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Bonding Agent: The Wonder Liquid in Adhesive Dentistry

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Abstract

The bonding agent is the one that connects the tooth and the restorative material micromechanically. The better the bond between these to substrates the greater will be the success of the restoration. The bond should have better wetting properties to flow in the Nano porosities of the enamel and dentin surface and form longer and more resin tags for higher bond strengths. This article highlights the composition of bonding agent and its properties.

Keywords: Bonding Agent; Monomers; Primers; Solvents.

Introduction

The composition of bonding agent determines the properties of that and eventually affects all the other factors like bond strength, Microleakage, longevity of the restoration in the myriad of conditions that exist in the oral cavity. With a range of bonding agents available in the market, it's difficult to choose the one that suits our needs. Also, not a single bonding agent can be claimed as universal that can fulfill our needs for various instances. It's very important to know the composition of the particular agent.[1,2]

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Composition of Adhesives in Bonding Agents[3,4]

Hydrophobic Monomers: BISGMA & UDMA

Diluents: TEGDMA

Wetting agents: HEMA

Carrier: acetone or ethanol

Self-Etch Primers and Self-Etch Adhesive Systems[5,6,1]

An aqueous solution of acidic functional monomers, with a pH relatively higher than that of phosphoric acid etchants. The 4-methacryloyloxyethyl trimellitic acid (4-MET) acts as demineralizing and an adhesion promoting monomer due to the carboxylic groups attached to the aromatic group 5.

The functional acidic monomers are able to chemically interact with hydroxyapatite and are composed by specific carboxylic, phosphonic or phosphate groups, such as: Phenyl-P, 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP), methacryloyloxy-dodecylpyridinium bromide (MDPB), 4-methacryloyloxyethyl trimellitate anhydride (4-META), 4-

methacryloyloxy ethyl trimellitic acid (4-MET), 11-methacryloyloxy-1, 1-unde canedi carboxylic acid (MAC- 10), 4-acryloyloxy ethyl trimellitate anhydride (4-AETA), 2-methacryloyloxy ethyl dihydrogen phosphate (MEP), phosphate methacrylates, acrylic ether phosphonic acid and other phosphoric acid esters.[6,7]

Primer

hydrophilic monomer used to wet and penetrate the tooth surface. Used to displace residual moisture, thus creating a surface upon which the hydrophobic bonding resin can adhere.[8]

Hydrophilic portion that interacts with the moisture present in the tooth structure, as well as a hydrophobic end that provides bonding sites for the methacrylate monomers in the bonding resin.[1,2]

For example, 2-HEMA and HEMA dissolved in acetone or alcohol. Dentin bonding agents are unfilled resins which have a role in formation and stabilization of hybrid layer (micromechanical attachment between resin and conditioned primed dentin).[9-11]

Even though tags are formed into tubules, bond strength is mainly due to micro mechanical bonding of intertubular dentin.

Adhesives

Are the resins used to bond composite to primed tooth surface. When exposed to water in wet demineralized dentin, dentin adhesives become moisture sensitive and phase separate into hydrophobic and hydrophilic rich phases. Monomers (cross linker and[2] hydroxyethy[l] methacrylate, HEMA) and a photo-initiator system that facilitates the start of a photo-polymerization reaction are the main elements of a dentin adhesive.[13,11,8]

***AD concep*t**

According to this concept all the acids interact with the calcium of hydroxyapatite forming ionic bonds. However, the stability of the formed salts depends on the proper mode of interaction of the monomers and it is inversely related to the monomer acidity. Thus, Phenyl-P and 4-META, like for phosphoric acid molecules, strongly interact with enamel and dentine tissues forming ionic bonds with hydroxyapatite calcium.[12,13,4]

Monomers

MDP monomer (10-Methacryloyloxydecyl di hydrogen phosphate), an acidic functional monomer used in self etch adhesives, will chemically bond to calcium, in hap and form hydrolytically stable 10-MDP calcium salts[1-3] through a self assembled Nano layered interaction. The MDP monomer has been shown to have the ability to bond to zirconia and alumina ceramic surfaces as well as to metals. The silane component allows the adhesive to bond to glass containing ceramic materials used for indirect restorations. These two components will allow the Scotch bond Universal adhesive to be used as a bonding agent to these substrates without the need to incorporate a separate ceramic or metal primer prior to the placement of the adhesive.[14,7, 8]

Besides the strong chemical affinity to calcium, a specific property of 10-MDP is that it builds a particular Nano-sized structure that improves bond stability: the self-assembled so-called 'Nano-layering'.

Solvents[16,17]

Diffusion wability in the porous conditioned substrate, especially in dentin due to the solvent's hydrophilic nature. *Water, ethanol and acetone* are the most commonly used solvents.

Monomers present in Adhese universal bonding agent.[15]

Monomer Name	Type	Purpose
MDP Methacryloyloxydecyl dihydrogen phosphate	Phosphoric acid methacrylate	Forms strong bond to hydroxyapatite surfaces. Promotes adhesion to tooth surface by formation of non-soluble Ca2+ salts.
MCAP	Methacrylated carboxylic acid polymer	Carboxylic acid functional polymer reacts with and bonds to hydroxyapatite. The presence of many carboxylic acid groups along a polymeric backbone/chain allows multiple bonds to the tooth surface.

