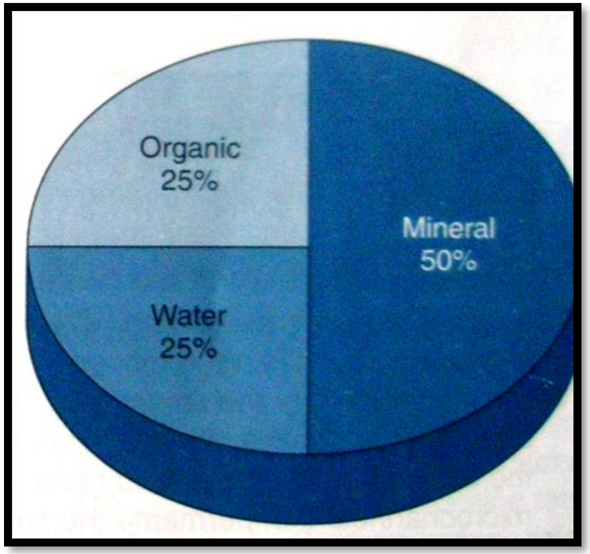
high speed stream of purified Aluminium Oxide particles (0.5 um) propelled by air-pressure.

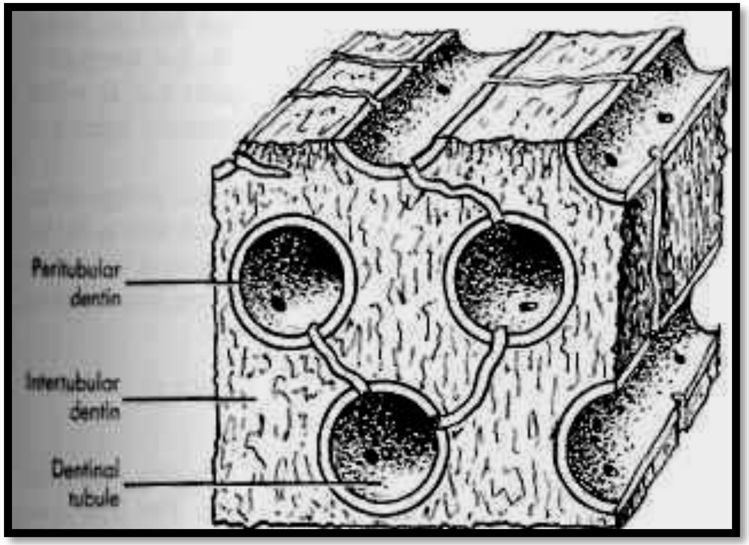
It can prepare enamel and dentin for bonding, similar to chemical etching.

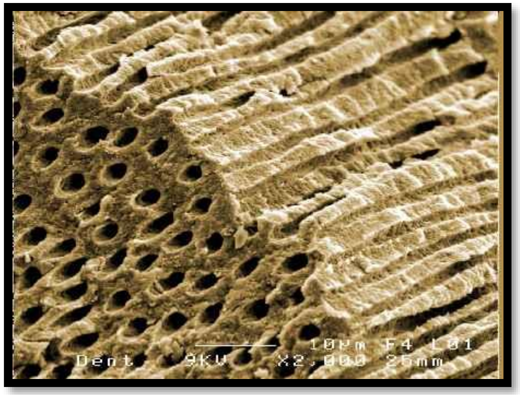
DENTIN ADHESION

CHALLENGES IN DENTIN BONDING

- Higher percentage of water and organic matter (Type I collagen).
- Heterogeneous
- Dentinal tubules with dentinal fluid
- Changes due to caries, trauma- sclerotic dentine.
- Smear layer







CHALLENGES IN DENTIN BONDING

SMEAR LAYER

- A

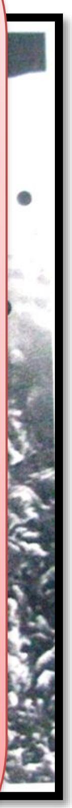
Smear layer is responsible for:

•Physical barrier for bacteria and bacterial products

•Restricting the surface area available for diffusion of both small and large molecules.

•Resistance to fluid movement.

•In vital teeth, the smear layer restricts the dentinal fluid from flushing the dentin surface.



the restorative material.

CHALLENGES IN DENTIN BONDING

TECHNIQUE OF SMEAR LAYER TREATMENT

No Treatment at all

Removal and replacement of smear layer

Dissolution of the smear layer

Removal of smear layer by acid etching

Modification of smear layer

Mod: all bond 2
Removal: scotchbond multipurpose
Disolvng: prompt l pop

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Eg. Sco
bond.

Removal of smear layer by acid etching and replacement with another mediation agent.

Tenure replaces smear layers with oxalate crystals which are deposited in dentinal tubules.

odification of smear layer
ows between interaction of
ntin bonding agent with the
ear layer.

. Bonding agent – Prisma 2,
R Bond, All bond.

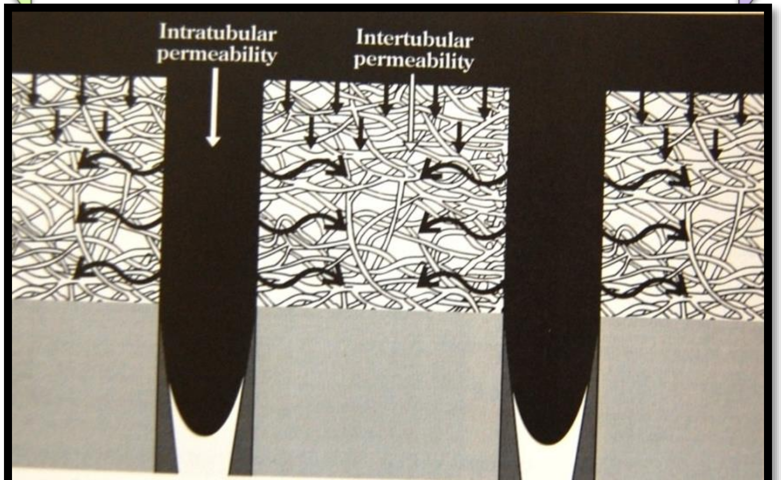
CHALLENGES IN DENTIN BONDING

DENTINAL PERMEABILITY

- It refers to the ease with which a substance can move into or across a diffusion barrier.
- Variation in permeability affects the bonding mechanism of dentin.

Intratubular

Intertubular



CHALLENGES IN DENTIN BONDING

DENTINAL PERMEABILITY

INTRATUBULAR PERMEABILITY

The movement of fluid

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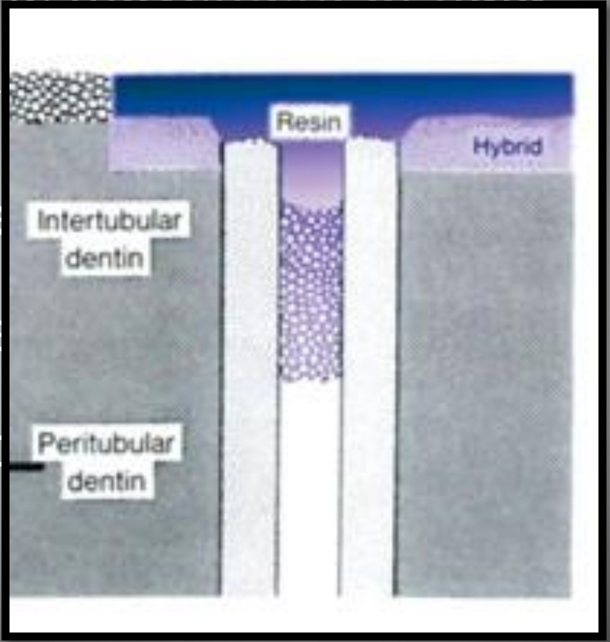

INTERTUBULAR PERMEABILITY

Diffusion of monomer into demineralized intertubular dentin,

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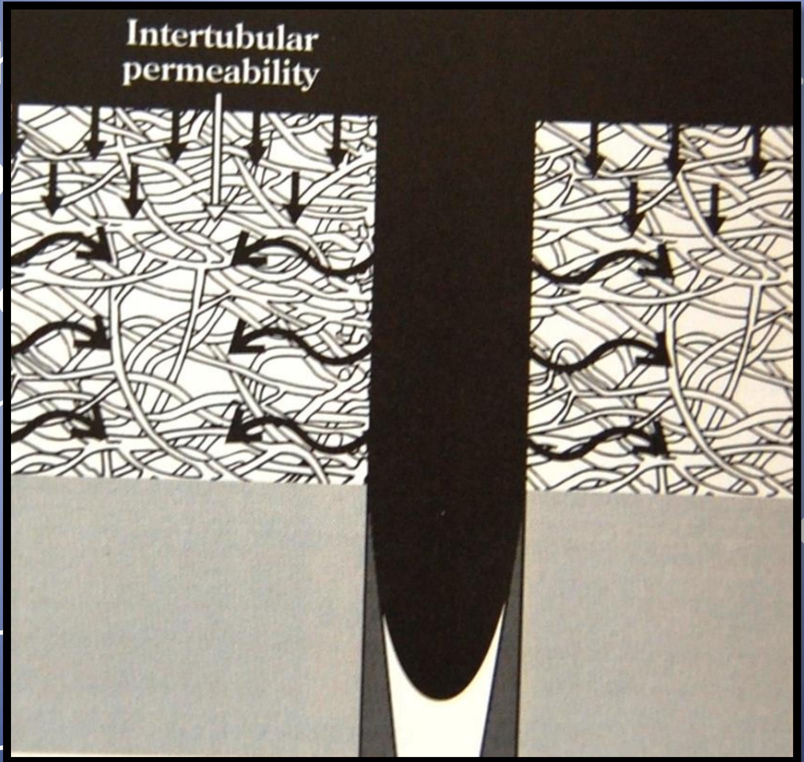
interconnected, narrow channels,

or pores



CHALLENGES IN DENTIN BONDING

FACTORS AFFECTING INTERACTION OF DENTNAL PERMEABILITY AND MONOMER DIFFUSION

Collagen fibril network

- Resin monomers penetrate acid etched collagen via spaces that can swell or shrink depending on bonding condition.
- Molecular entanglement of resin polymer with biologic polymer may be responsible for resin bonds to collagen.

Non collagenous proteins

- They are highly charged molecules that bind to water in demineralized dentin.
- Collagenous +non collagenous proteins + GAG's = hydrogel.
- Hydrogel- insoluble hydrophilic polymer network.

Primer solubility

- HEMA can replace water in spaces around collagen fibrils, it can serve as a polymerizable solvent for subsequently placed adhesive monomers, given sufficient diffusion time.

CHALLENGES IN DENTIN BONDING

FACTORS AFFECTING INTERACTION OF DENTNAL PERMEABILITY AND MONOMER DIFFUSION

Collagen fibril network

Non collagenous proteins

Primer solubility

Fluid flow

Tubular branching

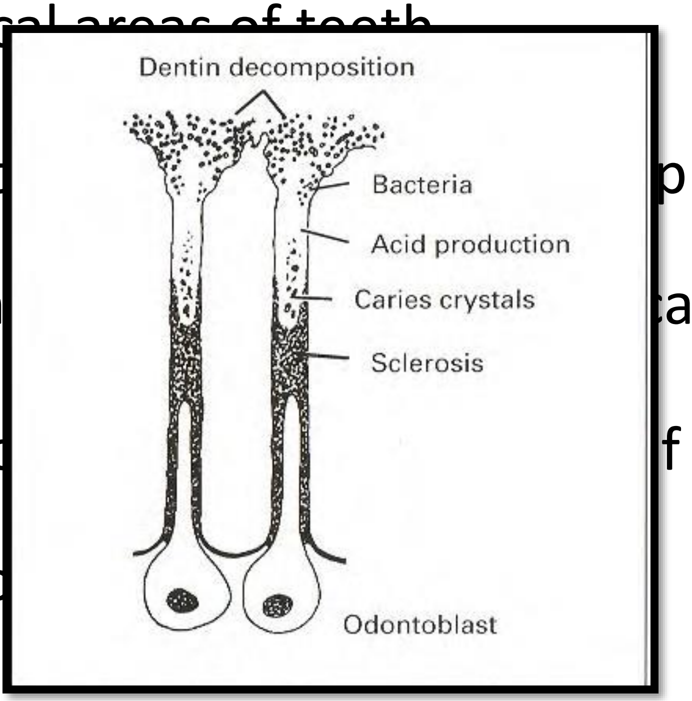
- Areas with high tubule density that are in direct contact with pulp are difficult to dehydrate.
- Multiple applications of primer allow sufficient occlusion with resin monomers to block diffusion of water from the pulp.

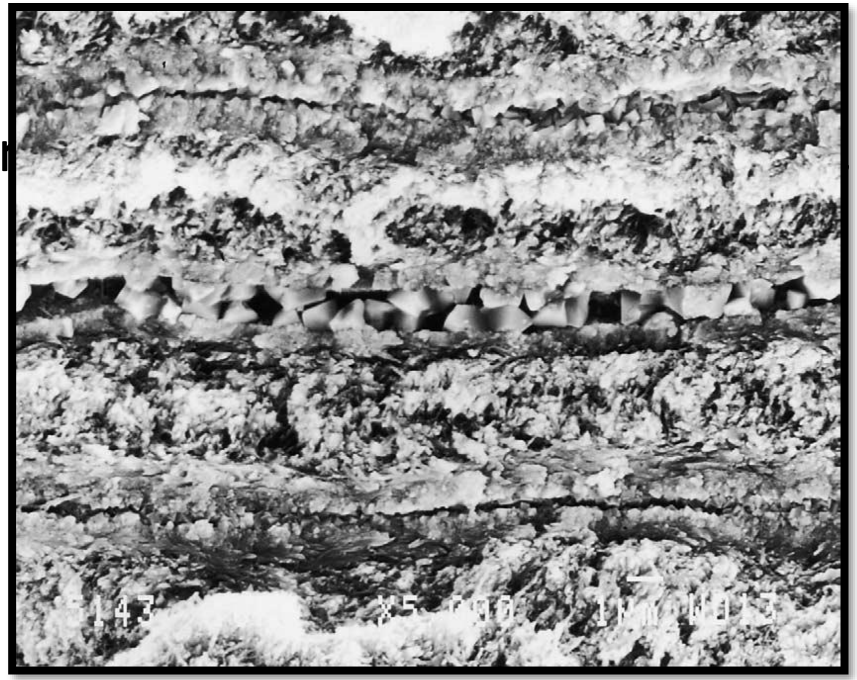
- Dentinal tubules permit adhesive monomers to flow.
- Most tubules contain lateral branches that radiate 2-6 µm from lumen.
- These branches provide route for monomer infiltration.

CHALLENGES IN DENTIN BONDING

CHANGES IN DENTIN: Sclerosed dentin

- Formation of transparent, glass like dentin. which occurs in the cervical areas of teeth.
- React pr
  mech ca
- Sclero f
  has lo





- It has areas of complete hyper-mineralization, without tubule exposure even when etched
- Thus, its less receptive to adhesive treatments than is normal

CHALLENGES IN DENTIN BONDING

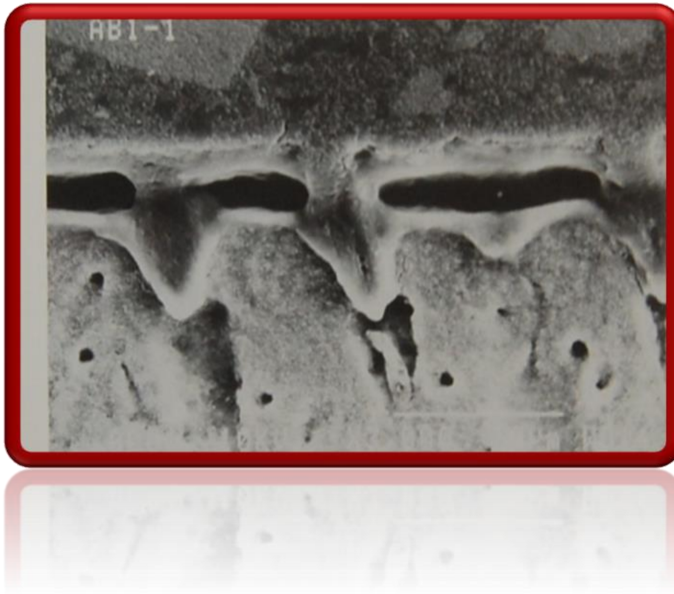
CHANGES IN DENTIN: Disease

Caries

Non caries cervical

Reduced permeability

Short resin tags



IDEAL REQUIREMENTS OF DENTIN BONDING AGENTS

✓Provide high bond strength to dentin that should be present immediately after placement and that should be permanent.

✓ Provide bond strength to dentin similar to that of enamel.

✓Show biocompatibility to dental tissue including the pulp.

✓Minimize microleakage at the margins of the restorations.

✓Prevent recurrent caries and marginal staining.

✓Be easy to use and minimally technique sensitive.

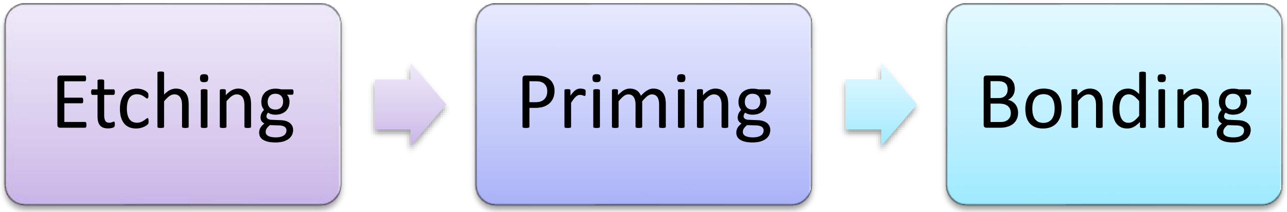
✓Possess a good shelf life.

✓Be compatible with a wide range of resins.

✓In addition it should be non toxic and non sensitizing to the operators or patients.

✓Bonding agents should seal the tooth surfaces from oral fluids.

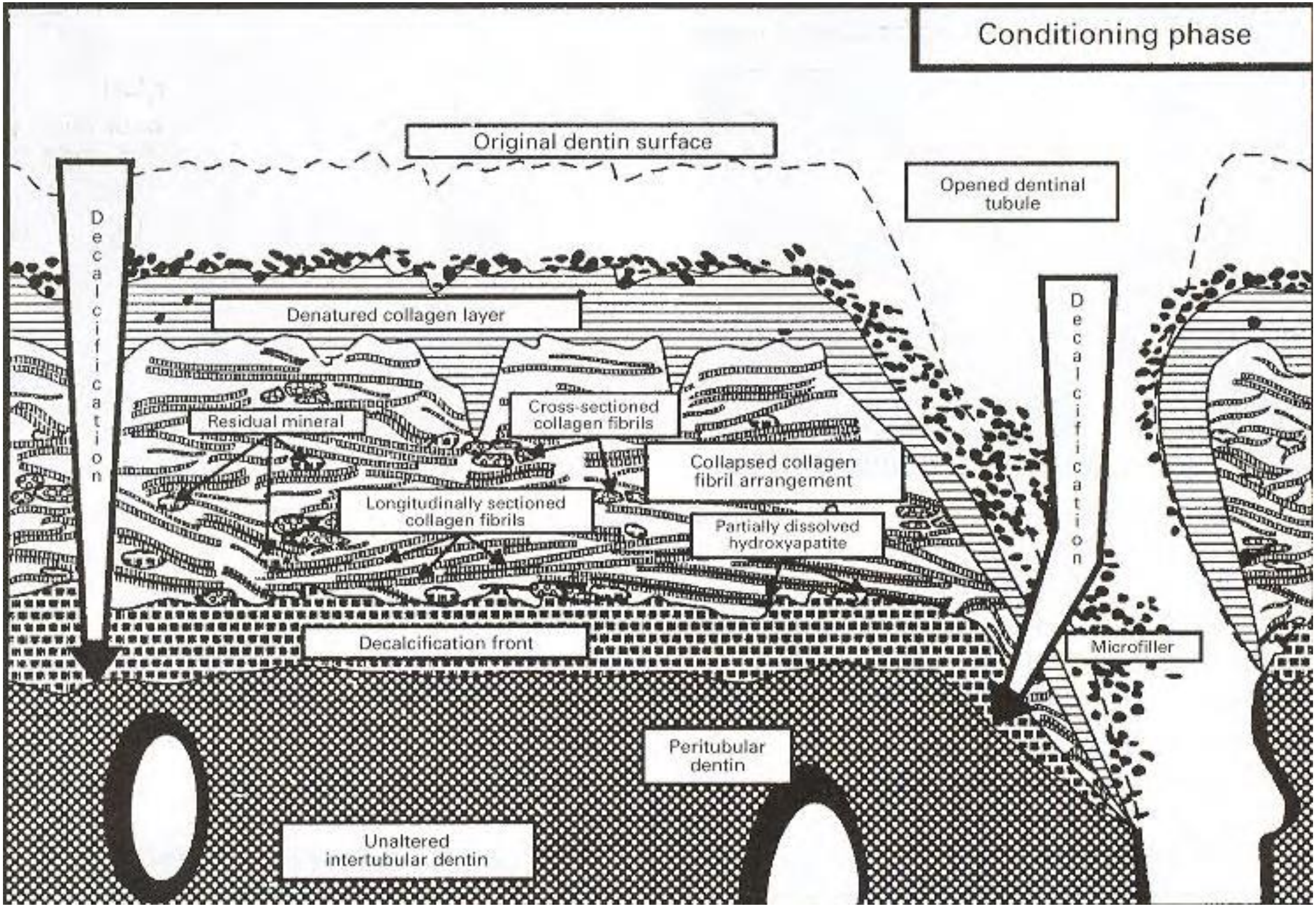
Adhesion to Dentin


Etching

Priming

Bonding

ETCHING/CONDITIONING



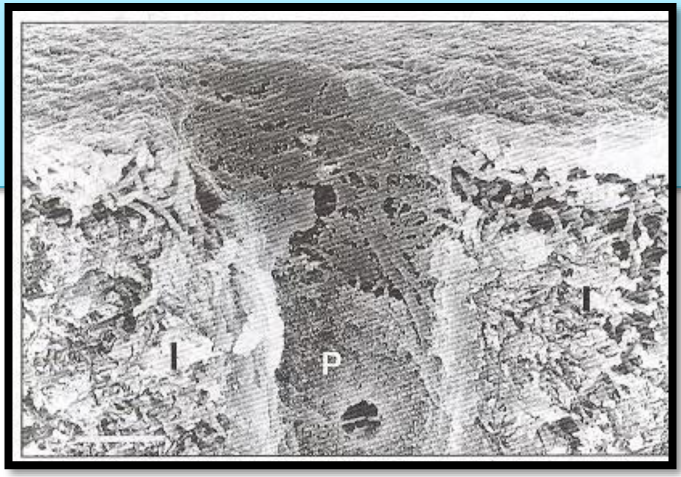
PRIMERS

Definition

Primers are the agents that promote wetting of the dentin with the bonding agent and increase the penetration of the bonding agent into the dentin.

