Adhesion and Adhesives in CONSERVATIVE DENTISTRY

Terminology

⇨ *Adhesion or bonding*

⇨ The energies between dissimilar molecules at an interface that hold two phases together.

Adherend-

⇨ The surface or substrate that is adhered.

Adhesive/ adherent/ bonding agent/ adhesive system-

A material that can join substances together i.e. resist separation.

Adhesive ~ monomer (or related) that penetrates and establishes Intimate contact with the conditioned tissue substrate, polymerizes, and forms a strong bond between such substrate and the restorative material

Adhesion forces across depend on:

1-Physical and chemical properties of both adhesive and the adherent.
2-Homogeneity.
3-Applied loads through the bonded Joint.
4-The thickness of interface.
5-Oral environment with its moisture.
6-Chewing habits.

1-Physical Interactions of adhesion

Van de Waals interactions
Attraction between opposite charges on ions and dipoles
ion / ion
dipole / ion
dipole / dipole

H-bond(water) ***Hydrogen-bond*** ***(particularly strong) can be included among physical forces example:-***

Molecule of water formed by hydrogen bond which is high in value to the extent that too much energy required evaporating the water i.e. the temperature much rose to 100 degree centigrade to rupture the O2 bond between two molecules of water.

The presence of high polar group such as oH&cooh in an adhesive should be of benefit in producing strong attachments to an appropriate substrate through the formation of hydrogen bond.

Materials generally either:

1- hydrophilic

2- hydrophobic

like attracts like

Physical force of attraction are responsible for:-

Tensile strength.

Surface tension.

Viscosity.

2-Chemical reaction of adhesion

- Converts adhesive to strong solid **Molecular attraction of ionic i.e. Transfer of electron from one shell to another.**
- **Covalent bond: Where sharing electron between two atoms or molecules.**

1-Ionic

Involve an actual transfer of electrons from one atom to another e.g. Reaction between Sodium and Chlorine

(e.g. acid + base = salt + water).

(e.g.Ion exchange adhesion mechanism in Glass Ionomer Cements)

2-Covalent bond

Sharing of electrons (two atoms of hydrogen to form a molecule of hydrogen).

Represent strong bonds.
Liberate considerable energy in their formation.
Present in all organic compounds.
e.g.Glass surface reacted with Di-methyl' Di-chloro-silane,
This methyl groups of the silane compound are strongly bonded by glass surface by means of strong covalent (Si-O-Si), Which is resistant to (hydrolysis), and, Act to repel water (hydrophilic). '

3-Metalic bond

Mechanical factors &bonding

Bonding interaction with surface :-
Micro – mechanical
-Polymer entanglements
Chemical reaction

Mechanical Retention

The retention of resin restoration on teeth by means of pins or undercuts is a form of gross mechanical retention.
Undercuts in cavity preparations is another mean of retention.
But not adhesion form.

The more fine forms of mechanical retention are related to:

The presence of irregularities:
1-naturally occurring.

2-artificially produced roughening an adherent surface

Factors affecting adhesion:

1-Water: (Enemy of adhesion)

It is the enemy of adhesion. Water has the capability to react with both materials by the a- high polar group

b- the presence of hydrogen bond that will spoil the adhesion.

Gross water must be eliminated. Water is strongly polar compound, can readily displace the physical attractive forces which exist between adhesives and enamel in the dry state.

2-Surface Contact (smooth)

a-Surface imperfection

Rough surface will prevent the intimate contact & so no adhesion.

b-Surface contamination

c- Contamination will prevent the adhesion. Dust , water, blood & saliva ect.

d-Function of adhesive

Fill the irregularities making the surface smooth allowing proper or intimate contact.

As a rule, all solid surfaces are rough. Theoretically, surfaces those are flat! and smooth on an atomic level should spontaneously adhere As result of physical and / or chemical forces when brought into contact.

3-Surface Contamination

Contamination preventing intimate contact of the two surfaces.