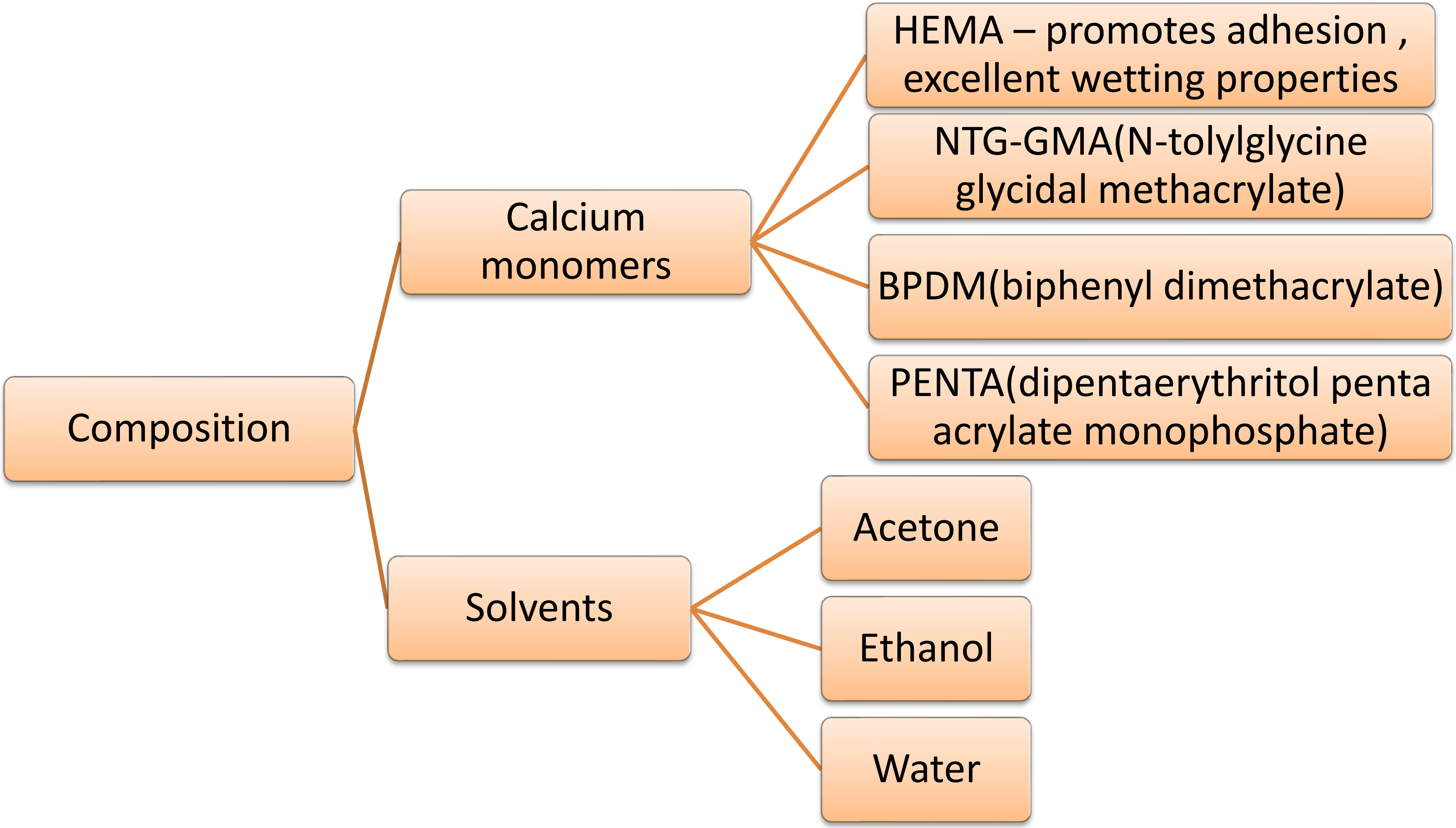
Objective-

Hydrophilic dentin → Hydrophobic and spongy → Allow resin penetration



Primer applied on etched dentin

PRIMERS



Composition

Calcium monomers

HEMA – promotes adhesion , excellent wetting properties

NTG-GMA(N-tolylglycine glycidal methacrylate)

BPDM(biphenyl dimethacrylate)

PENTA(dipentaerythritol penta acrylate monophosphate)

Solvents

Acetone

Ethanol

Water

PRIMERS

Acetone based primers

Advan

Excelle

c

Advantages :

Slow evaporation

Not sensitive to wetness of dentin.

Have capacity to raise collapsed fibers.(9%-50%)

Good surface energy and good penetration

Ethanol based primers

Disadvan

Evapora

va

compos

Sensitiv

Multiple coat

nsi

volatil

Disadvantage:

Long

Wate

remo

Water based primers

<u>Acetone & H_2O</u>

Eg: Tenure- quick

<u>Acetone & ethanol</u>

Eg: All bond 2 (Bisco)

<u>Ethanol & water</u>

Eg: Gluma comfort bond
Scotchbond

Combination

E

Amal

Prom

Scotc

One st

Prime and Bo

Gluma one bond.

ACETONE	ACETONE WATER	ACETONE ETHANOL	ETHANOL	ETHANOL-WATER	WATER
ABC Enhanced (Chameleon)	AQ Bond (sun Medical)	All –Bond 2 (BISCO)	Excite (vivadent)	Gluma Comfort Bond (kulzer)	Amalgambond Plus (parkell)
EG Bond (Sun Medical)	Reactmer (shofu)	Optibond solo plus(Kerr)	Optibond FL (kerr)	ARTBond (coltene)	Scotchbond Multi-Purpose(3M)
Gluma One Bond (Kulzer)	Tenure Quik (Den- Mat)	PQ 1(ultradent)	Permaquik (ultradent)	Clearfil SE Bond (kurary)	
One step(BISCO)				Quadrant unibond (Lavex)	Denthesive II(kulzer)
Permagen(ultradent)				Scotch bond1 (3M)	EBS (ESPE) Fujibond LC (GC)
Prime & Bond				Syntac sprint(vivadent)	One-Coat bond (colleen)
Solid bond (kulzer)				Xeno 111(dentsply)	Prompt-L-pop 1,2 (ESPE)
Solist (DMG)					Syntac single component (vivadent)

ADHESIVE RESIN

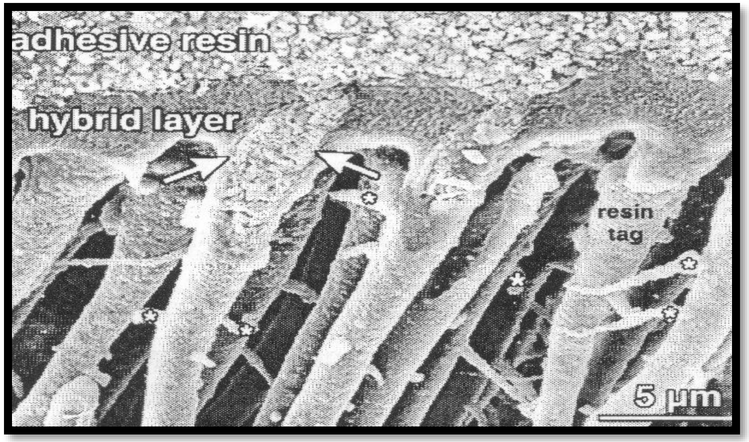
- Hydrophobic monomers- BIS-GMA, UDMA, TEG-DMA and hydrophilic monomers like HEMA
- Light cure/ auotcure

Fill up the remaining pores between the collagen fibrils

Form resin tags to seal open dentinal tubules

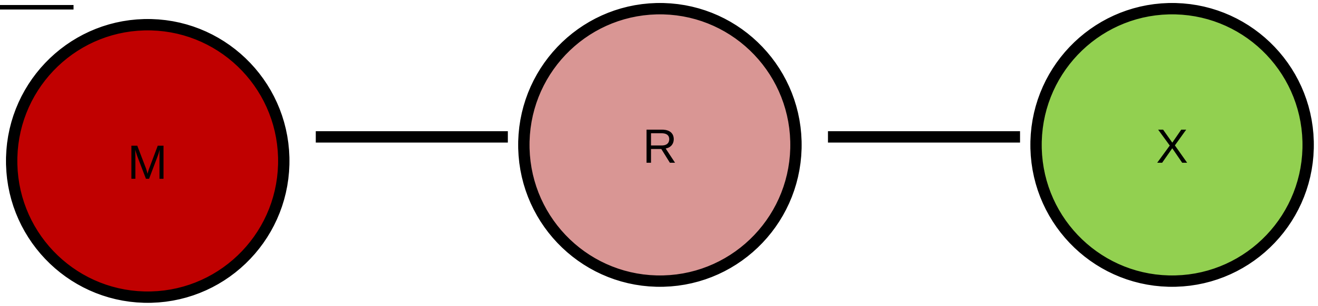
Initiates and advance the polymerization co polymerizes with the primer

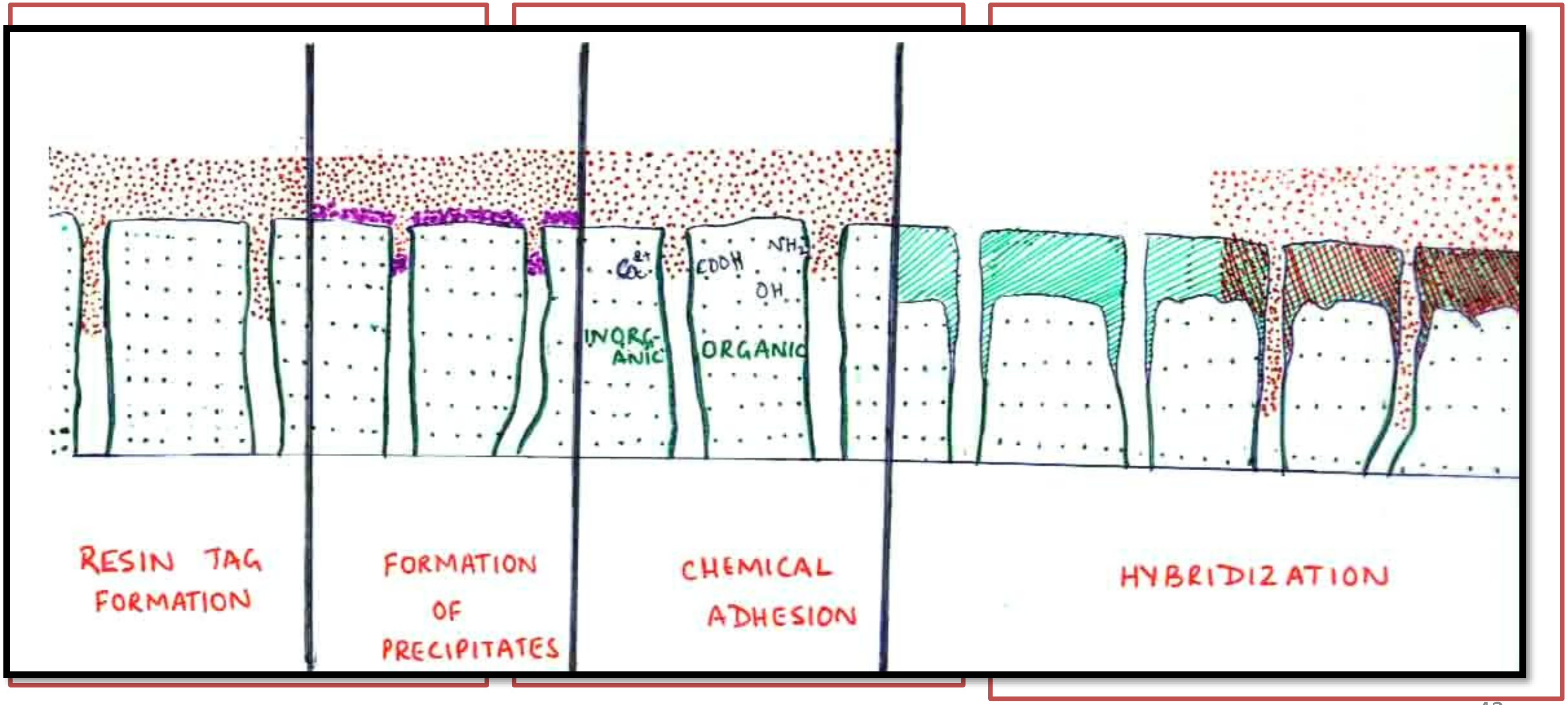
Stabilze hybrid layer and form resin tags



MECHANISM OF BONDING

STRUCTURE





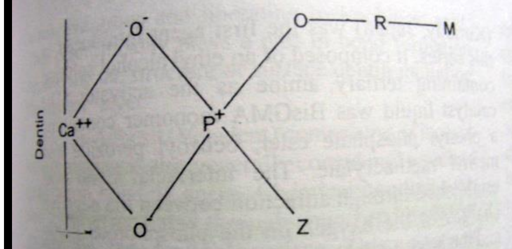
MECHANISM OF BONDING

Dentine

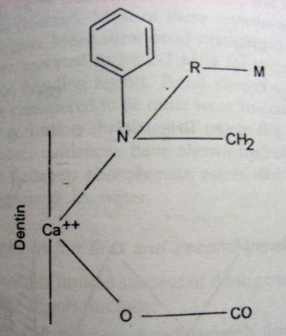
Adhesive

Inorganic portion

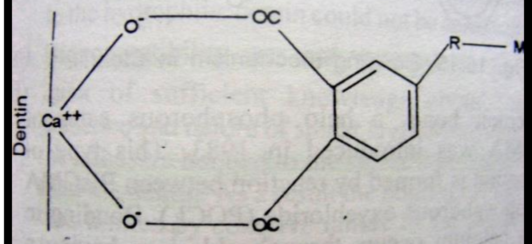
Between +ve Ca ions



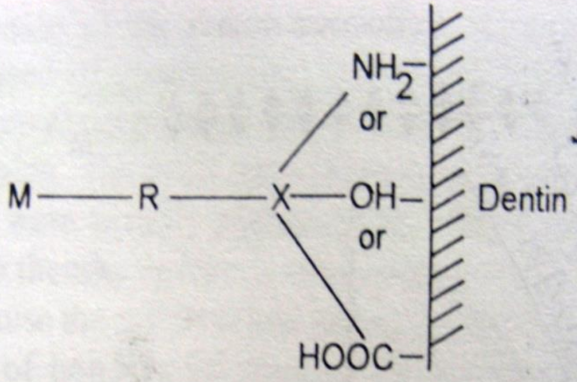
(a) Phosphate based adhesive



(b) Amino acid (NPG GMA) based adhesive



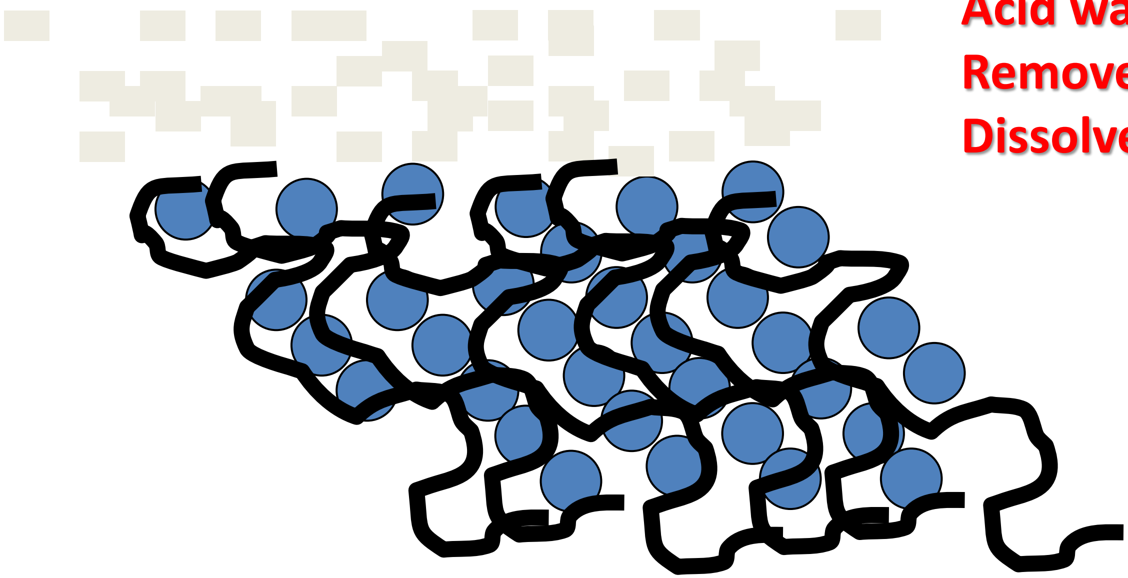
(c) Dicarboxylic acid (PAA) based adhesive



M – Methacrylate
X – Isocyanate, carboxylic acid chloride/anhydride or aldehyde
R – Spacer

Fig. 16.12. Bonding to organic part of Dentin.

MECHANISM OF BONDING

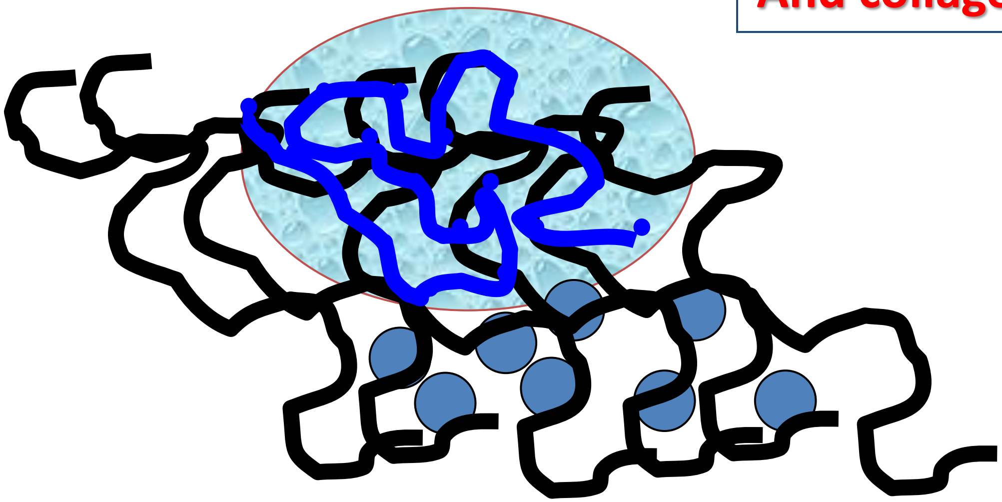


Acid washing / rinsing
Removes smear layer
Dissolves HA

Drying shrinks remaining
Collagen polymer molecules

Rehydration / priming
Swells collagen

MECHANISM OF BONDING



Monomer polymerisation
And collagen entanglement

Monomer penetration

CLASSIFICATION OF DENTIN BONDING AGENTS

- ✓ According to generations.
- ✓ According to adhesion strategy(No of clinical applications).
- ✓ According to chemical composition.
- ✓ According to treatment of smear layer.
- ✓ According to pH.
- ✓ According to bond strength.
- ✓ According to mode of curing.
- ✓ According to type of solvent.

EVOLUTION OF BONDING AGENTS

According to generations:

Evolution of bonding agents from

No etch to

total etch

and self etch.

FIRST GENERATION

- **Bonding mechanism:**

- The development of surface active co-monomer NPG-GMA was first commercially available agent in 1965.
- Chelation with calcium on the tooth surface to generate water resistant chemical bonds of resin to dentinal calcium.

- **Agents used in this generation:**

- NPG-GMA.
- Glycerophosphoric acid dimethacrylate (GPA-DMA).
- Cyanoacrylates
- Polyurethanes

FIRST GENERATION

- **Bond Strength: 2-3 Mpa.**
- **Disadvantages:**
  - The bond strength of these adhesives was poor (about 3 MPa).
  - Poor mechanical retention.

Eg: Cervident(S.S White, Lake wood, NJ) First commercially available bonding agent.

Cosmic bond(Amalgamated Dental Company)

Palakav(Kulzer, USA).

SECOND GENERATION

- In 1978, the Clearfil Bond System F(Kuraray, Osaka, Japan) was introduced in Japan, -the first product of the second generation adhesives.
- Phosphorous esters of methacrylate derivatives.

Agents used in this generation:

- Clearfil bond system F.
- Scotch bond dual cure(3M ESPE).
- Bondlite (Kerr).
- Prisma Universal Bond(Johnson and Johnson).

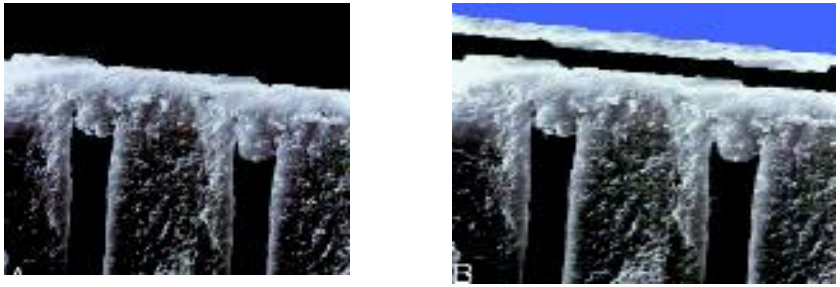
SECOND GENERATION

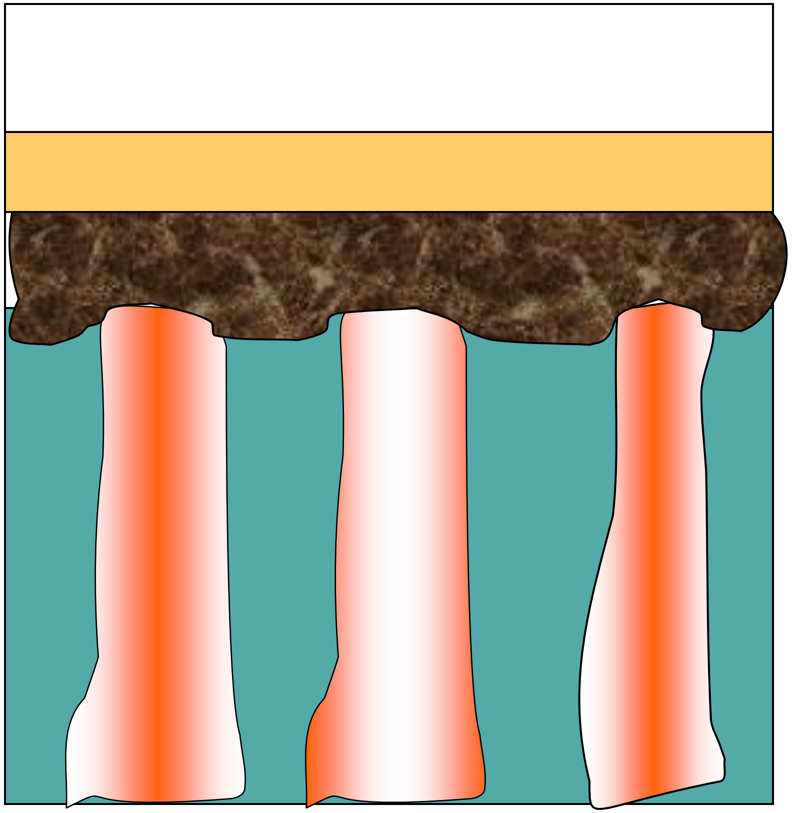
- **Mechanism of action:**

Surface wetting phenomenon and ionic interaction between negatively charged phosphate groups in the resin and positively charged calcium in the smear layer.

- **Bond strength:**

5 Mpa, which was considerably low





Smear layer not removed in second generation adhesives

THIRD GENERATION

- These adhesives were introduced in the mid to late 1980s.

  The third generation procedures involved two approaches:

  - Modification of smear layer to improve its properties.
  - Removal of smear layer partially without disturbing the plugs that occluded the dentinal tubules.

- The conditioning agents either:
  - Modified "SMEAR LAYER-MODIFYING SYSTEM" or
  - Removed "SMEAR LAYER-REMOVING SYSTEM" the smear layer before placement of adhesive resins.

THIRD GENERATION

- **Mechanism of action:**

The phosphate primers modifies the smear layer by softening it; after penetration it cures forming a hard surface

- **Bond strength**: **9-15 Mpa.**
- **Disadvantages**:

  More number of steps.