4-Wetting & contact Angles

Wetting is a manifestation of the attractive forces between molecules of adhesive and adherent and may be defined as; the process of obtaining molecular attraction. The stronger the attraction of the adhesive for the adherent, the smaller will be the contact angle. The molecules of the adhesive are attracted to the molecules of the adherent. More than, they are to themselves.

i- Contact angle. The zero contact angle is the best to obtain wetting.

ii- Energy of wetting(heat of adsorbs ion)

iii-Wetting &bond strength

iv-Wetting & surface free energy

the surface should have higher surface energy than the adhesive.

5- Surface Energy

A low surface energy is difficult to wet.Teflon has a low surface energy.

The large contact angle is on surfaces.Water has a low affinity or wetting to low surface energy.

6-Surface Tension of Adhesive

It is the result of the inward attraction of surface molecules in the interior of a liquid. i.e. Least surface area per unite of volume. More energy will be expanded in extending the surface of a liquid of high surface tension.

a-surface tension & irregularities

b-surface tension and bonding area.

7-Viscosity of adhesive

Thick adhesive gives weaker joints than the thin ones. As a greater number of imperfections, such as voids and cracks . Wetting with Low Viscosity Resin Low viscosity resin

a-viscosity and irregularities

b-viscosity and smooth surface

c-viscosity and contact adhesion

d-viscosity and polymerization

8-Thickness layer of adhesive

A-Internal stresses developed during polymerization of the adhesive will concentrate about these imperfections,

Early failure under load related to its number and size

B-They are more likely to become failed in thick than thin ones.

9-polarity of the adhesive

10-Dimentional change of adhesive

11-Thickness of adhesive

12-Voids in adhesive layer.

It is essential to understand what is meant by the terms contact angle and wetting.

Contact angle refers to the angle formed between the surface of a liquid drop and its adherent surface. The surface tension of the liquid, and the surface energy of the adherend, will ultimately determine the degree of wetting that occurs.

- A low contact angle can be found with a low surface tension, such as the current prime/bond agents, which often contain acetone, and on **solids with a high surface energy, such as freshly acid-etched enamel.**

- **Virtually complete wetting will occur and, in the latter case, the etching gel will give a rough pattern resulting in a greater surface area which the bonding agent can literally be drawn into.**
- **Contact angles and wetting are important wherever it is necessary for a "liquid" material to flow rapidly and thoroughly over a surface.**

Adhesive Cure

Chemical reaction converts adhesive to strong solid
Ionic.
Covalent (e.g. in C-C backbone in polymers)
Bonding interaction with surface adherend
Micro – mechanical
Polymer entanglements
Chemical form of adhesion

Composition of enamel and dentine

	E	D
Hydroxyapatite	95	70
Water	3	10

Noncollagenous proteins	1	2
Collagen	-	18

Adhesive liquid characteristics

Factors determining performance:

1. Operator factors: etching, washing, drying, and bonding techniques
2. Design: (prep.) and Substrate factors (smear layer, moisture)
3. Materials factors (product, modulus, thickness, ...)
4. Tooth location factors (lesion size and shape, local morphology, flexure, arch)
5. Patient factors: (diet, age, occlusal stress, ...)

Rapid flow

Low viscosity
High surface wetting
Adhesive surface tension 擠 < surface energy E Strong liquid / solid physical interaction. To fill pores / roughness. High surface tension
Wetting and hybridization of dentin

Wetting

The surface tension of a liquid that allows its spreading over a surface to a zero contact angle (Yc=X dyne/cm).
Accomplished by acidulous alterations to the dentin and hydrophilic resin Which cause a low critical surface tension (Yc) by coating the collagen fibrils

Permeability

~ a measure of the ease of which a substance can penetrate a membrane or diffusion barrier; the substance is depending on molecular weight
and the membrane/barrier on porosity characteristics.