  Technique sensitive

  Retention decreased with time (longevity questionable)

FOURTH GENERATION

- **Total – etch concept (3 step)**
- **“ideal bonding agent”**
- **Bertolloti “ total etch, total seal, total success**
- Introduced in late 1980s by Bertolotti and Kanca
- Fear of damage to pulp- discouraged as very little acid actually penetrates dentin
- Mild acids- didn’t remove smear layer completely
- Involved phosphoric acid etching of dentin as well as enamel.

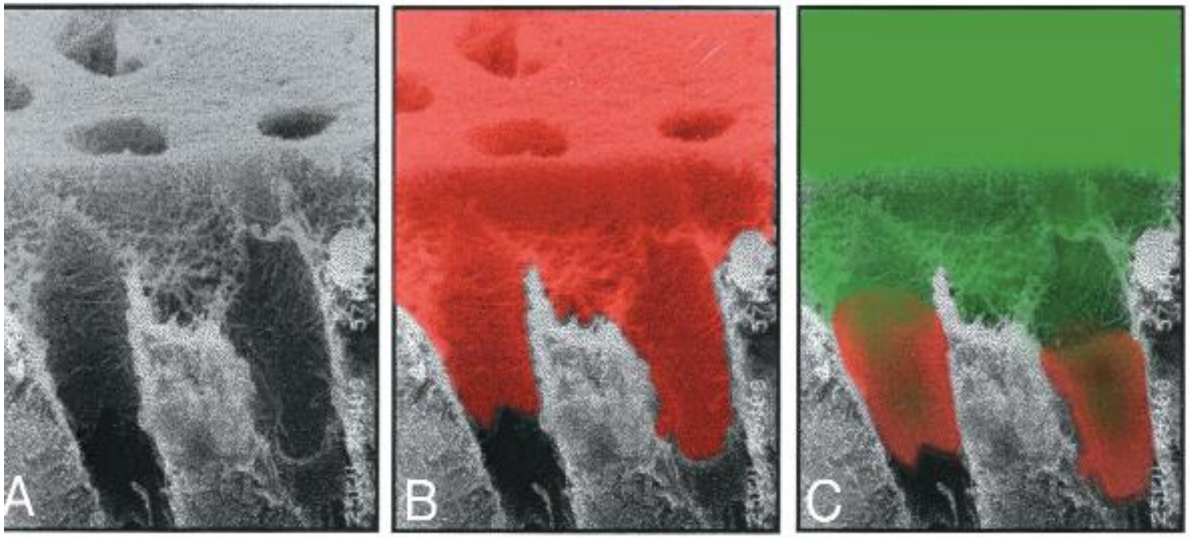
FOURTH GENERATION

Universal bonding systems

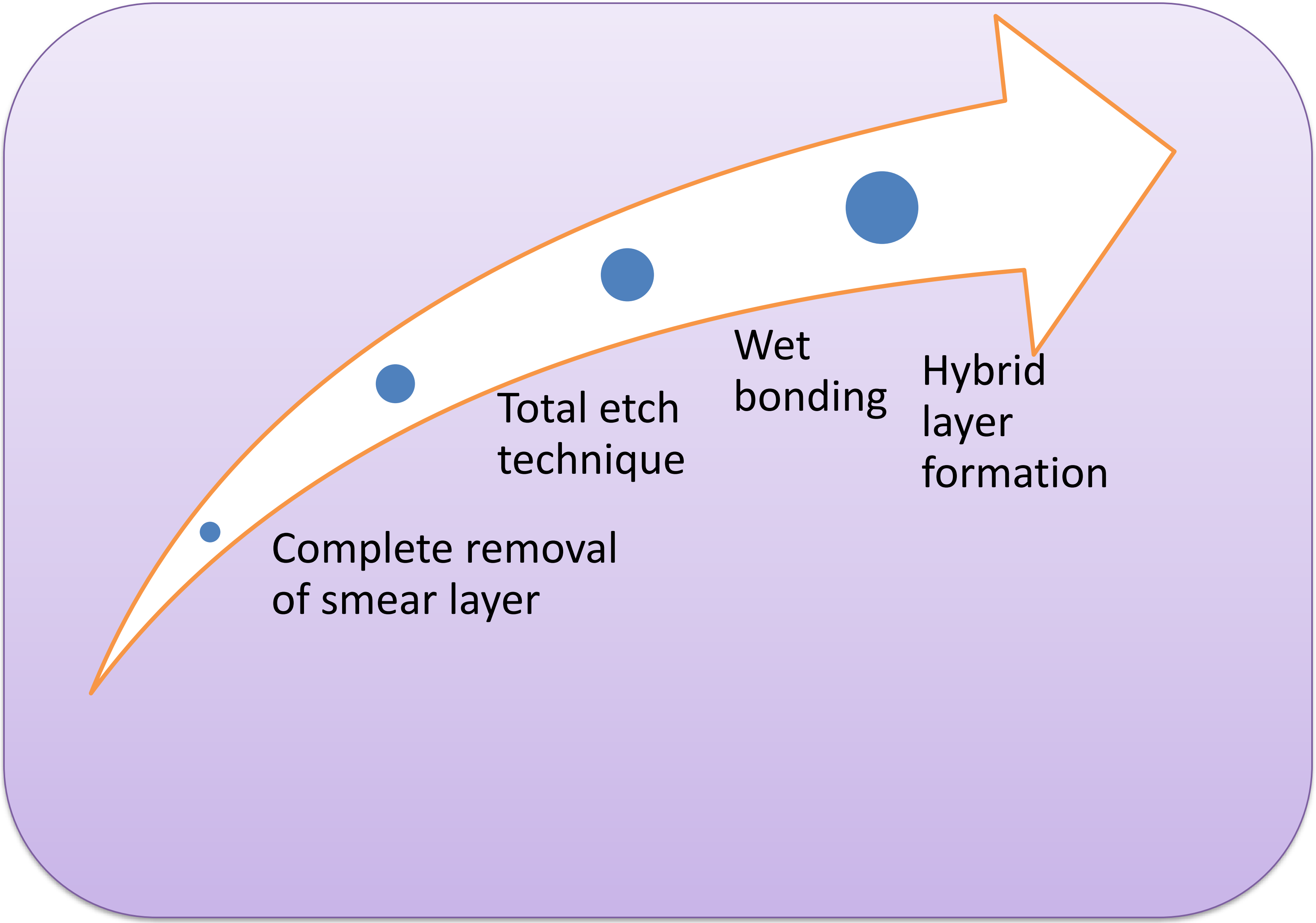
Mechanism of action :

- Etching removes smear layer completely , opens the tubules upto 7.5 µ and increases the permeability.
- Primer wets & penetrates the collagen meshwork and increases its surface energy and wettability into which the resin flows.

Bond strength : 17-30 Mpa



FOURTH GENERATION



Complete removal of smear layer

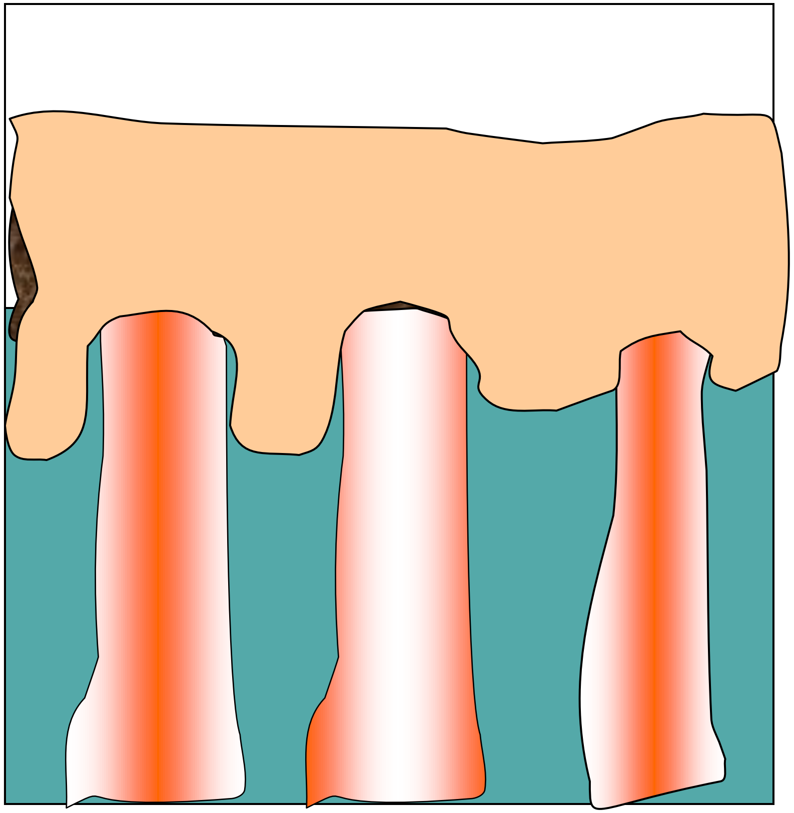
Total etch technique

Wet bonding

Hybrid layer formation

FOURTH GENERATION

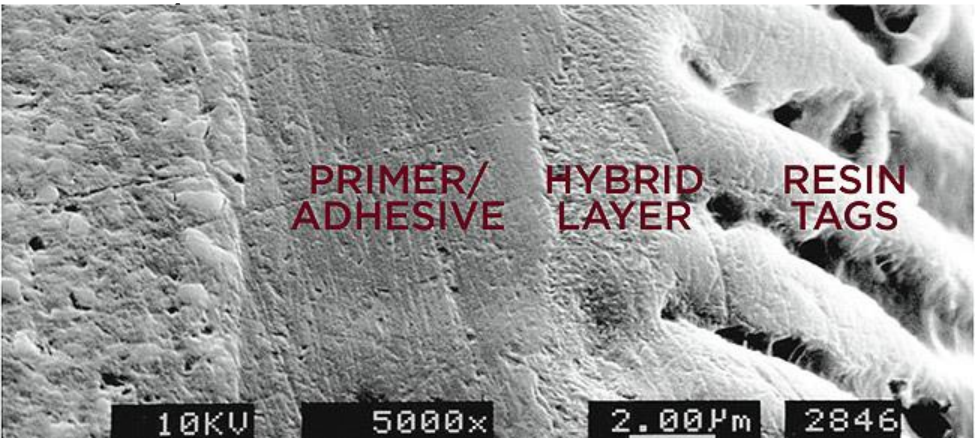
Total etch and Complete removal of smear layer



HYBRID LAYER

- Concept introduced in 1982 by Nobuo Nakabayashi
- " A process of diffusion and impregnation of resins into the substrate of partially demineralized dentin followed by its polymerisation creating a "resin – reinforced hybrid layers" or a "resin – dentin interdiffusion zone"

  (Nakabayashi1991)
- " 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" is known as Hybridized dental hard tissues; hybrid

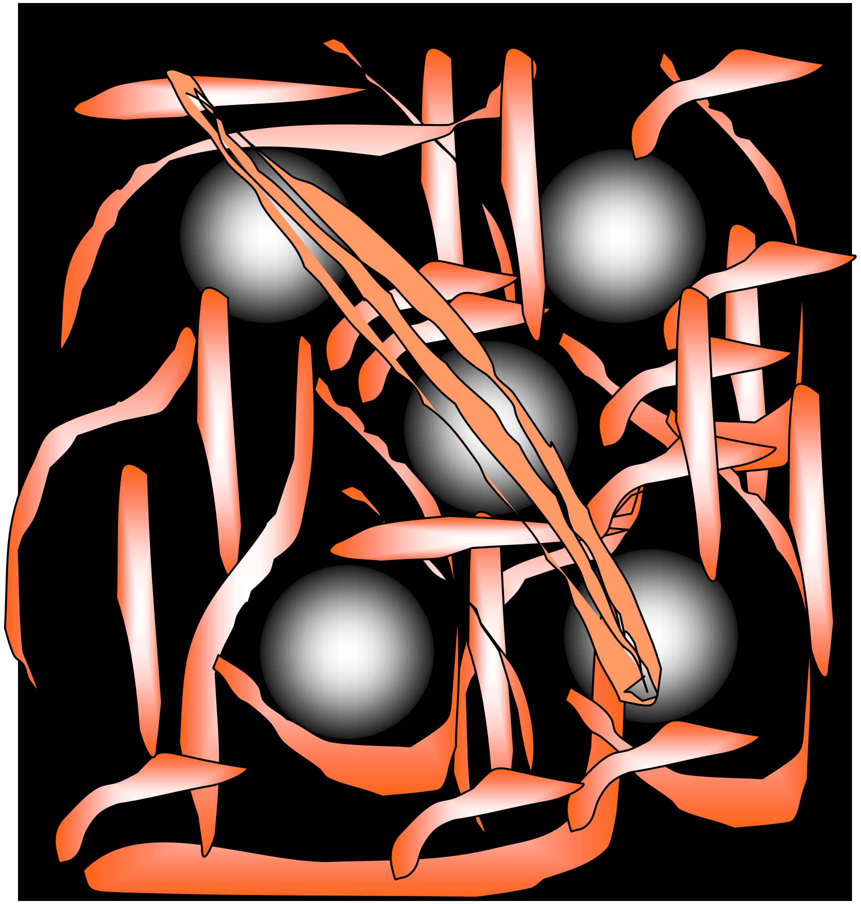


(Nakabayashi, Pashley

HYBRID LAYER

- Fundamental principle of hybridization is a micromechanical bonding mechanism, leading to formation of resin reinforced zone .
- Exchange process

Inorganic tooth material is exchanged for synthetic resin.



HYBRID LAYER

Involves 2 phases

Removal phase

- Removing calcium phosphate
- Micro porosities exposed at both the enamel and dentin tooth surface

Hybridization phase

- Infiltration of resin monomers by diffusion
- In situ polymerization of resin within the created surface micro porosities
- Micro mechanical interlocking

HYBRID LAYER

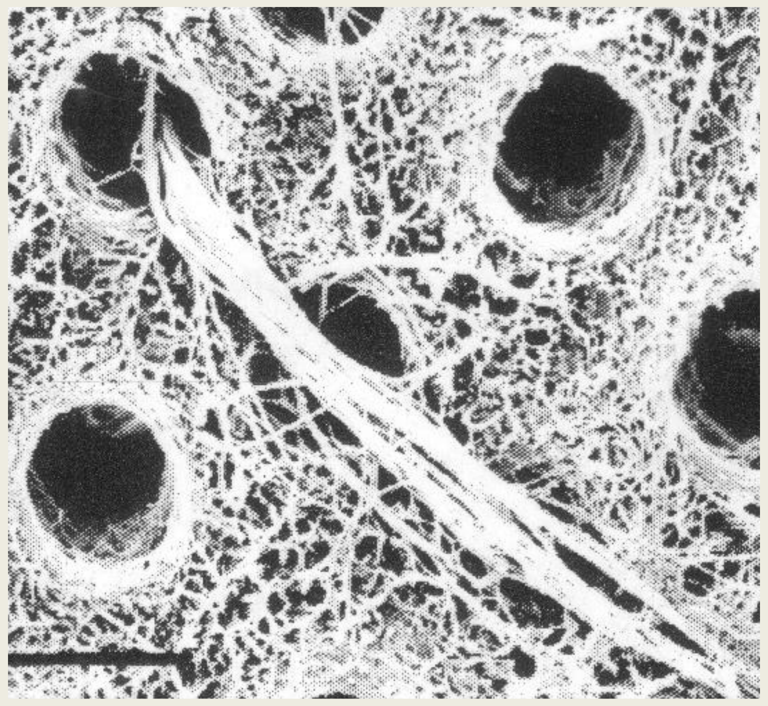
Specific structure seen in hybrid layer

Shag carpet appearance

Appears when dentin surface after being acid etched is actively scrubbed with an acidic primer solution.

Mechanism of action:

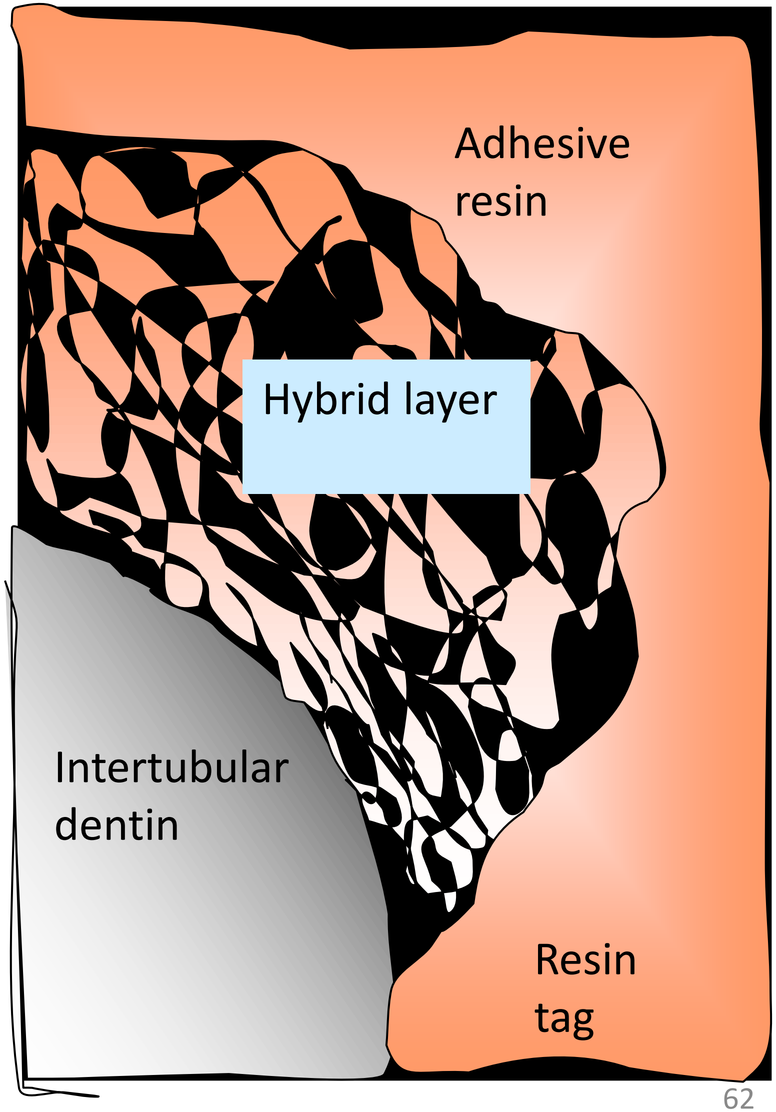
The combined mechanical and chemical action of rubbing the acid etched dentin with an acidic primer dissolves additional mineral salts while fluffing and separating the entangled collagen at the surface.



HYBRID LAYER

Tubule wall hybridization:

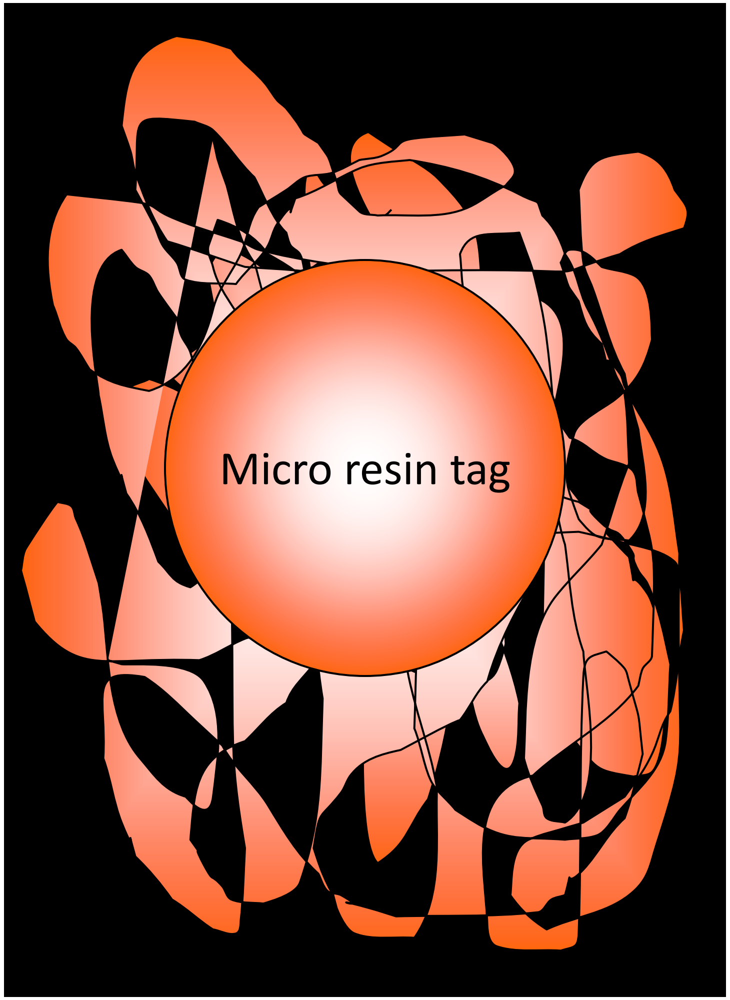
- Extension of the hybrid layer into tubule wall area.
- Hermetically sealing the pulpodentinal complex against microleakage
- Especially protective when bond fails at top or bottom of the hybrid layer
- The resin tags keep tubules which ensures a leakage free seal of tubules.



HYBRID LAYER

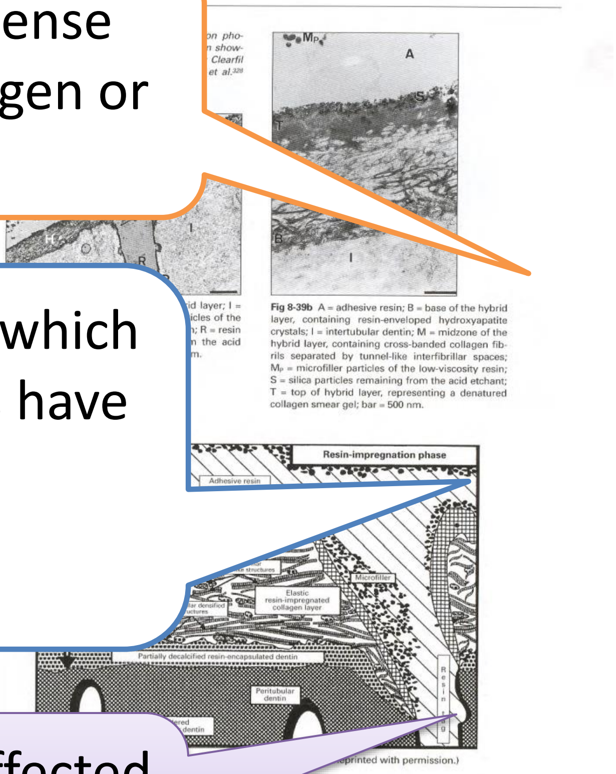
Lateral tubule hybridization :

- Formation of tiny hybrid layer into the walls of lateral tubule branches.
- This microversion of hybrid layer typically surrounds a central core of resin called microresin tag.



HYBRID LAYER

LAYERS



Amorphous electron dense layer –denatured collagen or very loosely arranged collagen

Interfibrillar spaces in which hydroxyapatite crystals have been repalced by resin monomer because of hybridization process

Consists of almost unaffected dentin with partially demineralized zone of dentin

Fig 8-39b A = adhesive resin; B = base of the hybrid layer, containing resin-enveloped hydroxyapatite crystals; I = intertubular dentin; M = midzone of the hybrid layer, containing cross-banded collagen fibrils separated by tunnel-like interfibrillar spaces; M_P = microfiller particles of the low-viscosity resin; S = silica particles remaining from the acid etchant; T = top of hybrid layer, representing a denatured collagen smear gel; bar = 500 nm.