Parameters Affecting Adhesion to Enamel and Dentin

The adhesive system must sufficiently wet the solid surface,
Have a viscosity that is low enough to penetrate the micro porosities,
Able to displace air and moisture during the bonding process.
Current resin composites shrink 3-7% by volume.Bonding interface to tooth is a weak component. Bond strength should be in the range of 17-20 MPa.
Compensation for polymerization contraction. Thermal expansion coefficient
Transmission of stress across the restoration-tooth interface

Enamel can be wet by hydrophobic or hydrophilic monomers
Dentine requires hydrophilic monomers
Both surfaces need roughening for good adhesive contact.

It is worth noting that the bond to etched enamel is purely mechanical, as opposed to the combined chemical/mechanical ones we shall come across with dentine.

The resin must flow over the etched enamel surface and penetrate the micro spaces.
Capillary action aids this flow by helping to draw the resin in.
After polymerization, the tags of resin act as mechanical retainers.
The resin/etched enamel bond is the ideal of dental bonds; those to dentine are not as reliable.

Etching
~ dissolution of the substrate, removed by rinsing to enhance intimate contact of adhesives with collagen
Addition of phosphoric acid for 15 seconds. Frosty appearance. SEM structure show preferential etching of hydroxyapatite prism
Cores
Periphery

Enamel bonding

Penetration of methacrylate monomers into rough surface provides micromechanical bonding
Microscopic processes for formation of adhesive joint
Bond strengths to enamel =25-30 MPa.

Smear layer

Dentine bonding processes Phosphoric acid etch for 15s gives
Smear layer removal Hydroxyapatite dissolution. Drying causes. Collagen collapse. Priming gives. Collagen rehydration. Monomer penetration into tubules and collagen provides. Micromechanical adhesion on polymerisation
Tubule sealing

Basic Anatomy

Dentin is a fiber reinforced with:-minerals, collagen and water.
The mineral component is mostly:-calcium phosphate in the form of hydroxyapatite.
Cutting dentin with a rotary bur produces a smear layer of dentinal debris

Surface Treatment

Etching dentin removes the smear layer,
dissolves the minerals at the surface
exposing the collagen fiber matrix,
and slightly opens the dentinal tubules.
Dentin etchants (maleic, nitric and phosphoric acid) achieve the same results.

Priming

~ cleaning, structural alteration, and increasing adhesiveness of the substrate

Adhesive Primer

This is referred to as the "hybrid layer"

1-Provides micromechanical retention.
2-Permanently seals the tubules,
3-Desensitizes the tooth
4- Protects the pulp.

Dentine and enamel resin adhesion

Dentine Bonding Agents = Dentine Adhesives = Coupling Agents.

They have a common principle When applied to unetched or Etched tooth structure,They produce a di-functional groups.
This difunctional; group will:- adhere to parts of tooth substance in a physic-chemical way, and it will bind to the applied composite resin in a Chemic physical way, thus, assuring cavity seal.
These agent may interact with either organic or inorganic phases of dentin.
Composite of the same manufacture is essential.

DENTIN BONDING GENERATIONS

FIRST GENERATION

Acid etch enamel (not dentine) . Self cured bonding agents
Glycero phosphoric acid dimethA. (GPDM) could bond to etched E.

Bond strengths in 2-3 **3 MPa**

First commercially available dentin bonding agent introduced with N-phenylglycine glycidyl methacrylate (NPG-GMA), will not show ionic bonding to inorganic.

No interference with the smear layer, micro-organism found in the dentinal tubules under composite filling.

the phosphate end react with calcium in hydroxyapatite, C=C double bond at the other end react with composite.

SECOND GENERATION

Based on: phosphorous esters of methacrylate derivates. Hydrophobic enamel adhesive Hydrophilic dentine adhesives.Bond strengths in 5-6 MPa range.
Bond to smear layer. light cure systems

In this Generation started to pay attention to adhesion to dentine.
The best place to start to look at adhesion to dentine is the cavity preparation.

Cutting dentine with a bur leaves debris on the surface.

- This will contain some enamel and dentine chippings, the size and shape of which will be determined by the speed and material of the cutting instruments.
- The use of a water spray will wash the debris away from certain areas of the cavity, and this remaining layer of variable thickness may also contain blood, glyco proteins and assorted bacteria.
- It is called the smear layer and can play an important part in the process of bonding to dentine.
- One potential problem lies in the fact that the smear layer is never uniform in presence or thickness.
- It may be present in varying degrees in the cavity, or it may be washed away in the process of cutting the cavity or its cleansing after preparation.

Smear Layer summerised as :-

- Preparation debris
- Thin (< 5 um)
- Irregularly arranged
- Sticky but chemically removable
- Penetrates tubules (Smear Plugs)

- There are generally three recognized methods:
  - Hydrophobic enamel adhesives
  - Hydrophilic dentine adhesives
    Light cure systems.
    Bond strengths in 5-6 MPa range which is still lowas it bond to smear layer.
    Based on phosphorous esters of methacrylate derivates.

THIRD GENERATION

Acid etch of dentine. Acidic hydrophilic monomers for dentine priming
Hydrophobic low viscosity resin adhesive.Primer and adhesive systems introduced. Removal or modification of the smear layer.
Hydrophobic and hydrophilic. Bond strengths 10 MPa. Third generation and Smear layer?
Hydrophobic adhesive nature that will not bond to hydrophilic dentin.

FOURTH GENERATION

Polymerisable Hydrophilic monomers with lower acidity carboxylic acid groups on

CH2=CH
|
R
|
COOH

Total etch concept?

Common dentine and enamel adhesives. Light and dual cure systems
Hybrid zone formation in dentin. Etchant and primers. Low viscosity unfilled/ semi filled adhesive resin.
Copolymerization.

Etchant

37% Phosphoric acid gives Smear layer removal Hydroxyapatite dissolution. 15 seconds. Rinsed with water. Dried with air
Up to 10 擠m penetration. Surface irregularities. Surface area increase

Etching of dentin

Dentin is categorized as inter- or peritubular .
Peritubular dentin is devoid of fibrous structure and forms a highly mineralized sheath around the tubules. This is the total-etch technique, and it is rapidly gaining popularity. Acidic primers are used to remove the smear layer completely, followed immediately by the application of a low-viscosity resin before the pulpal pressure fills the dentinal tubules with fluid.

Thirty-seven per cent phosphoric acid gel is applied to the enamel and dentin for 15 seconds. The enamel will have the dull etched appearance, and the dentine will be decalcified in inter and peritubular dentine to a depth of 7-9 microns. The acid gel is then washed away completely for 20 seconds .The enamel and dentin then dried but not desiccated to prevent dentinal fibril collapsed & weak bond.

Primer

Hydrophilic monomer + initiators. HEMA or MMA
Polymerisable carboxylic acid (COOH)
4-META (anhydride) or BPDM, GPDM (acid containing dimethacrylates)
Solvent

Acetone or ethanol / water Priming gives. Collagen rehydration
Monomer penetration into tubules and collagen provides
Micromechanical adhesion on polymerisation. Tubule sealing Primer can be used to re hydrate the collagen of dentinal fibril
Dentine is primed (HEMA usually used)
Primer (adhesion promoting agent).It is a hydrophilic monomer in a volatile solvent that will displace water in dentinal tubules allowing the infiltration of adhesive monomer in and around the decalcified dentinal tubules

Adhesive

BISGMA (resin) TEGDMA (diluents) + initiators
Inorganic fillers (0.5 to 40 wt%).Fluoride

Adhesion to Dentin

Chemically alters the dentin surface with the objective to remove or alter the smear layer, simultaneously demineralize the dentin surface, and expose the micro porous scaffold of collagen fibrils. Cross banded collagen
Primer does not plug tubules.