HYBRID LAYER

Properties of hybrid layer

- Primarily organic composition of top 2-4 µm of dentin
- Acid – resistant

  Proteolysis – resistant
- Modulus of elasticity is lower than dentin
- More tough than dentin

Modulus of Elasticity (G Pa)	**Mineralized Dentin**	**Demineralized**	**Resin infiltrated**	**Restorative resin**
	14-17	**0.005**	**2-6**	**4-27**

	Mineralized	Demineralized	Resin infiltrated
Fracture Toughness MN/mm3	4.2±1.1	11.3±3.5	27.7±10.8

HYBRID LAYER

Reverse Hybrid layer:

- Acid etched surface of dentin, when subjected to treatment with NaOCl, , dissolution of exposed collagen fibrils occurs.
- Further the use of self etching primers results in superficial etching of the surface. Here the hybrid layer is surrounded by more of inorganic material

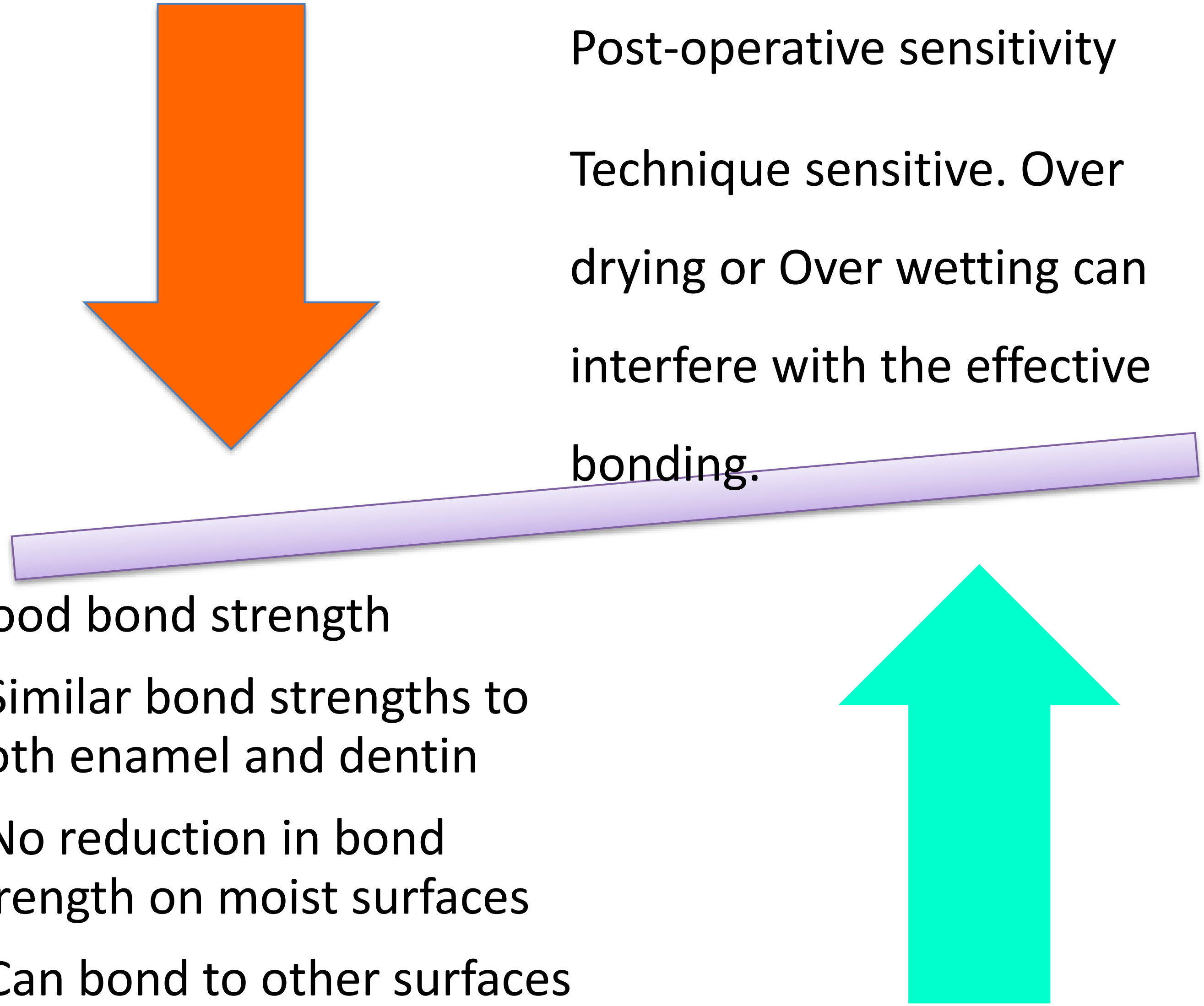
Ghost hybrid layer:

- Formed due to incorporation of air bubbles at the substrate adhesive interface.

- *Albaladejo A et al (2010)* evaluated the effectiveness in the formation of resin tags, adhesive lateral branches and hybrid layers of etch and rinse & self etch adhesive systems, when bonding to dentine
- They stated that hybrid layer (resin tags) formed were longer in etch and rinse adhesive systems.

Hybrid layers of etch-and-rinse versus self-etching adhesive systems. Albaladejo A[1], Osorio R, Toledano M, Ferrari M. Med Oral Patol Oral Cir Bucal. 2010 Jan 1;15(1):e112-8.

FOURTH GENERATION



Multiple bottles- cumbersome.

Post-operative sensitivity

Technique sensitive. Over drying or Over wetting can interfere with the effective bonding.

Good bond strength

- Similar bond strengths to both enamel and dentin
- No reduction in bond strength on moist surfaces
- Can bond to other surfaces (metals, amalgam, porcelain)

FOURTH GENERATION

Name	Bond Strength	Conditoner	Primer	Unfilled resin
All bond 2 bisco	21.2+7.8Mpa	37% phosphoric	2%NTG- GMA 16%BPDM	BisGMA 40% 30%UDMA 30%HEMA
Scotch bond multipurpose-3M	21.8 MPa to wet dentin 17.8 Mpa to dry dentin	10% maliec acid 3Mic M depth	Aqueous solution of HEMA Polyalkenoate polymers	Bis GMA containing HEMA
Amalgam Bond		10% Citric acid 19% Ferric Chloride	HEMA with water	4- META MMA-TBB.
Panavia 21 Kuraray	21+_1.5 Mpa	MDP HEMA 5 NMSA		Phosphoric acid ester of MDP

FIFTH GENERATION

"ONE BOTTLE" SYSTEMS / SELF PRIMING SYSTEMS

Objective-

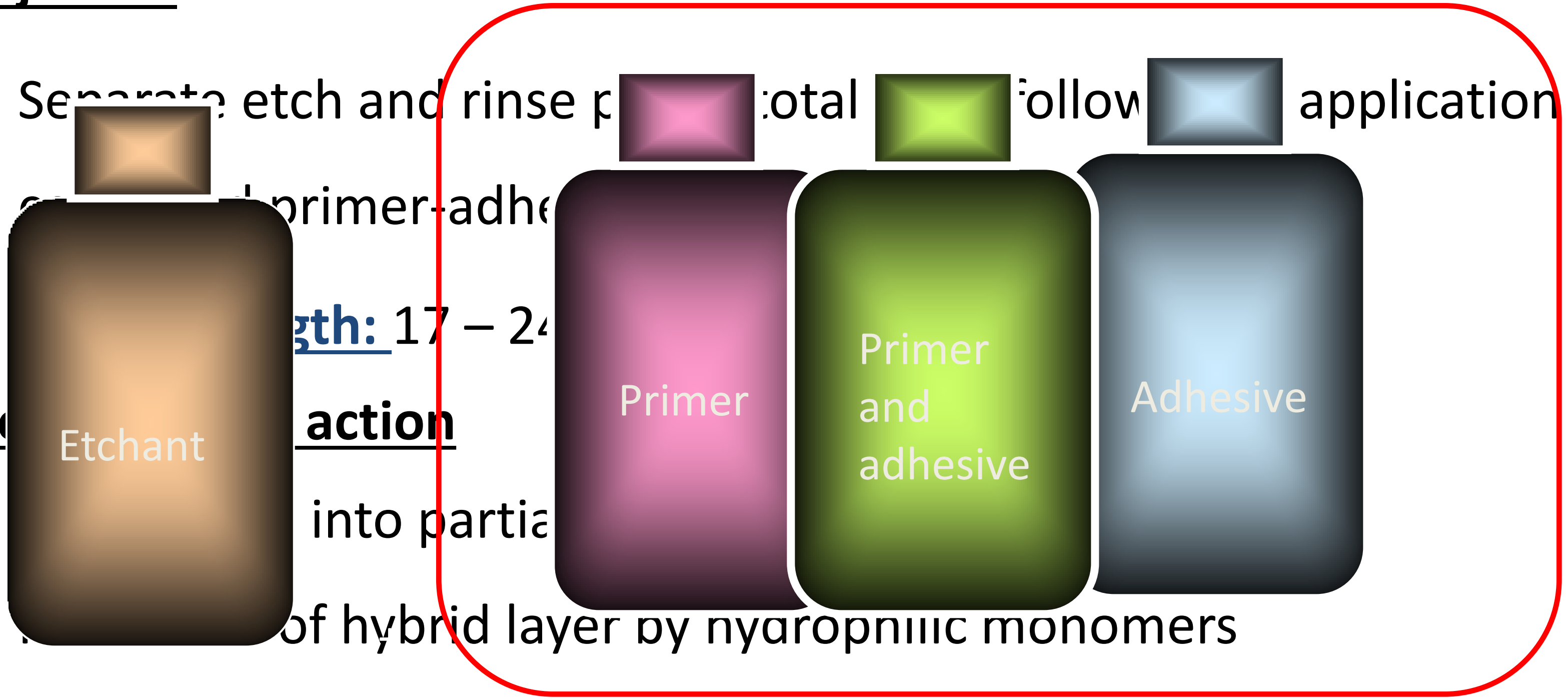
- Separate etch and rinse p total follow application of primer-adhe
- **gth:** 17 – 24

Me action

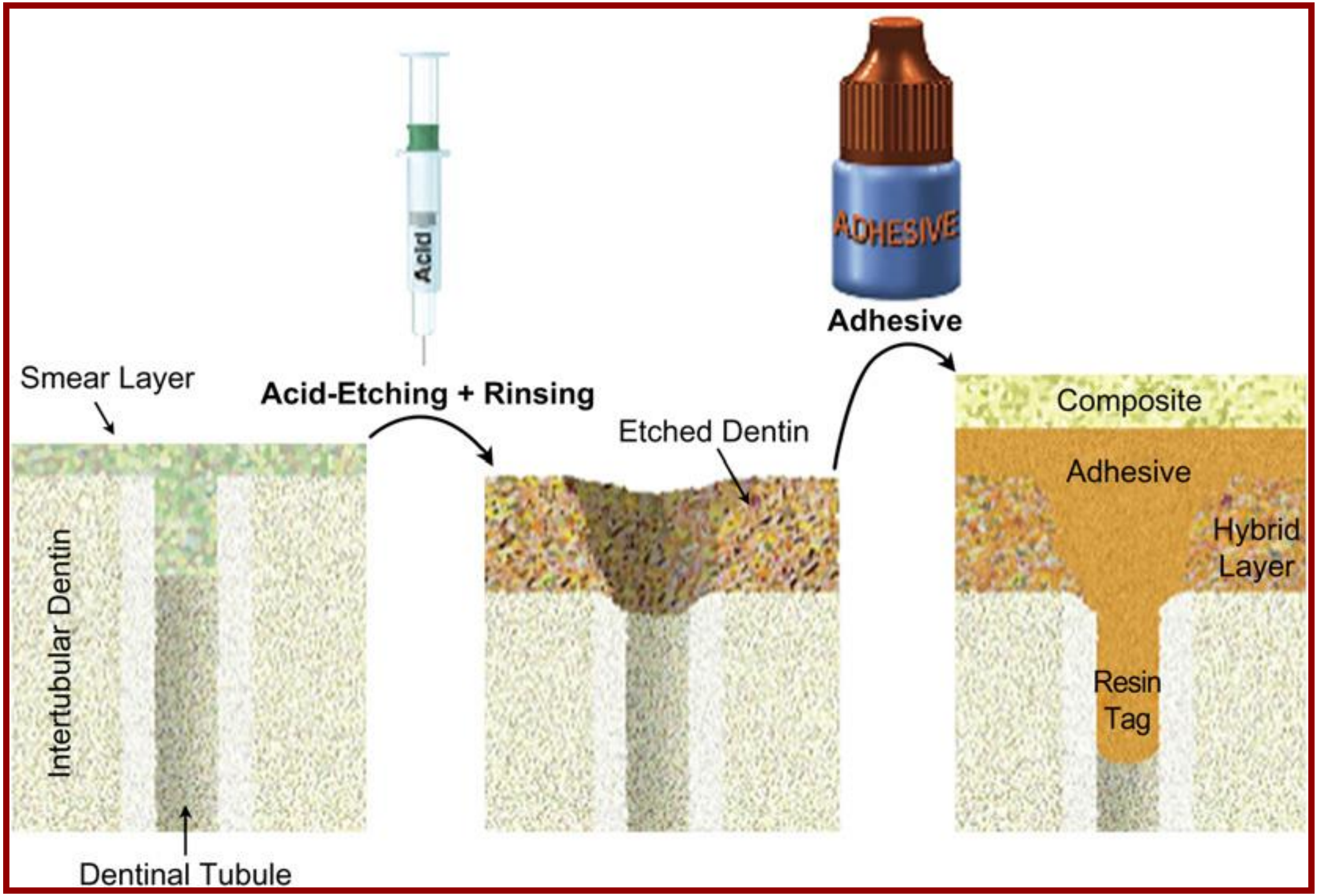
➢ into partia

➢ of hybrid layer by hydrophilic monomers

➢ Chemical interactions using first and second order bonding



FIFTH GENERATION



FIFTH GENERATION

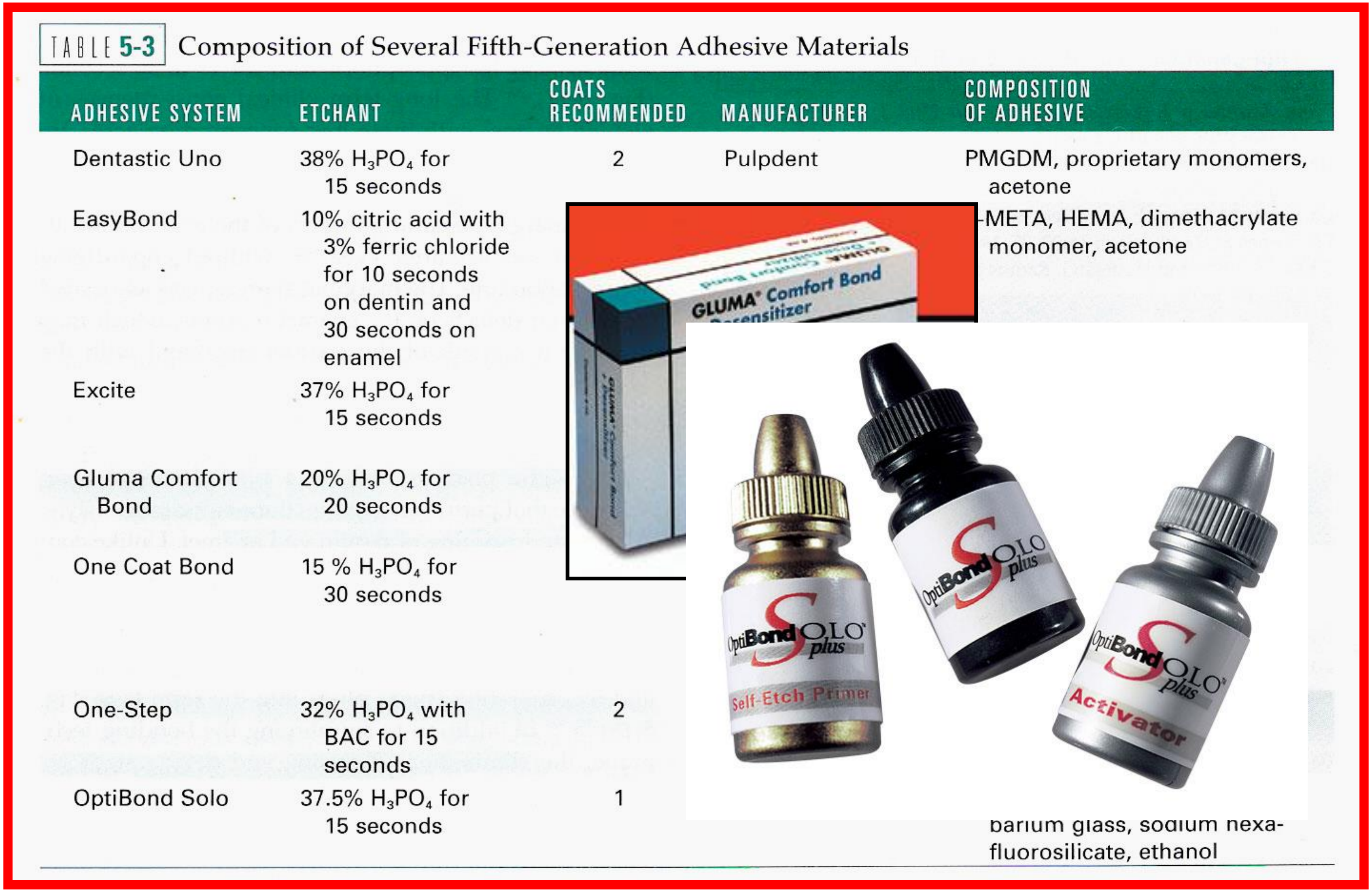
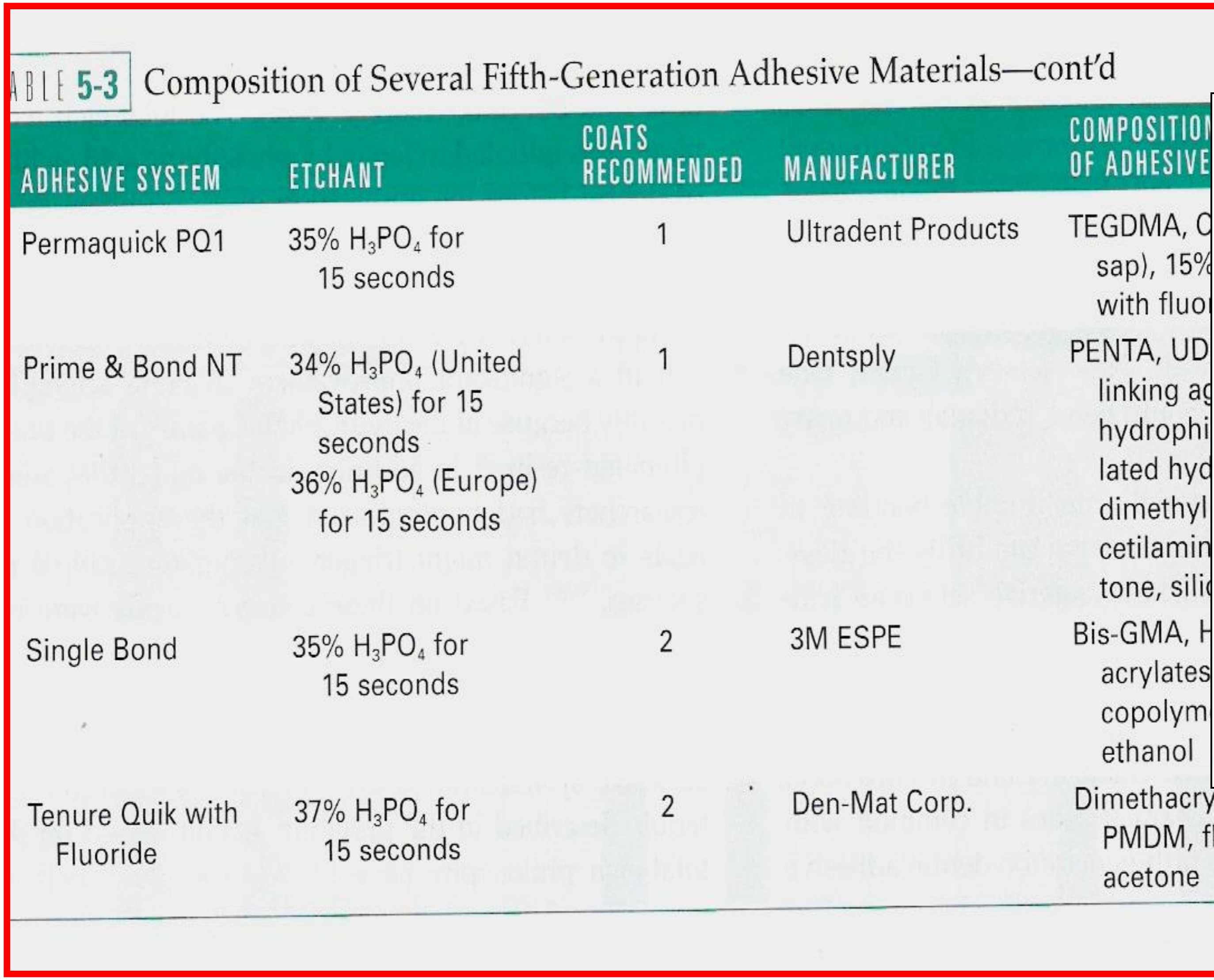


TABLE 5-3 Composition of Several Fifth-Generation Adhesive Materials

ADHESIVE SYSTEM	ETCHANT	COATS RECOMMENDED	MANUFACTURER	COMPOSITION OF ADHESIVE
Dentastic Uno	38% H_3PO_4 for 15 seconds	2	Pulpdent	PMGDM, proprietary monomers, acetone
EasyBond	10% citric acid with 3% ferric chloride for 10 seconds on dentin and 30 seconds on enamel			-META, HEMA, dimethacrylate monomer, acetone
Excite	37% H_3PO_4 for 15 seconds			
Gluma Comfort Bond	20% H_3PO_4 for 20 seconds			
One Coat Bond	15 % H_3PO_4 for 30 seconds			
One-Step	32% H_3PO_4 with BAC for 15 seconds	2		
OptiBond Solo	37.5% H_3PO_4 for 15 seconds	1		barium glass, sodium hexafluorosilicate, ethanol