Adhesion to Dentin
Hydrophilic wetting agents. Compatible with dentin and resin
Bi-functional molecule
Monomers include HEMA, NTG-GMA,NPG-GMA, PMDA, BPDA, and PENTA
Adhesive resin
Low viscosity unfilled/ semi filled adhesive resin.
Copolymerization.
Hybrid zone formation in dentin

The resin will attach itself around the fibers and form what is to be known as the hybrid layer. The surface energy of the dentine, coupled with the low viscosity of the prime/bond agent, will result in good

wetting of the dentine. The fibers would appear under the **SEM like bristles in a new toothbrush.**

The application of bonding agent have both hydrophobic and hydrophilic monomer after priming dentin gives a bond strength of good clinical significance ie. resist the force of composite shrinkage that will result in loss of bond with dentine . The hydrophobic one toward the composite filling material & to bond with it, while the hydrophilic monomer toward dentin and bond well with it.

FIFTH GENERATION

One-component' systems or Single Component
1-Primer and adhesive or
2-Etchant and primer
One component combine
Etchant, Primer and Adhesive

Development of resin dentinal adhesivese in a form of Single component bonding systems

does not represent improved bond strength or microleakage reduction. **Dentine bonding processes**

- Phosphoric acid etch for 15s gives
  - Smear layer removal
  - Hydroxyapatite dissolution
- Drying causes
  - Collagen collapse
- Priming gives
  - Collagen dehydration
- Monomer penetration into tubules and collagen provides
  - Micromechanical adhesion on polymerisation
  - Tubule sealing, Hybrid layer and resin tags

6th generation

One component combine
etchant, primer and adhesive
6th (eg Prompt L-pop (3M ESPE) generation adhesives often have more acidic phosphoric acid group on polymerisable monomers

CH2=CH
L
R
I
CH2PO(OH)2

6th generation adhesion mechanism
Dissolution of smear layer and HA by methacrylated phosphate. Solvent evaporates
Dissolved components bound into polymerised matrix

It is proved that the 6th generation has a lower bond strength than is needed. Leave the smear layer intact and infiltrate with resins.

The phosphonated ester group of bonding materials relies on this principle. Basically, the acidity of the primer removes some of the smear layer and leaves some “plugs”. It also exposes the collagen network. The phosphonated ester penetrates the smear layer and becomes entangled with the collagen. It then polymerizes and so a bond is formed with the dentine. The air-inhibited moist layer is left on the surface whenever a resin is polymerized. This is available to form a bond to the resin present in the composite restorative material. The phosphonated resin may also combine with the calcium ions present in the smear layer, but the presence of some moisture can cause difficulties with this reaction. Currently, a no-mix system typical of this genre of bonding agents will consist of:
Dentine primer: often an aqueous solution of maleic acid and HEMA. The primer only partially removes the smear layer, leaving the plugs.

The adhesive resin: this contains HEMA (hydrophilic) and Bis-GMA (hydrophobic) resin. When added to the primer layer, the HEMA present in both will polymerise and so a bond to composite resin material is formed.
Another common variation on this system occurs when the primer contains a phosphonated dimethacrylate ester and camphorquinone, and the adhesive contains a urethane dimethacrylate resin. The urethane resin systems are said to be more biocompatible and are being used to a greater extent in these materials.

Fixing the smear layer

Glutaraldehyde is used to "fix" the smear layer to the dentine. Cross-linking of the collagen fibres within the smear layer is said to increase, enhancing cohesive forces.

Bond strength and fatigue

- Initial resin bond strengths to enamel and superficial dentine can be 15-35 MPa
- Combined mechanical and thermal cycling can rapidly decrease bond strength
- Deep dentine bond strengths generally lower
- Removes or restructures smear layer
- Dissolves inorganic component of dentin
- Exposes and denatures collagen
  - Phosphoric acid
  - Dentin primer
  - Hydrates collagen

Wetting with Low Viscosity Resin

- Low viscosity resin
- HEMA-rich
- Surrounds collagen

- Polymerized for 20 seconds
- Strong mechanical interlock
  – "Hybrid layer"

The hydrophilic acidic monomers can etch and penetrating the enamel.

Employed as self-etching primers in dentin adhesives
The reactive components are esters from bi-valents alcohols with meth-acrylic acid and phosphoric acid or derivates.
The phosphate residue etch the enamel, while the methacrylate component of the molecule is available for co-polymerization with bonding agent and composite resin. No need to rinse off, because both are subsequently polymerized into the bonding layer.
When the water is evaporated during air drying ,the concentration of solubelized calcium and phosphate within the primer may exceed the solubility product constant for a sodium or calcium phosphate salts. There-by limit the depth enamel surface de-mineralization.
Also the binding of Ca ions to the phosphate residues in primer molecules inactivates molecule's acidity.
Evaporation of water during air drying & light curing pf the primer & applied bonding agent, will restrict & inhibit self-etching effect of the primer molecules.

Minerals will then precipitate within the primer.
These high concentration of Ca and phosphate will tend to limit further dissolution of the appatite.
Bond strengths of 17 to 20 mpa are required to resist concentration forces.

Ormocers Bonding Agent

Inorganic siloxane network selectively modified by organic groups, manufactured by a sol-gel process, which begins with compound, e.g. alkoxy-silane with polymerizable groups.

Inorganic network builders fundamentally distinguish them from the TEGMDA (Bis-GMA), and UMDA.

This enables formation of an unlimited chemical and structural combinations using A, B and C which makes possible the precise creation of desired properties.

The inorganic network molecules formation of type

a- proceeds by hydrolysis and polycondensation of the –Si(OR) groups.

Starting with silane, polysiloxane and polymerizable groups formed.

They occur as polymeric liquid as polysiloxane matrix.

It is further processed to a filling material by adding filler particles.

The synthesis of the matrix's inorganic polymer occur in a technical reactor.

Thus compared to the organic monomers in the oral cavity (composite) create the material properties desired.

This matrix is : Polysiloxane building blocks covalently bonded by the silicon atoms to the photo-polymerization, an inorganic-organic network (compound polymer) is formed.

Classified as lying between: inorganic silicates and organic polymers.

Due to its structural similarity to silicate glass or ceramics, it can also be called Organo-Ceramic.

Composition and function of the main components in Ormacer filling material.

Dimethacrylate added for handling and optical properties of the matrix paste.

These molecules form a homogenous mixture with the methacrylate -functionalized polysiloxane molecules.

Biocompatibility:-

Dimethacrylate clearly reduced by the use of methacrylate functionalized polysiloxanes as the main component of the matrix. This made it possible to avoid using TEGDMA, a relatively high solubility dimethacryla

Markedly demonstrated less polymerization shrinkage.

The principle of self-etching &Ormacer :-

Ability of a bonding material in one step to conduct acid induced dissolution of the mineral components of hard tooth structures. And the penetration of the adhesive monomers into retention's and exposed collagen's tissue.

The steps are hence reduced to one.

Attained by simultaneous use of an acidic monomer (pyro-phosphate) and a hydrophilic monomer 2 hydroxy ethyl methacrylate,(HEMA) in a water /; ethanol mixture.

The acidic component is neutralized during dissolution of the inorganic substance (Calcium phosphate apatite) and after precipitate the dissolved inorganic particles enter the bonded or hybrid layer as filler particles.

The liquid monomer fill the retentive structures and after curing, form a network which is anchored micromechanically in the structures and/or as hybrid layer bond or hybrid layer as filler particles.

Etch and prime contains water as a solvent.

Care to dry well with and air jet before curing with polymerization lamp but not to blow away the bonding material completely. (Light-bodied silicone-rubber impression materials form another example where a low contact angle is essential for good wetting to take place).

Rapid Flow Definitions

Hybridisation ~

Infiltration of resin monomers into :- The collagen fibrillar matrix of Demineralised dentin, Followed by polymerization.