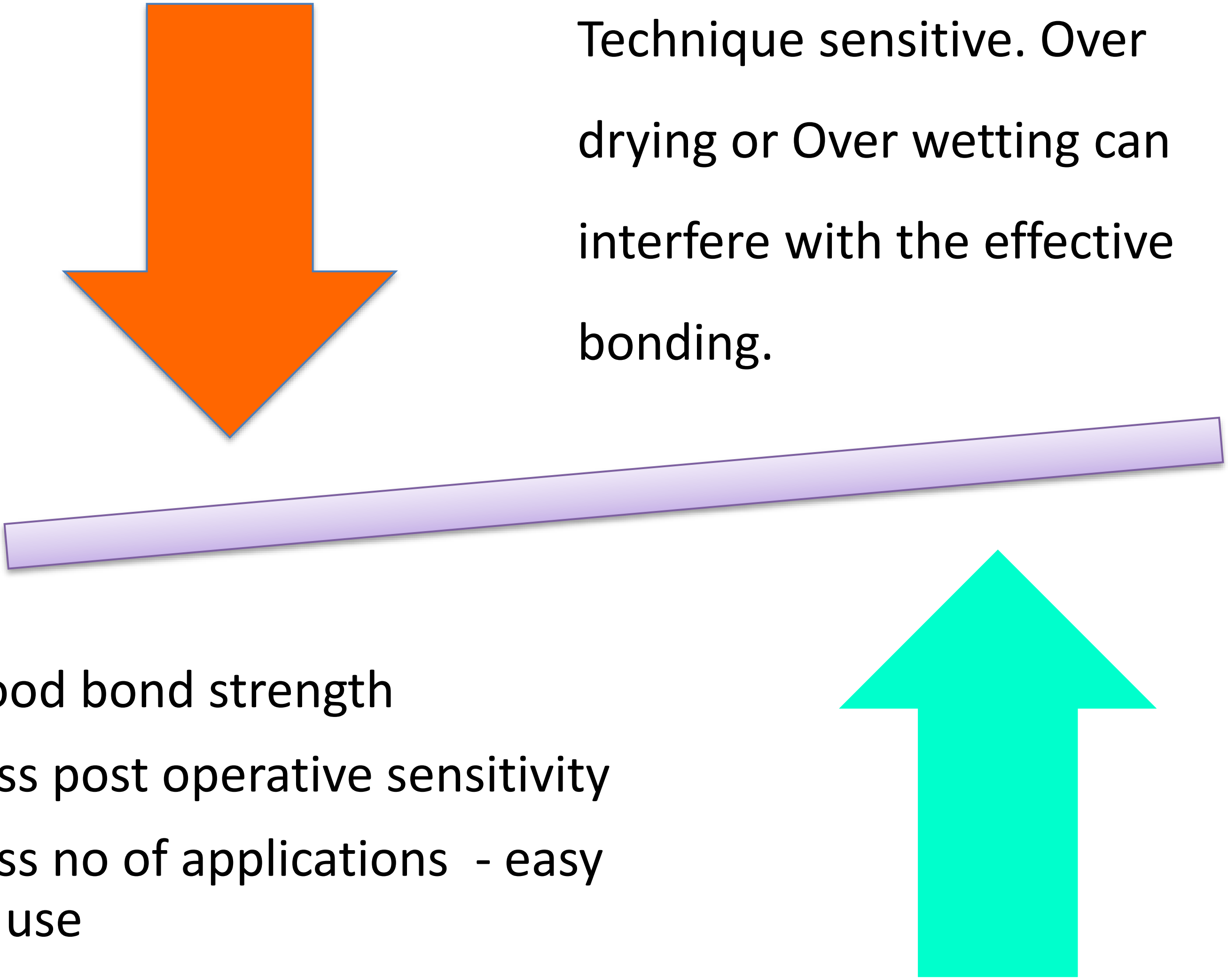
FIFTH GENERATION



ABLE 5-3 Composition of Several Fifth-Generation Adhesive Materials—cont'd

ADHESIVE SYSTEM	ETCHANT	COATS RECOMMENDED	MANUFACTURER	COMPOSITIO OF ADHESIVE
Permaquick PQ1	35% H_3PO_4 for 15 seconds	1	Ultradent Products	TEGDMA, C sap), 15% with fluo
Prime & Bond NT	34% H_3PO_4 (United States) for 15 seconds 36% H_3PO_4 (Europe) for 15 seconds	1	Dentsply	PENTA, UD linking ag hydrophi lated hyd dimethyl cetilamin tone, sili
Single Bond	35% H_3PO_4 for 15 seconds	2	3M ESPE	Bis-GMA, H acrylates copolym ethanol
Tenure Quik with Fluoride	37% H_3PO_4 for 15 seconds	2	Den-Mat Corp.	Dimethacrylate resins, HEMA, PMDM, fluoride, initiator, acetone

FIFTH GENERATION



Technique sensitive. Over drying or Over wetting can interfere with the effective bonding.

Good bond strength

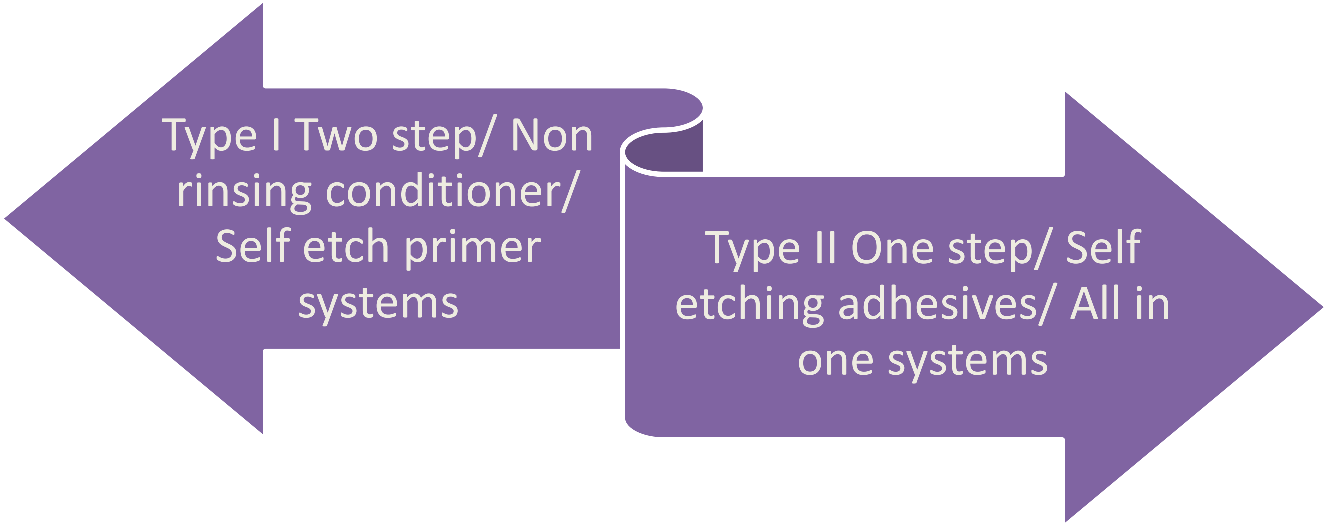
Less post operative sensitivity

Less no of applications - easy to use

SIXTH GENERATION

Sixth Generation Bonding agents:

- *Self - etching primers*
- **Late 1990s**
- **Primer and etchant are combined in one step.(Self etching primers)**



Type I Two step/ Non rinsing conditioner/ Self etch primer systems

Type II One step/ Self etching adhesives/ All in one systems

SIXTH GENERATION

Etchant

Self etching primer

Primer

Adhesive

Etchant

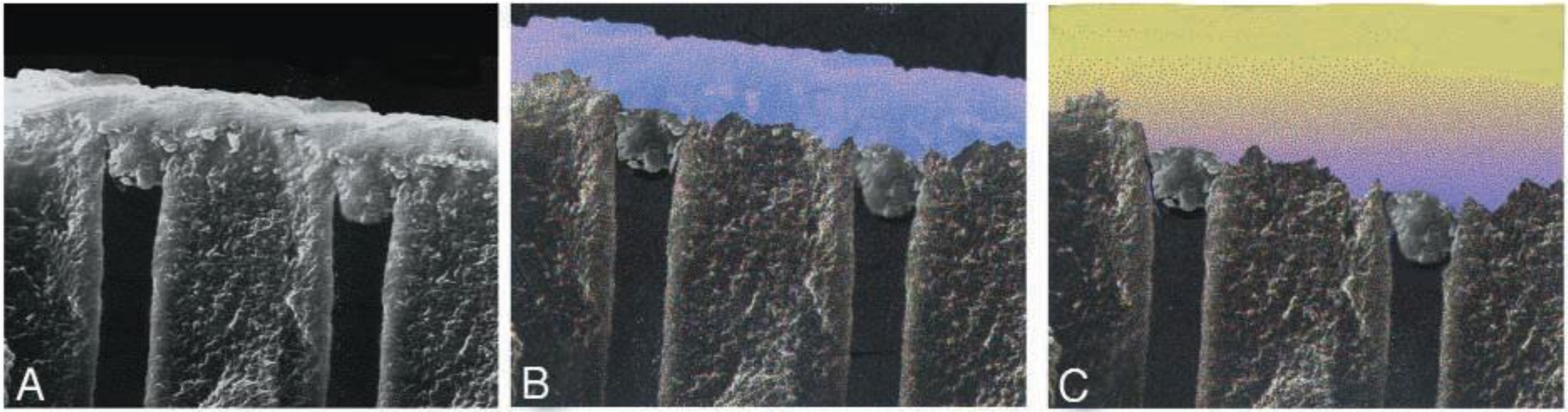
1step self etch adhesives

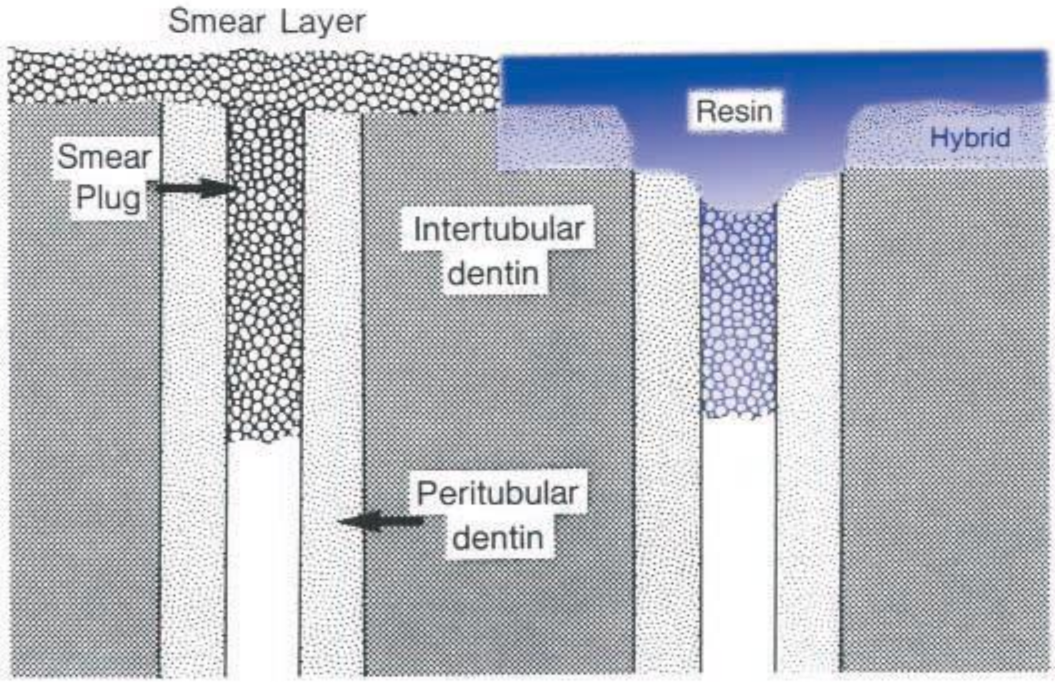
Adhesive

Sixth Generation

Type ii

SIXTH GENERATION



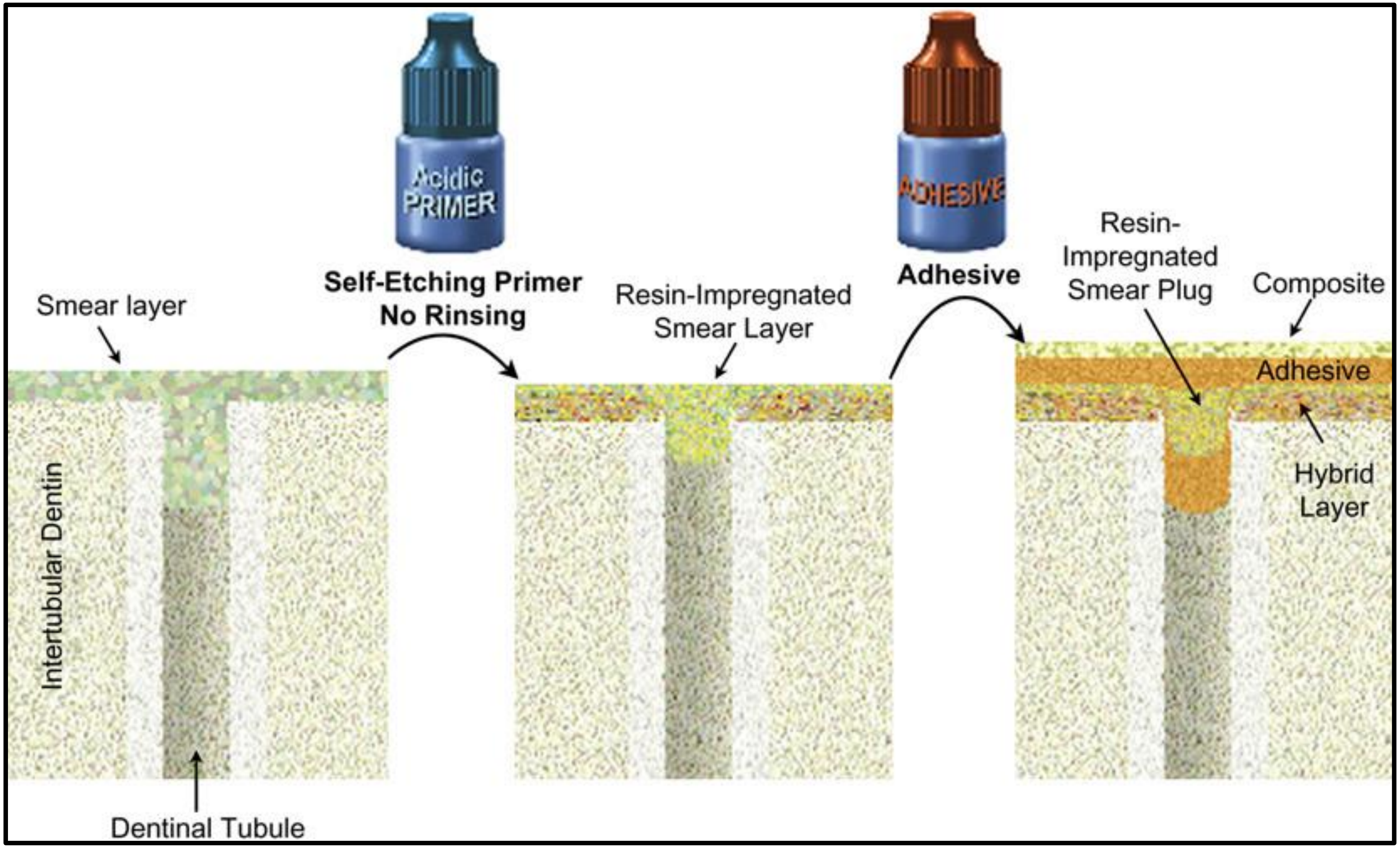


SIXTH GENERATION

Type I Two step/ Non rinsing conditioner/ Self etch primer systems:

- NRC followed by Prime and Bond NT (Dentsply)
- Clearfil SE Bond
- Clearfil Liner Bond IIV.
- Tryian(BISCO, Inc, Schaumburg,)
- Simplicity(Apex Dental Materials, Inc, Sandwich, IL)
- UniFil Bond(GC America, Alsip, IL)
- OneCoat Self-Etching Bond(Coltene)
- AdheSE(Ivoclar Vivadent)

SIXTH GENERATION



SIXTH GENERATION

Type II 6 th Generation Bonding agent :One step/ Self etching adhesives

•Attempt to incorporate all the primary components into a single container.

•Incorporating all components and having it remain stable is a significant challenge.

• In reality, many of these are not all in- one systems at all but require premixing of chemical components (Prompt-L-Pop) or the use of chemically activating pellets or brushes that come with the kit (Touch & Bond, Brush & Bond).

SIXTH GENERATION

PROMPT L-POP

It has 3 compartments:

- Compartment 1: Methacrylated phosphoric acid, photo initiator, stabilizers
- Compartment 2: Contains water, complex fluoride.
- Compartment 3: Microbrushes

The blister is activated by squeezing compartment 1, thereby releasing its content into compartment 2 and freshly mixed solution is released onto the microbrush into compartment 3 by squeezing compartment 2.

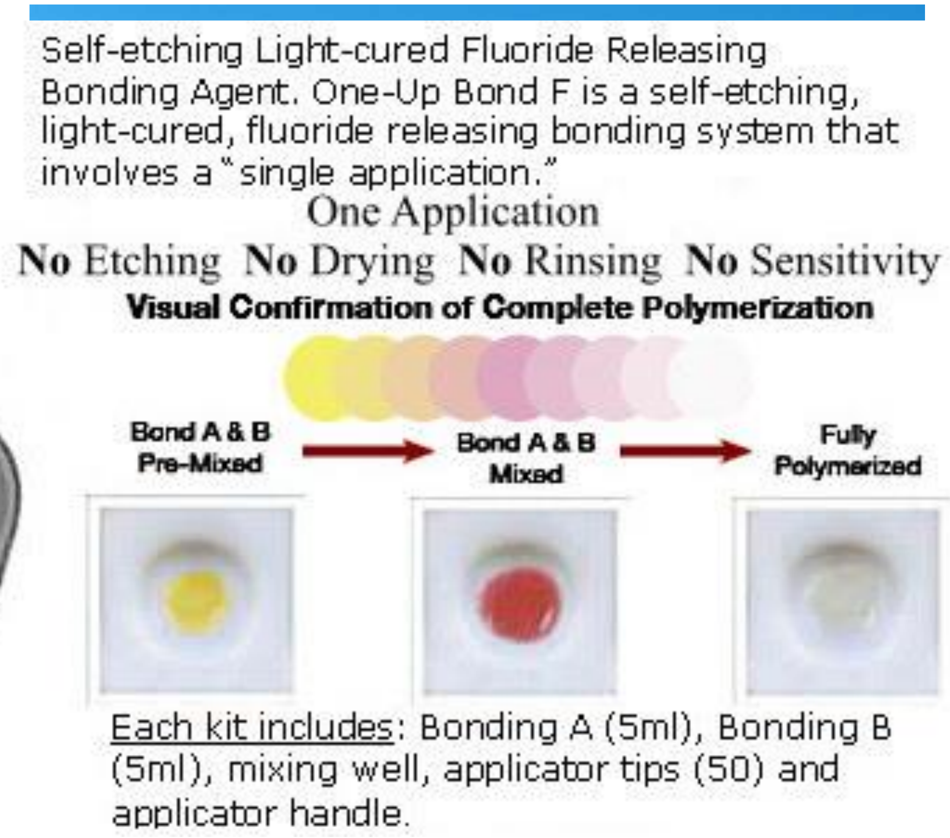
SIXTH GENERATION

BRUSH AND BOND

- The brush contains chemically impregnated bristles which when come in contact with the liquid triggers a cocatalytic action and improves subsequent cure.
- Chemically impregnated bristles which when come in contact with the liquid triggers a co catalytic action and improves subsequent cure.

SIXTH GENERATION

ONE UP BOND



Self-etching Light-cured Fluoride Releasing Bonding Agent. One-Up Bond F is a self-etching, light-cured, fluoride releasing bonding system that involves a "single application."

One Application

No Etching No Drying No Rinsing No Sensitivity

Visual Confirmation of Complete Polymerization

Bond A & B Pre-Mixed → Bond A & B Mixed → Fully Polymerized

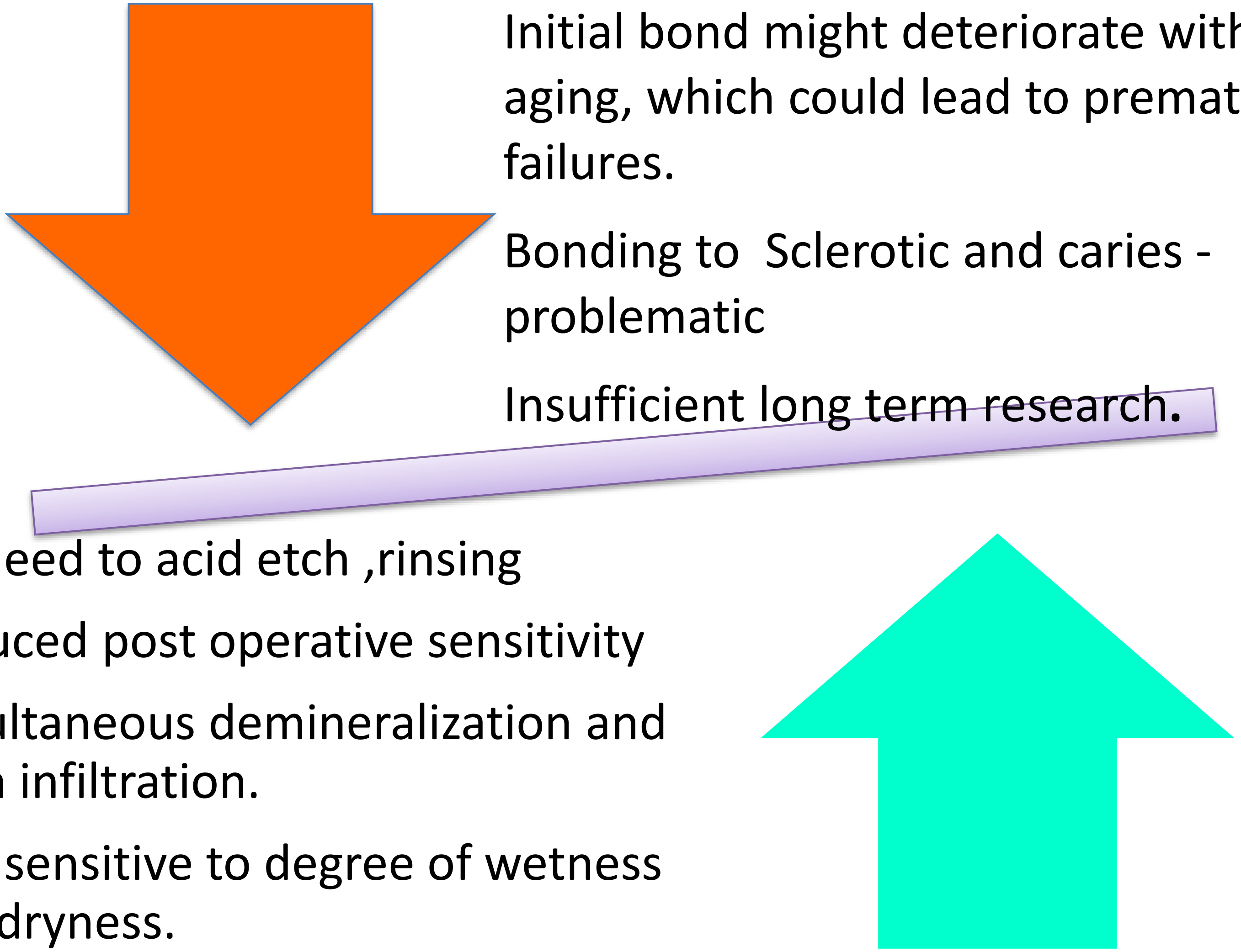
Each kit includes: Bonding A (5ml), Bonding B (5ml), mixing well, applicator tips (50) and applicator handle.

SIXTH GENERATION

TOUCH AND BOND

- The acetone-based liquid contains the acidic monomer 4-META (4-methacryloxyethyl trimellitate anhydride, 13% concentration), which serves as an etchant and primer
- The pledgets are impregnated with the co-initiator (sodium p-toluenesulfinate) that initiates a polymerization reaction when combined with the 4-META-containing liquid

SIXTH GENERATION



Less effective bonding of enamel:

Initial bond might deteriorate with aging, which could lead to premature failures.

Bonding to Sclerotic and caries - problematic

Insufficient long term research.

No need to acid etch ,rinsing

Reduced post operative sensitivity

Simultaneous demineralization and resin infiltration.

Less sensitive to degree of wetness and dryness.