The total inherent strength of dehydrated, demineralized dentin < dematerialized dentin < than sound dentin < hybridized dentin !

Clinical implications:

Acid etched

air-dried dentin easily collapses by water loss and shrinking of collagen matrix.

This problem can be partially salvaged by rewetting;

rather prevent by the application of acetone-based priming systems i.e.

A colloidal suspension of calcium phosphate (smear layer) precipitate is dispersed throughout the HEMA;

There is often incomplete hybridization and lack of substance in the middle of the layer with HEMA.

This is improved by adding a water-miscible component such as acetone (or alcohol)

Hybrid layer and resin tags

Acidified primer is applied to the dentin .Not rinsed off. Moderately acidic with a pH that between 1.8 and 2.5. The primer acts to :1-alter and 2-penetrate the smear layer, demineralize surface dentin, expose collagen fibrils, and penetrate the treated area with resin.This is believed to reduce sensitivity because:(1) they etch the dentin less aggressively.

(2) the demineralized dentin is completely infiltrated by resin during the etching process .

(3) Smear plugs are retained in the orifices of the dentin tubules, the tubules remain sealed.

This system showed lower tensile-bond strength

Failed to prevent microleakage .

It may be due to:

Higher sensitivity of water-containing adhesive systems in bonding techniques.

NANOFILLED BONDING AGENT

Contains nanometer fillers.Has a: Greater concentration of resin. A smaller molecular weight resin that have been added. DBA tougher, stronger, Claimed to penetrate dentin better, Provide improved marginal integrity, A low film thickness.

sclerotic and old dentin showed:

1- A thinner hybrid layer.
2- Short resin tags .
3- Fewer lateral branches than normal dentin.
Dentin bonding agents do retain resin composites well in sensitive,
Dentin contains open dentin tubules and less mineralized
intertubular dentin.
Resins flow easily into this type of dentin
(after conditioning)
Provide maximum mechanical retention.
The forms of dentin can be differentiated clinically.

Bond strength and fatigue

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Combined mechanical and thermal cycling can rapidly decrease bond strength

Deep dentine bond strengths generally lower

Wetting with Low Viscosity Resin

Low viscosity resin
HEMA-rich
Surrounds collagen
Polymerized for 20 seconds
Strong mechanical interlock
"hybrid layer"
Presence of Bacteria in Dentinal Tubules
Is a heterogenous material composed of a solid (circumpulpal) phase surrounding a network of tubules.
contain elongated cell bodies .

Density is about 30 000 tubules/square mm.
Contains 69 % (w/w) polycrystalline calcium HA [Ca10(PO4)6(OH)2],
18 % (w/w) proteins and
13 % (w/w) water.
Structurally dentin is composed of mineral crystals deposited between a network of protein fibrils.
Approximately 90% of this network is type I collagen,
the balance consisting of a sheath of phospho-proteins surrounding the collagen, and other proteins in small amounts.

Dentin bonding systems use high concentrations of phosphoric acid which etches the enamel and dentin.
A hybrid layer of collagen and polymerized monomers are formed.
Which is another way of saying that you have partially demineralzed dentin in contact with the polymer(bonding agent).

Potential Advantages

Micro-leakage reduction.
Postoperative sensitivity reduction.
Marginal staining reduction.
Reinforce weakened tooth structure.
Does not act like a wedge.

Potential Advantages

Repair
deteriorating or debonded restorations. without additional loss of tooth structure.
Expands range of esthetic possibilities.
Minimizes removal of sound tooth structure.

Dentin is further categorized as
Peritubular dentin is devoid of fibrous structure and forms a
highly mineralized sheath around the tubules.

Uses

1. Prior to the luting of Inlays cast ceramic, porcelain,
Advantages may include:
    a- increased bond strength,
    B- reduced microleakage,
    c- reduced post-treatment sensitivity,
    d- increased fracture resistance.
    e- film thickness
2. A dentin desensitizing agent
3. Retention of resin-based restorative materials,