Low technique sensitivity

SEVENTH GENERATION

The o

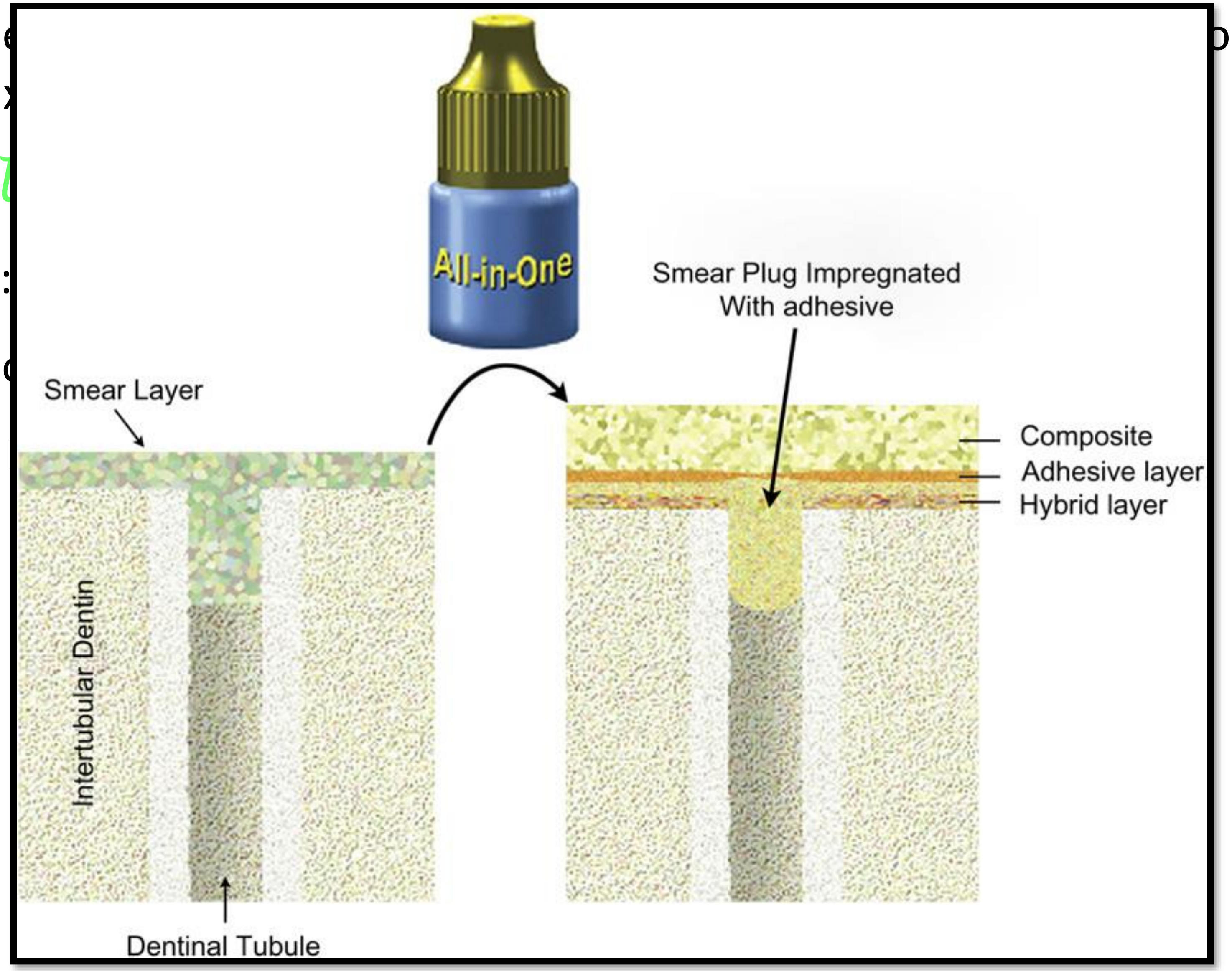
mix

Al

Eg:

I bo

G



SEVENTH GENERATION

I BOND

Heraeus Kulzer

- Single step no mix bonding system

- Five in one solution :

- ➢ Etch
- ➢ Disinfect
- ➢ Desensitize
- ➢ Prime
- ➢ Bond

-Composition :

Matrix – UDMA ; 4- META

Solvents – Acetone ; water

Photoinitiators – Camphoroquinone

SEVENTH GENERATION

G BOND

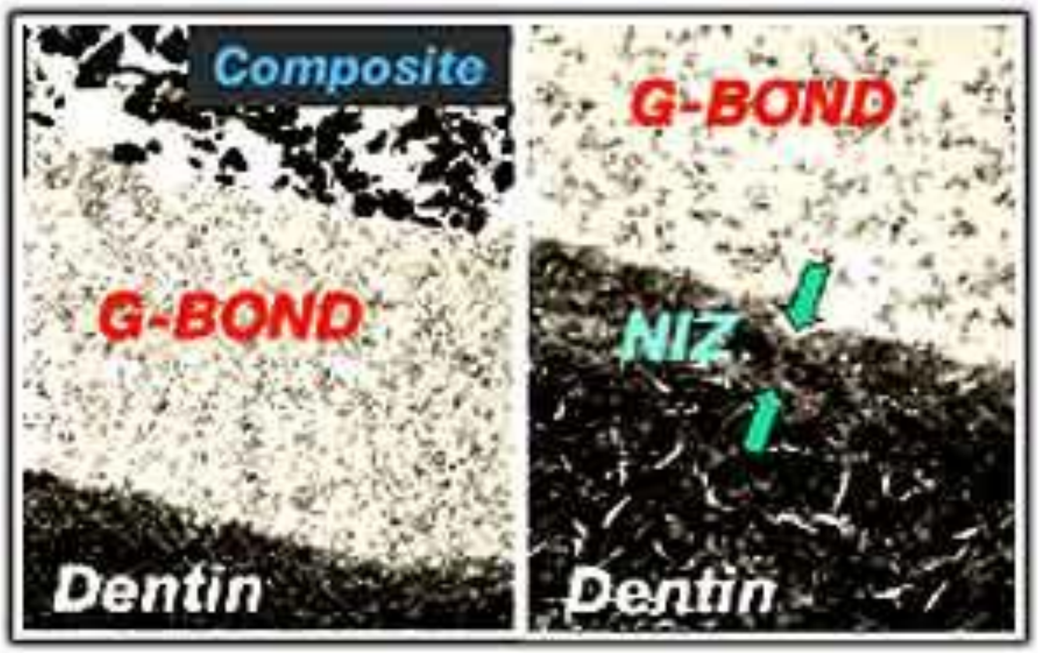
COMPOSITION –

- Advanced formulation of Phosphoric acid ester monomer,
- 4-MET monomer, nanofilled particles,
- Acetone & water as solvent used.

M.O.A –

This decalcifies the tooth, provides wetting property, diffuses monomer into the tooth structure, then polymerizes and hardens when light-cured and creates an ionic bond with the apatite in the tooth structure. Based on nano

SEVENTH GENERATION



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 exposure to collagen fibers.Ionic bond with hydroxyapatite of tooth structure,

- Hurmuzlu F et al (2007) evaluated the microtensile bond strengths of a total etch, 2-step self-etch and single-step self-etch adhesives.

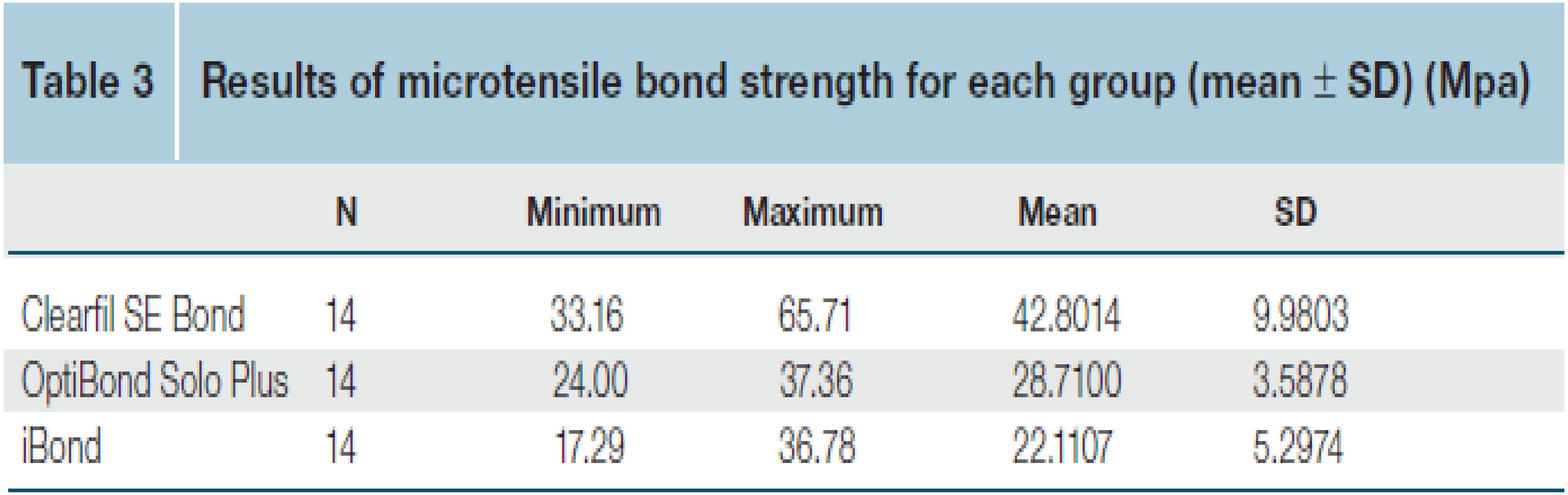


Table 3 Results of microtensile bond strength for each group (mean ± SD) (Mpa)

	N	Minimum	Maximum	Mean	SD
Clearfil SE Bond	14	33.16	65.71	42.8014	9.9803
OptiBond Solo Plus	14	24.00	37.36	28.7100	3.5878
iBond	14	17.29	36.78	22.1107	5.2974

- The results of bond strength were - Clearfil SE Bond (2 step) > 1-bottle adhesive system OptiBond Solo Plus (total etch system) > 1-bottle self etching adhesive system iBond.

Feridun, Özdemir,, Ihsan H, Akin C, Seyda H. Bond strength of adhesives to dentin involving total and self-etch adhesives. *Quintessence Int 2007;38:358.e206–212.*

- **Asande A O et al** determined the microshear bond strengths of five 'all-in-one' adhesives and two 2-step self-etching primer adhesives to dentin with different tubule orientations and to compare bond strengths between the adhesives.
- Two 2-step self-etching primer adhesives
  - (Clearfil SE Bond (CSE),
  - Optibond Solo Plus SE Bond (Op. SE) and
- Five all-in-one adhesives
  - (Clearfil S(3) Bond (S(3)),
  - Optibond All-in-One Bond (Op. AIO), G-Bond, Go!, and Xeno IV).

Asande A O, Francis B M, John T. Bonding of one-step and two-step self-etching primer adhesives to dentin with different tubule orientations. Acta Odontol Scand 2008 Jun;66(3):159-68.

- Results showed that all-in-one adhesives (Op. AIO, G-Bond, Go, and Xeno IV) showed no significant differences in microshear bond strengths regardless of dentin depth (superficial or deep) or dentin tubule orientation.
- CSE, Op. SE, and S showed significantly lower bond strengths to deep dentin with a tubule orientation perpendicular to the surface.

Asande A O, Francis B M, John T. Bonding of one-step and two-step self-etching primer adhesives to dentin with different tubule orientations. Acta Odontol Scand 2008 Jun;66(3):159-68.

- *Manuja Nair et al* compared the shear bond strength of sixth generation and seventh generation bonding agents to dentin.
- Sixth generation bonding agents, Adper SE Plus and Xeno III
- Seventh generation bonding agents, Adper Easy One and Xeno V.
- The highest value of shear bond strength was obtained from Adper Easy One system, while Adper SE Plus gave the lowest shear bond strength values

Manuja Nair, Joseph, Satheesh Kumar, Yadav Chakravarthy, Vel Krishna, Shivaprasad. Comparative evaluation of the bonding efficacy of sixth and seventh generation bonding agents: An In-Vitro study. Journal of Conservative Dentistry | Jan-Feb 2014 | Vol 17 , 1

EIGHTH-GENERATION

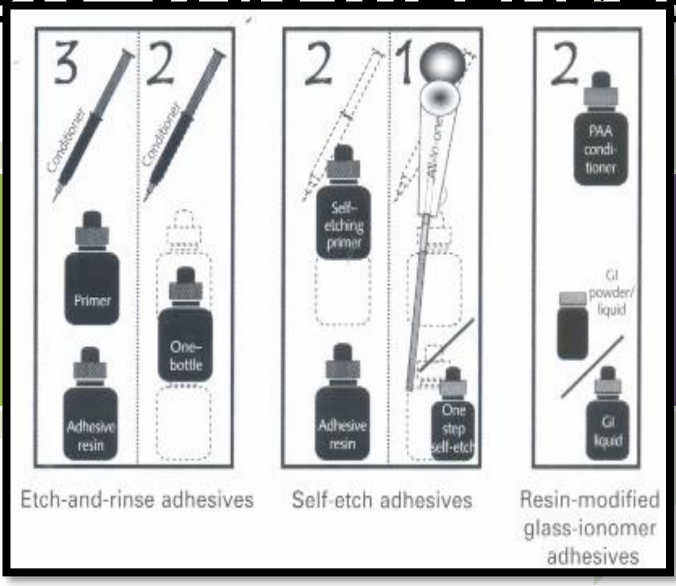
- Self etching- self bonding.
- A new category of composite resin restorative materials, which include what could be referred to as an "eighth-generation" bonding system, has just become available for use.
- This new technology features a bonding agent which is contained within the composite resin restorative material.
- A self-etching, self-adhering flowable composite technology eliminates the need for a separate bonding application step with composites for direct restorative procedures.
- Surpass, vertise flow, futurabond.

Nazarian A. Simplifying Direct Composites With New Material Technology. *Dentistry Today* [serial online]. January 2010;:128-130.

BASED ON VAN MEERBEEL ET AL

Etch and rinse

lass inomer adhesive



Etch-and-rinse adhesives

Self-etch adhesives

Resin-modified glass-ionomer adhesives

ETCH AND RINSE APPROACH

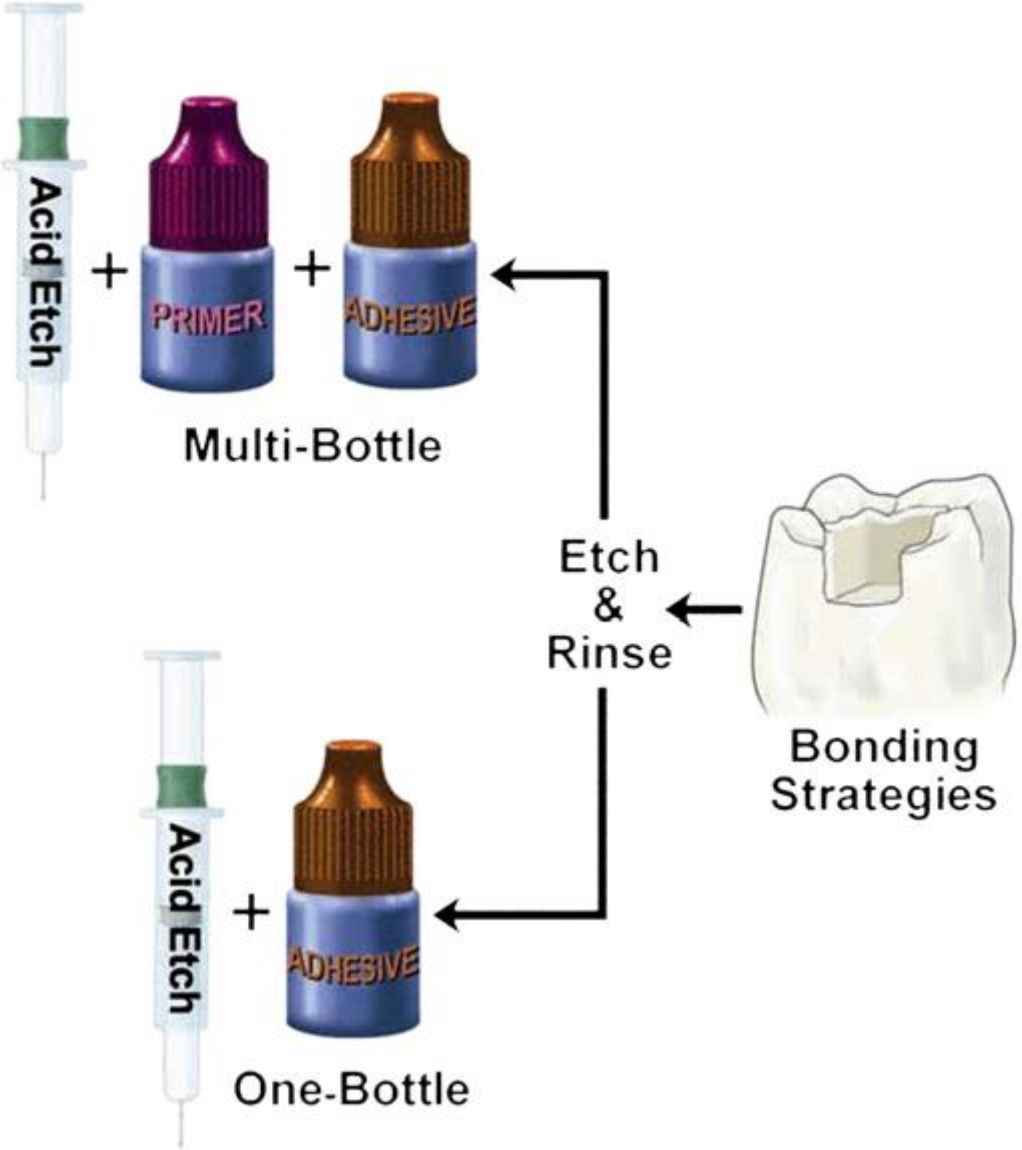
Conditioner or acid etchant

Primer or adhesive promoting agent

Actual bonding agent or adhesive agent

TOTAL ETCH APPROACH

- Etch and rinse approach
  - Total etch- 3 steps
  - 2 steps



SELF ETCH APPROACH

- Monomers into which carboxylic or phosphate acid groups are added.

Self etch approach

3 steps

2 steps

GLASS INOMER APPROACH

- Self adhesive
- Important when coarse cutting diamond is used or thick smear layer is produced
- Polyalkenoic acid – 10-20 sec then rinsed, tooth air dried without dehydrating
- Milder than phosphoric acid .

Bonding increases due to –

- Cleaning effect- loose debris removed
- Partial demineralization- surface area increased
- Chemical interaction of polyalkenoic acid with residual hydroyappetite
- Network of hydroxyapatite coated collagen fibrils interspread with pores is typically exposed up to 1um in depth.

BASED ON pH

- Etching aggressiveness- strong, intermediary, mild

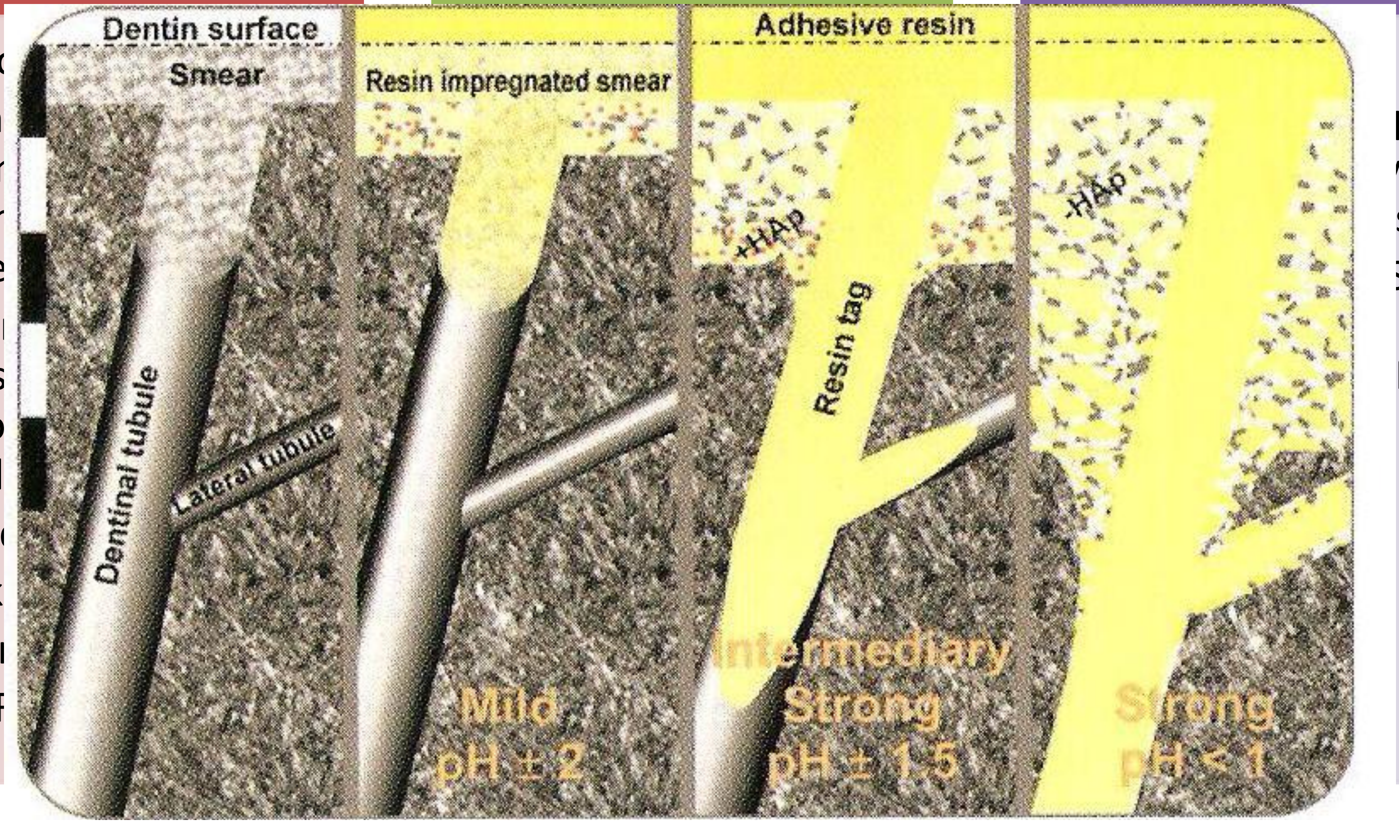
Strong

- pH 1 c
- Enam
  demir
  resem
  acid e
- Denti
  expos
  hydro
  dissol
- Hybri
- Weak
- Water
- Ex: NF

Mild

Intermediary

p
/
se
SE
Solo
Bond



According to chemical composition (Craig)

- Polyurethanes(1-6 Mpa)
- Polyacrylic acids(2-4 Mpa)
- Organic phosphonates
- 4 META (3-7 Mpa)
- HEMA+GA(11-17 MPa)
- Ferric oxalate+ NPG GMA(

4-12.5 Mpa)

According to bond strengths

- 5-7 Mpa:
    Scotch bond dual cure
    Gluma
- 8-14 Mpa
    Tenure
    Mirage bond
- 17-20 Mpa
    Scotch bond 2
    Scotch bond

multipurpose

    All bond

According to treatment of smear layer

- Removed:
  - Tenure
  - Mirage bond
  - Clearfil liner bond system
- Modified:
  - All bond
  - Scotch bond 2
  - XR Bond
- Preserved:
  - Scotch bond dual cure
  - Prima universal bond

According to their mode of curing:

- Chemical cure:
  - Amalgabond plus
- Light cure:
  - One bond
  - Gluma comfort bond
- Dual cure:
  - Clearfil liner bond 2V
  - Prime and Bond NT

Text book of operative dentistry – Vimal sikri (3rd Edition).

CRITICAL STEPS IN BONDING

Isolation

- Bonding to acid etched enamel requires a surface to allow the photopolymerizable hydrophobic bonding resin to be drawn by capillary attraction into the etched surface.

Internal wetness.

- Caused by pulpal fluids that flow from pulp through dentinal tubules

External wetness

- Ambient or environmental humidity

Hence methods of isolation- important

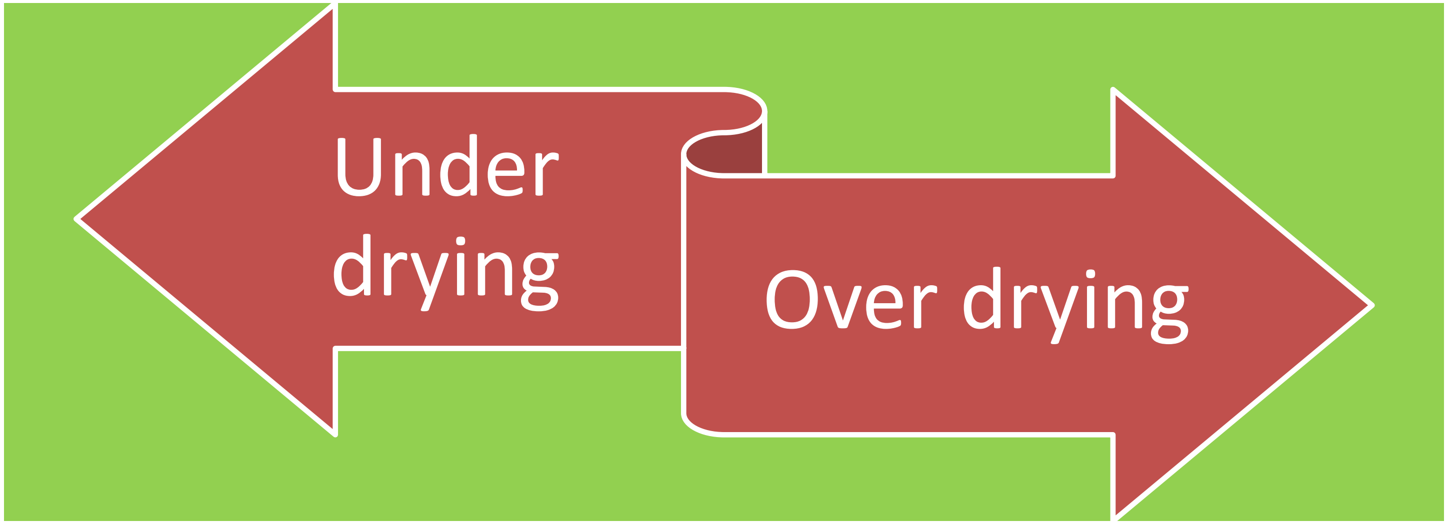
CRITICAL STEPS IN BONDING

Dentin and pulp protection

- Non-adhesive liners and bases not recommended.
- Calcium hydroxide-choice in deep cavities- pulp healing capacity. High solubilty- shouldn’t be etched.
- Resin modified GIC- chemical coploymerization with adhesive resin and is resistant to acid etching.
- Adhesive systems- pulp healing and have bacterial sealing but not recommended for pulp capping

CRITICAL STEPS IN BONDING

- **Universal enamel and dentin conditioning**
- **Phosphoric acid - 30-40% phosphoric acid.**
- **Applied for 15 sec**
- **Scelortic dentin-longer**
- **Rinsing thoroughly to remove- acid**



OVER DRYING

- When the etched dentin is air dried the collagen network will collapse and the microchannels opened by the removal of apatite systems will be closed from a compact coagulate that is impenetrable to resin.
- Drying the dentin will produce a relatively impermeable amorphous layer:
  - Denatured collagen
  - Collapse of collagen layer
  - Affects bonding

Hybridoid region – If surface air dried for more than 3 sec. Collapse of collagen resulting in improper penetration of primer & resin and thus ineffective hybrid layer reduced bond strength.

OVER DRYING

Collapse and Re-expansion of Collagen :

Passive theory

- Demineralized collagen network is suspended in H_2O with each fibril separated from one another by water filled spaces, when H_2O evaporates the collagen fibrils come close together in all dimensions resulting in passive collapse of collagen network.

Bonding theory

- When H_2O evaporates there is collapse of collagen. At that moment, the collagen peptide may form intermolecular hydrogen bonds with the nearest neighboring collagen peptides which may contribute to further collapse of network.

Perdigão J. Dentin bonding—Variables related to the clinical situation and the substrate treatment. *Dental Materials* . February 2010;26(2):e24-e37

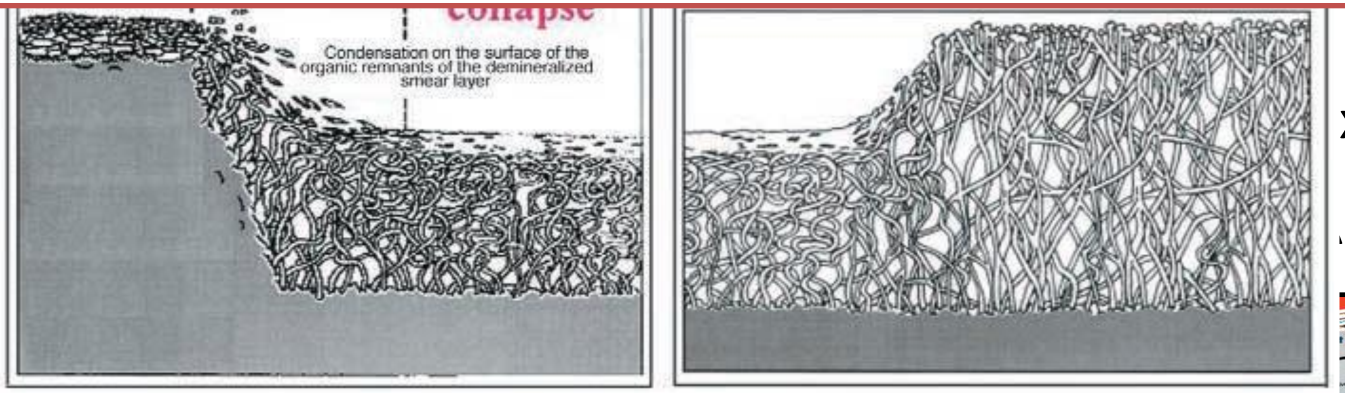
OVER DRYING

Various materials have been tested as rewetting agents:

- Wate
- Aque … or Gluma

  Dese … raldehyde,

Dry Bonding: refers to the bonding in which the acid etched dentin is dry and uses the adhesive systems that provide water based primers. These rehydrate and reexpand the collagen fibers , allowing the resin to infiltrate.



- Chlor
- Prim … xpand the

  colla … CITY”.
- Wate

UNDERDRYING/OVERWETTING

- Areas of the cavity preparation to pool too much water such as the axio gingival line angles of the proximal boxes.
- When the primer and adhesives are applied, the solvent may diffuse into the water
- Formation of resin tag impaired
- Affecting the bond
- Hence, water should be removed

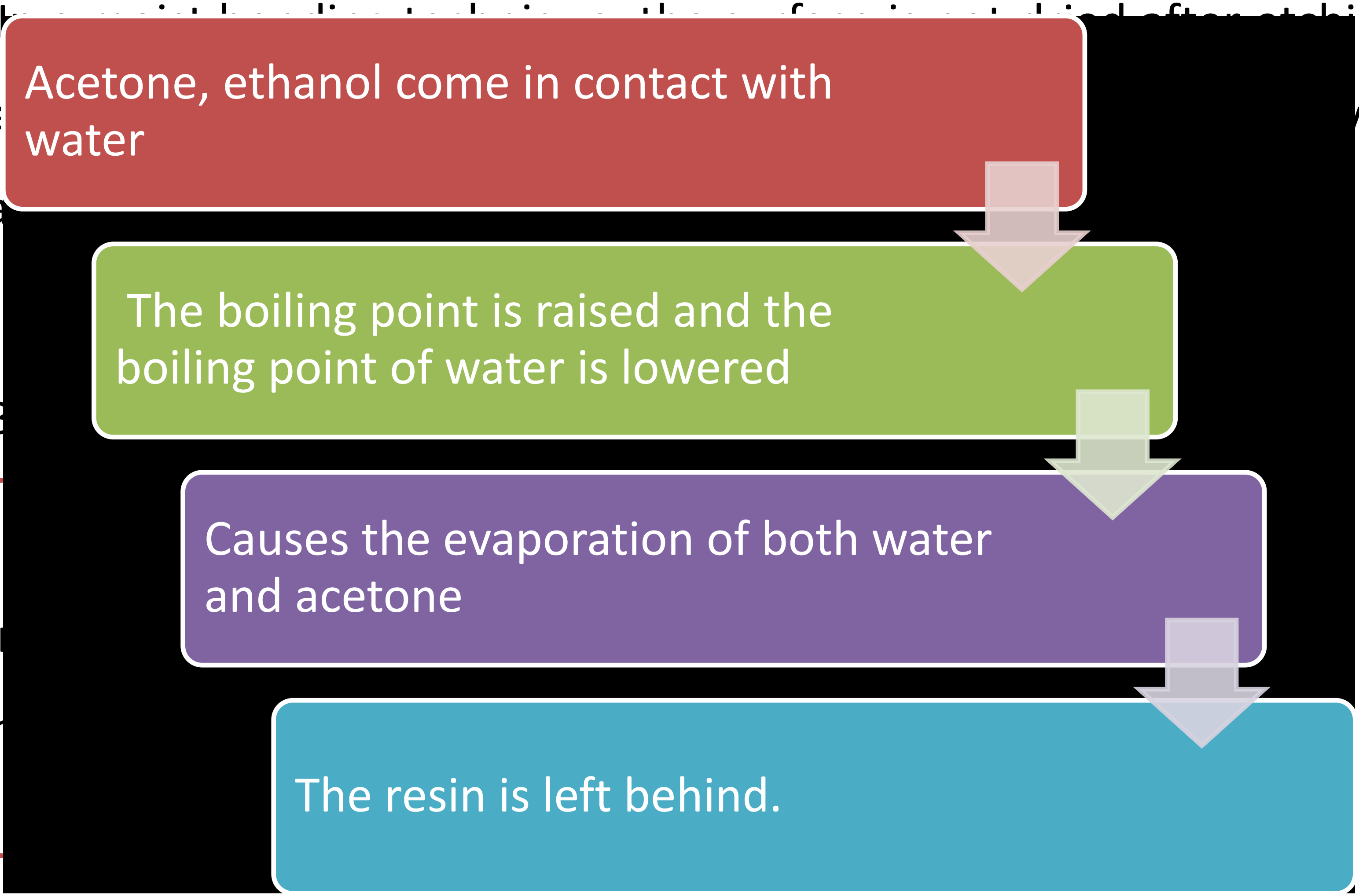
WET BONDING

- ing
  a es
  a
- B

The

resi

Tech



Acetone, ethanol come in contact with water

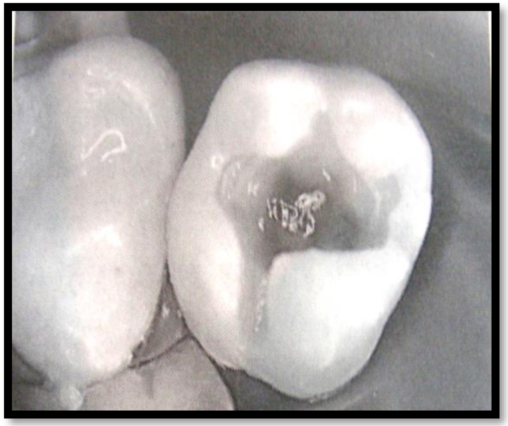
The boiling point is raised and the boiling point of water is lowered

Causes the evaporation of both water and acetone

The resin is left behind.

WET/DRY BONDING

- Enamel-dry preferred
- Dentin – moisture needed to avoid collapse of collagen, shrink
- Keep substrate dry and use water based primers thus re-expand collagen.
- Shiny hydrated dentine- moist dentin
- Pooled moisture removed by blotting or wiped off with slightly damp cotton pellet.



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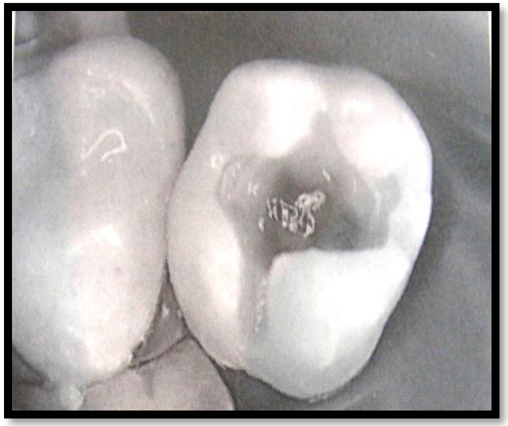


MICROLEAKAGE

- Microleakage is the passage of bacteria and their toxins between restoration margins and tooth preparation walls.
- Clinically, microleakage becomes important when one considers that pulpal irritation is more likely caused by bacteria than by chemical toxicity of restorative materials .
- An adhesive restoration may not bond sufficiently to etched dentin to prevent gap formation at margins .
- The smear layer alone may be a pathway for microleakage through the nanochannels within its core.

- **Deliperi S et al** conducted a study to evaluate the efficacy of a total-etch and three self-etch adhesives in reducing **microleakage.**
  - Group I: Xeno III one-step self-etch adhesive
  - Group II: Prime & Bond NT total-etch adhesive
  - Group III: i-Bond one-step self-etch adhesive and
  - Group IV: Clearfil SE Bond two-step self-etch adhesive.
- Clearfil SE Bond yielded more dye penetration at the occlusal than at the gingival wall

Deliperi S, Bardwell DN, Wegley C. Restoration interface microleakage using one total-etch and three self-etch adhesives. Oper Dent 2007 Mar-Apr;32(2):179-84.

NANOLEAKAGE

Presence of sub micron spaces within the hybrid layer in the absence of gap formation between resin composite and the hybrid layer

(Sano et al 1995)

Over etching

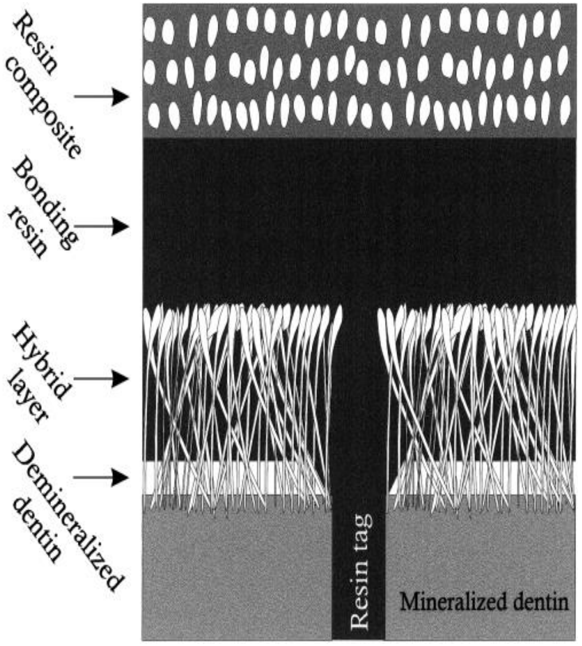
Collapse of collagen – air drying

acidic denaturation

Retained water

Poor polymerization

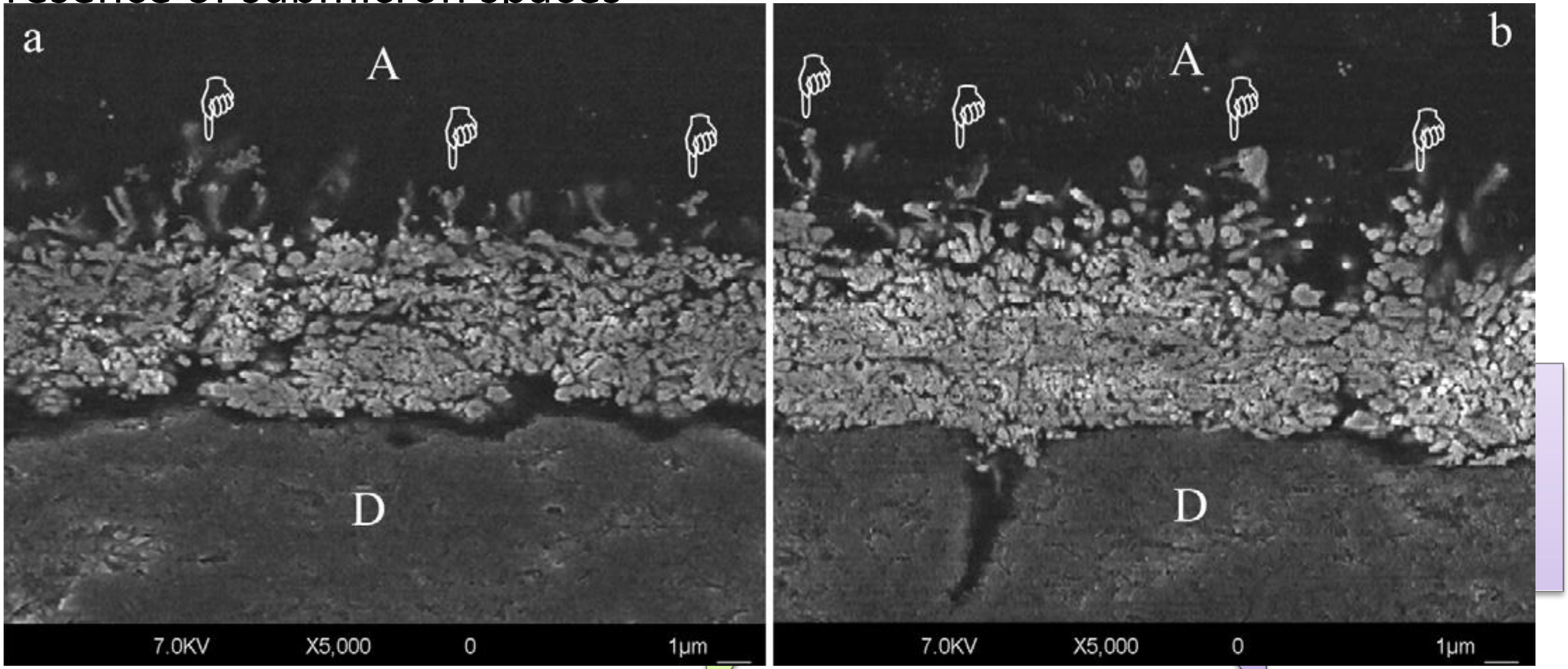
Phase separation.



NANOLEAKAGE

METHODS TO DETECT:

Presence of submicron spaces

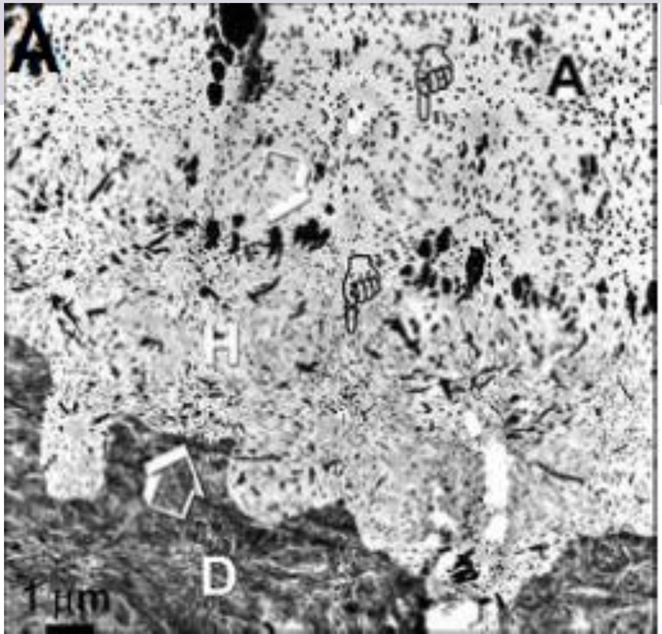


In etch-and-rinse adhesive systems, nanoleakage is created by the discrepancy between dentin demineralization and adhesive impregnation along the resin–dentin interface

NANOLEAKAGE

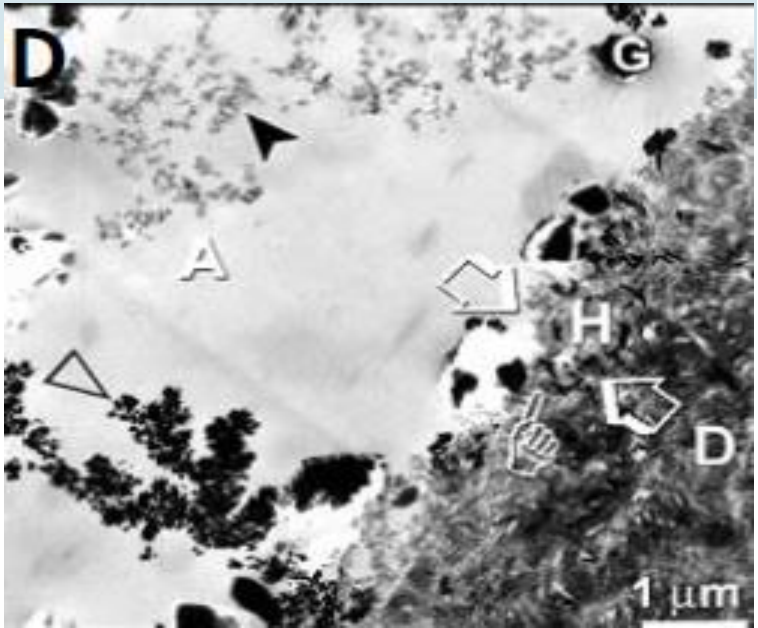
Spotted pattern

- Hybrid layer of self etch adhesives
- Incomplete resin infiltration



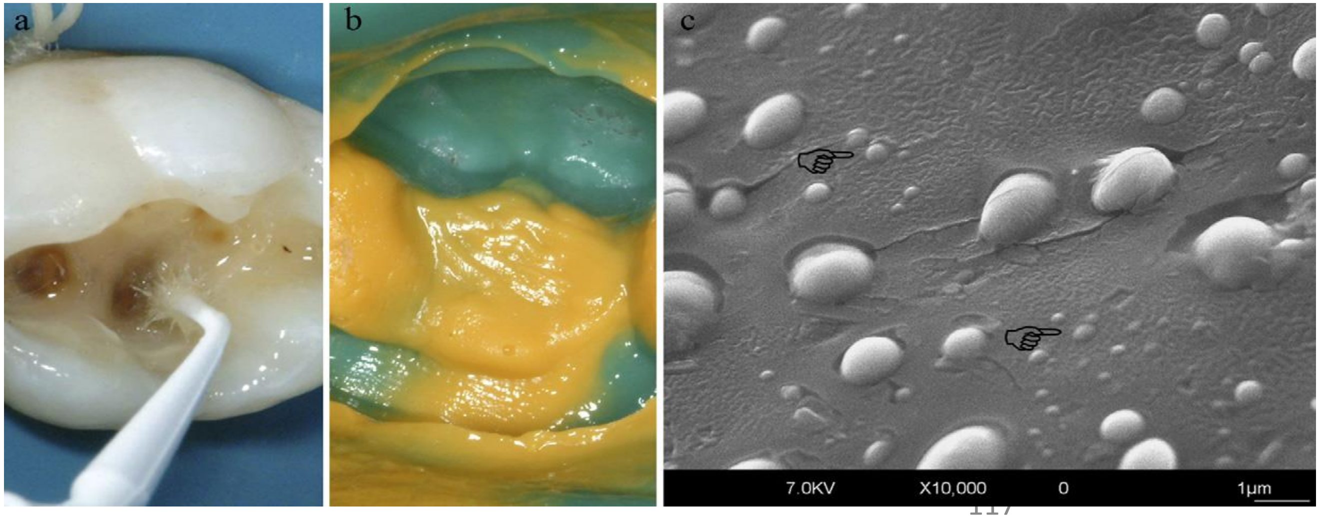
Reticular pattern

- Adhesive layer
- Incomplete removal of water



WATER TREES

- Tay et al -transition initial nanoleakage
- Heat of polymerization generated during light activation—upward convective movement of water from dentin ,vertically oriented water trees
- In region over dentin tubules ---osmotically induced outward movement of water
- The presence of water filled voids are disclosed by soaking the bonded specimens in silver nitrate solutions.

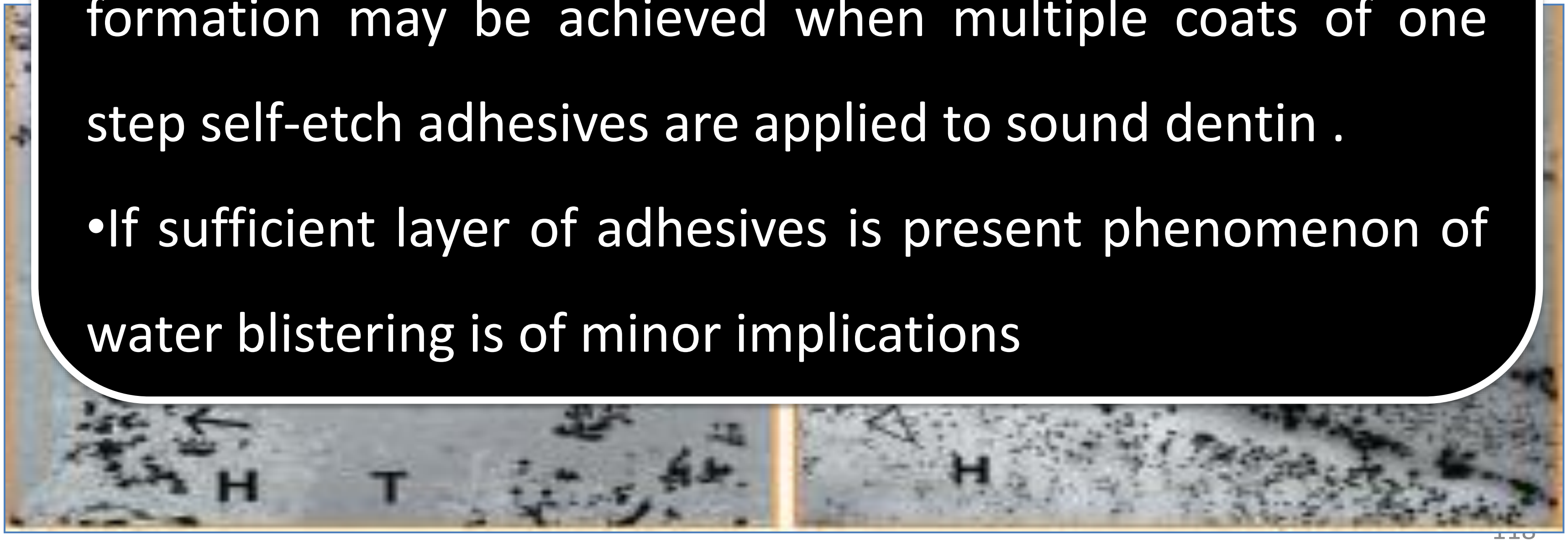


WATER TREES

- Associated with porosities in the polymerised adhesive layer.
- Polymerized resin impregnated with water.
- Self etch adhesive- increased permeability in polymerised resin from

Functional implications of water treeing

- Functionally reduction in nanoleakage and water tree formation may be achieved when multiple coats of one step self-etch adhesives are applied to sound dentin .
- If sufficient layer of adhesives is present phenomenon of water blistering is of minor implications



- *Joao CF et al* conducted a study to evaluate nanoleakage within the hybrid layer yielded by etch-and-rinse and self-etch adhesive systems, with different solvents and compositions.
- They found that two-step self-etch adhesive system (AdheSE) might contribute for lower nanoleakage deposition and showed better performance in dentin adhesion.

Joao C F, Patricia T P .Influence of Solvents and Composition of Etch-and-Rinse and Self-Etch Adhesive Systems on the Nanoleakage within the Hybrid Layer. The Journal of Contemporary Dental Practice, July-August 2013;14(4):691-99.

ADDITIVES FOR DENTIN /ENAMEL ADHESION

- Filler contents though in minute quantity play a vital role in dental adhesion.
- The addition of fillers in total etch adhesives improves their bond strength.
- In single step system silica fillers are often used as thickener to increase the viscosity, resulting in adequate film thickness. It also prevents over thinning and incomplete polymerization due to oxygen inhibition.
- Recently adhesives with fluoride releasing properties are introduced

ADDITIVES FOR DENTIN /ENAMEL ADHESION

- Polysiloxane encapsulated sodium fluoride particles are used as a source of fluoride.
- Fluoride is introduced because of its anti-cariogenic activity
- Certain adhesives uses dyes with the intention to clearly indicate the proper mixing of components .
- Example- One up bond and Tyrian SPE
- In One up bond the color changes from yellow to pink and when it is light cured the color fades.

BIOCOMPATIBILITY

- Typically skin irritants.
- HEMA is not considered biocompatible as a monomer.
- local and systemic reactions.
- Even with double gloves, contact with these aggressive solvents and monomers will produce actual skin contact in a few minutes.
- Follow all reasonable precautions, and if unwanted contact occurs, immediately flush the affected areas with copious amounts of water and soap. Once the material is polymerized, there is very little risk of side effects.
- Adverse pulpal reactions after a restorative procedure may not be caused by the material used in that procedure, but by bacteria remaining in, or penetrating the preparation

BIOCOMPATIBILITY

- In some cases, adverse reactions are caused by a combination of factors, such as the following:

✓ Bacterial invasion of the pulp, either from the tooth preparation or from an existing carious lesion

✓ Bacterial penetration into the pulp caused by a faulty restoration

✓ Pressure gradient caused by excessive desiccation or by excessive pressure during cementation.

✓ Traumatic injuries

✓ Iatrogenic tooth preparation-excessive pressure, heat, or friction.

APPLICATIONS OF BONDING AGENTS

- ✓Bonding of directly placed resin based restorative materials.
- ✓Bonding of indirectly placed restorative materials.
- ✓Bonding of ceramic restorations.
- ✓Bonding of amalgam restorations.
- ✓Bonding of prefabricated and cast posts.
- ✓Bonding orthodontic brackets.
- ✓Bonding periodontal splints
- ✓Repair existing restorations.
- ✓Sealing of pits and fissures of posterior teeth.
- ✓Treatment of cervical sensitive dentine.
- ✓Reattachment of fractured tooth fragments.
- ✓Reinforce fragile roots internally.
- ✓Seal apical restorations placed during endodontic surgery.

APPLICATIONS OF BONDING AGENTS

Bonding to amalgam

- Agents that bond amalgam to cavity.
- Amalgabond, panavia , optibond solo.
- 4- META based adhesives.

Bonding to indirect restorations

- Bonding requires agents for both the tooth structure and the undersurfaces of the indirect restoration.
- Resin composite cements are usually used to fill the space between the two surfaces.

Desensitization

- The adhesives block the dentinal tubules preventing transmission of pain and desensitizing the tooth.
- GLUMA, All bond.

APPLICATIONS OF BONDING AGENTS

Porcelain and ceramic repair

- Etching of surface to clean and produce micromechanical relief
- Silanating the etched surface to enhance wetting and create chemical bond.
- Apply bonding system and add composite.

Cast restoration bonding

- Roughening and etching the casting surfaces and the dentin surfaces.
- Use bonding system on both the surfaces
- Minimize cement thickness in both the joints.

GIC bonding

- The phosphate and the calcium ions are released from hydroxyapatite and absorbed in unset cement.
- intermediate layer between the ‘pure’ GIC and the pure hydroxyapatite; the so-called ‘ion-exchange’ layer.
- Ionic bonding between the carboxyl ions from the cement acid and the calcium ions from the tooth

COMMON CLINICAL BONDING PROBLEMS

Problem	**Solution**
Dentin surface too dry	Use moist cotton pellet to rehydrate surface.
Dentin surface too wet	Gently blot dry to achieve glistening surface
Contamination with saliva and blood	Rinse, re etch if contamination is moderate or greater
Contamination with caries detector, handpiece lubricant or hemostatic agent	Rinse and reetch
Contamination by eugenol	Avoid eugenol containing provisional materials and temporary cements.
Remaining caries affected dentin	Remove caries

COMMON CLINICAL BONDING PROBLEMS

Surface does not glisten after application of primer	Apply additional coats of primer
Self cured composite debonds from adhesive	Use dual cure bonding agent with self cured composite or resin cement
Bonding agent under cured	Cure recommended time with properly maintained light curing unit, be sure the bonding agent is compabtible with light curing unit.
Recent bleaching procedure	Wait one week after bleaching.
Flourosed teeth	Double the etching time
Smooth single surface lesions lack of bonding	Create surface roughness and mechanical undercuts

BOND STRENGTH TESTING

- The bond strength can be measured statically using a MACRO- or MICRO-test set-up, basically depending upon the size of the bond area.
- The MACRO-bond strength, with a bond area larger than 3 mm^2 , can be measured in ‘shear’, ‘tensile’, or using a ‘push-out’ protocol.
- MICRO-bond strength is typically measured in tensile, micro-tensile bond-strength testing (µTBS) was developed in 1994.
- The bond area tested is much smaller compared to that of the ‘MACRO’ tests, being about 1mm^2 or less.

Van Meerbeek B, Peumans M, De Munck J, et al. Relationship between bond-strength tests and clinical outcomes. *Dental Materials* February 2010;26(2):e100-e121

BOND STRENGTH TESTING

FIG. 5-26 Preparation of specimens for microtensile bond strength testing.

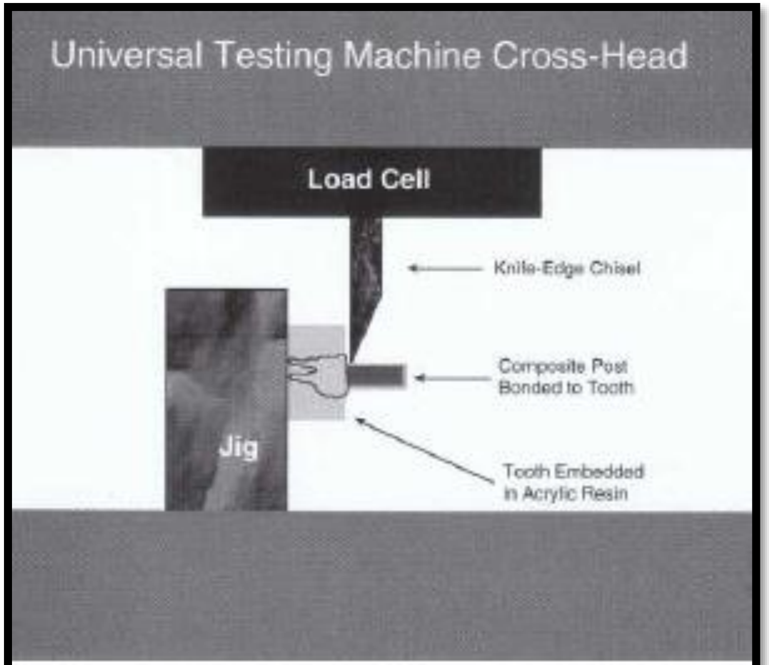


FIG 5-25 Schematic representation of shear-bond strength testing.

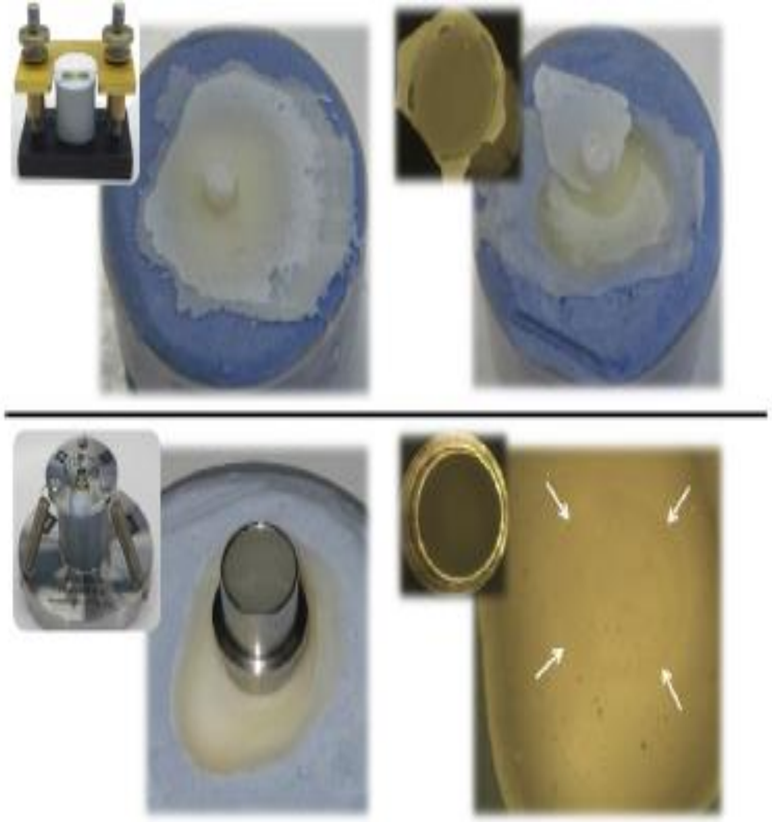
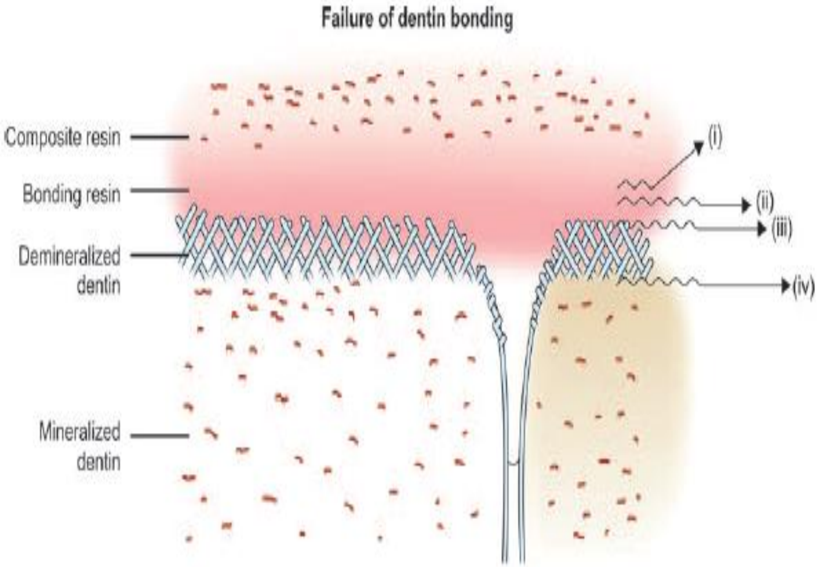


Fig. 7 – Figure showing the Ultradent jig (top) and the SDI rig (bottom), both specifically designed and fabricated for shear bond-strength testing. An inappropriate, though commonly used specimen-preparation technique involves the application of the adhesive to the entire tooth surface, on top of which a composite cylinder is bonded (top). As shown by the fractured specimen (top right), the shear stress caused the specimen to de-bond at a much larger area than the area to which the composite cylinder was bonded. The SDI rig much better enables both the adhesive and the composite be applied to a confined area (bottom).

Van Meerbeek B, Peumans M, De Munck J, et al. Relationship between bond-strength tests and clinical outcomes. *Dental Materials* February 2010;26(2):e100-e121

FAILURES IN BONDING

- 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
  - size of lesion
  - substrate
  - material factors



. 16.31: Failure of composite adhesive and tooth joint can occur between: (i) mineralized and dimineralized dentin; (ii) bonding agent and dentin; (iii) bonding agent; (iv) composite and bonding agent

MEASURES TO IMPROVE BOND STRENGTH

STRATEGIES

BOND…AGING HYDROLYTIC ENZYME DEGRADATION

Tjaderhane.l, Oper Dent 2015

MMPS, CYSTEINE CAPTHEPSINS

1 Inhibitors of collagenolytic enzymes

2 Ethanol wet bonding

3 Collagen cross linking agents

4 Remineralizing the hybrid layer

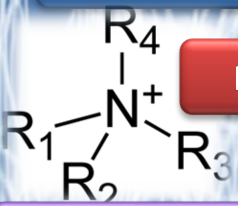
5 Remineralizing by adhesives containing bioactive particles

6 Biomimetic remineralization

Chlorhexidine 0.2-2%

Tetracycline

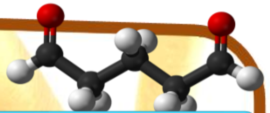
Galardin (0.2 mM)



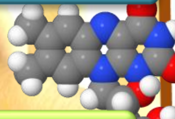
MDPB

Benzalkonium chloride(0.5%)

DMSO



Glutaraldehyde

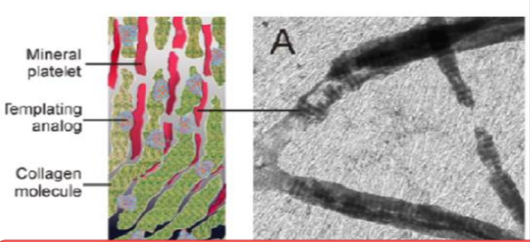


Riboflavin

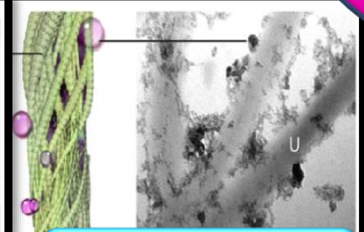
Carbodiimide

Proanthocyanidins

Fluoride containing adhesives



Template-non collagenous phospho -proteins



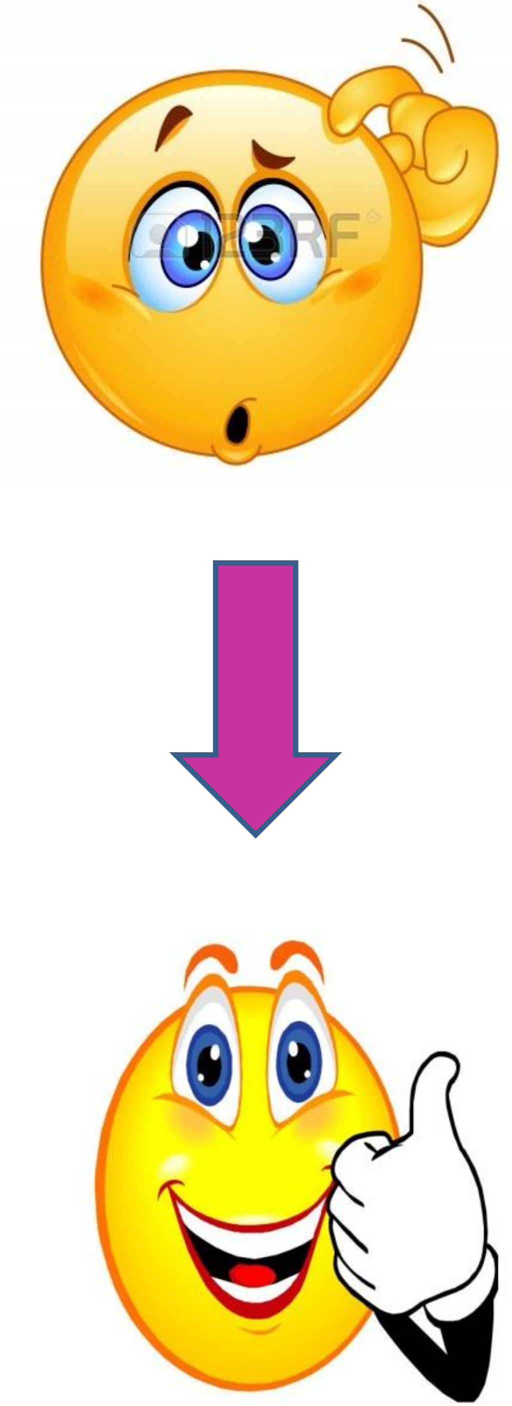
ACP nanoprecursors

Biodegradable polymers

Bioactive silicates

CONCLUSION

What we have to choose:



The choice may be Confusing.

It is easy for the clinician to believe that a new system is better over the old ones but this may not always be true.

SO:

Chemistry is more important than the company.

Technique is more important than the

REFERENCES

- ✓ Sturdevant C.M, Theodore M. Roberson, Herald O.Heymann, Edward J. Swift; the art science of operative dentistry. Fundamental concepts of enamel and dental adhesion 235-268.
- ✓ James B Summitt . Fundamentals of operative dentistry. 2nd edition.,. Karl F.Leinfelder. Dentin adhesives for the twenty-first century.
- ✓ Nakabayashi . Hybridization of dental hard tissues by. Quintessence Publication
- ✓ Kenneth.J.Anusavice –philips science of dental materials 11th edition.
- ✓ Dental clinics of North America vol 45. Number 1. January 2001.
- ✓ David H Pashley et al: The effects of dentin permeability on restorative dentistry, DCNA 46; 2002; 211-245..
- ✓ Saraf K.K, Mishra S.K, Kumar A. Current perspective on self etching primers (SEPs) adhesives. Journal of conservative dentistry. Vol.7, no.4. Oct-Dec-2004.
- ✓ Adhesion and its application with restorative materials. DCNA; vol. 37, No.3, July 1993.
- ✓ Bonding to enamel and dentin : a brief history and state of the art, 1995 – Quintessence Int 1995; 26: 95-110.

REFERENCES

- ✓ Feridun, Özdemir,, Ihsan H, Akin C, Seyda H. Bond strength of adhesives to dentin involving total and self-etch adhesives. *Quintessence Int 2007;38:358.e206–212.*
- ✓ Asande A O, Francis B M, John T. Bonding of one-step and two-step self-etching primer adhesives to dentin with different tubule orientations. Acta Odontol Scand 2008 Jun;66(3):159-68.
- ✓ Nazarian A. Simplifying Direct Composites With New Material Technology. *Dentistry Today*. January 2010;:128-130.
- ✓ Perdigão J. Dentin bonding—Variables related to the clinical situation and the substrate treatment. *Dental Materials*. February 2010;26(2):e24-e37.
- ✓ Deliperi S, Bardwell DN, Wegley C. Restoration interface microleakage using one total-etch and three self-etch adhesives. Oper Dent 2007 Mar-Apr;32(2):179-84.
- ✓ Joao C F, Patricia T P .Influence of Solvents and Composition of Etch-and-Rinse and Self-Etch Adhesive Systems on the Nanoleakage within the Hybrid Layer. The Journal of Contemporary Dental Practice, July-August 2013;14(4):691-99.
- ✓ Van Meerbeek B, Peumans M, De Munck J, et al. Relationship between bond-strength tests and clinical outcomes. *Dental Materials* February 2010;26(2):e100-e121


Thank
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