HEMA Hydroxyethyl methacrylate	Hydrophilic mono-functional methacrylate	Promotes wetting of polar / inorganic and moist surfaces. Assists penetration of liquid filled dentinal tubuli.
Bis-GMA Bisphenol A glycidyl methacrylate	Hydrophilic / hydrophobic crosslinking dimethacrylate	Facilitates compatibility of hydrophilic HEMA and hydrophobic D3MA in the presence of water, thereby preventing phase separation of adhesive. Imparts high mechanical strength and resilience to adhesive layer.
D3MA Decandiol dimethacrylate	Hydrophobic crosslinking dimethacrylate	Enables the reaction of the adhesive with the less polar monomers of the filling or luting composite.

Courtesy: Scientific Documentation Adhese® Universal

The composition of bonding agent differs with manufacturers.

Adhesive System	Composition
Adper Prompt Self-Etch	Adhesive (Liquid 1)A : Methacrylated phosphoric esters, Bis-GMA, Initiators based on camphorquinone, stabilizers; (Liquid 2): water, HEMA, polyalkenoic acid co-polymer, stabilizers
OptiBond Solo Plus Self-Etch	PrimerB : Ethyl alcohol, water, Alkyldi Methacrylate resins, Stabilizers and Activators. AdhesiveB : Ethyl alcohol, Alkyl dimethacrylate resins, 10-20% fillers: fumed silica (silicon dioxide), barium aluminoborosilicate glass, sodium hexafluorosilicate
AdheSE	PrimerC: Phosphonic acid acrylate, Bis-acrylamide, water, initiators and stabilizers AdhesiveC: Dimethacrylate, HEMA, highly dispersed silicon dioxide, initiators, stabilizers
Tyrian	PrimerD: 2-Acrylamino-2-methyl propanesulfonicacid, Bis (2-(methacryloyloxy) ethyl phosphate, ethanol AdhesiveD: BPDM, HEMA, acetone, 8.5% fillers (Glass frit ±0.93µm)
Clearfil SE Bond	PrimerE : HEMA, hydrophilic dimethacrylateMDP (10-methacryloyloxydecyl dihydrogen phosphate), N,N-diethatol-p-toluidine, D,L-camphorquinone, water AdhesiveE : Silanated colloidal silica, Bisphenol A diglycidyl-methacrylate, HEMA, MDP, hydrophobic dimethacrylate, N, N-diethatol-p-toluidine, D,L-camphorquinone
Single Bond	AdhesiveF : Bis-GMA, HEMA, dimethacrylates, polyalkenoic acid co-polymer, water, ethanol

Source: A) 3M ESPE (2002) Adper Prompt Self-Etch Adhesive Technical Product Profile, St Paul, MN, USA. B) Kerr Co (2002) Opti Bond Solo Plus Self-Etch Adhesive System Technical Manual, Orange, CA, USA. C) Ivoclar/Vivadent (2002) Scientific Documentation Adhese, Liechtenstein. D) BISCO Inc (2002) Tyrian MSDS, Schaumburg, IL, USA. E) Yamada T & Sugizaki J (2000) Basic properties and clinical applications of the Clearfil SE Bond Osaka, Japan. F) 3M (1996) Single Bond Dental Adhesive System Technical Product Profile, St Paul, MN, USA.

Adhesive[18-20]

Acetone of ethanol diffuses into the moist dentin while water diffuses into ethanol or acetone (water chasing effect). They occupy the spaces previously filled with water, and then evaporate rapidly leaving enough space for the resin to be applied. The surface tension of acetone and ethanol is less allowing penetration of resin within the collagen Fibres and increasing the bond strength. The number of coats with Water based agent is 1 coat as water is less volatile and will take more time to diffuse Throught the collagen Fibres in dentin.[3]

Silane coupling agents alter the properties of material surfaces, which are modified by means of an organic functional group of specific silanes.[21,4]

Acetone based or ethanol based? Which is better?[22,12,13]

The amount of solvent and water retention in polymer networks is dependant on resin polarity. Acetone, with a relatively high Vapour pressure of 184mmHg at 200C, evaporates much quicker than ethanol or water with a Vapour pressure of 43.9 and 17.5mmHg, respectively.[9,10] Water and ethanol both can hydrogen bond to monomers that are capable of hydrogen bonding. This is the reason why more water and ethanol were retained in ethanol based adhesives. Another reason is that both water and ethanol can hydrogen bond to each other and to Bis GMA or HEMA or Comonomer blends 4 (TCDM) and 5 (2MP) have carboxyl and phosphate functional groups, respectively, that permit solvent to form more hydrogen bonds with those polar groups. As more organic solvents evaporate the molar concentration of the comonomers increases fast, that allows them to H-bond with additinal water and ethanol.

CONCLUSION

The knowledge about the composition of bonding agent can't be undermined as this is the foundation for adhesive dentistry. The substrate at the same time should also be understood for the success of the restoration. With a wide range of bonding agents today at our disposal, proper understanding of the make up of bonding agent will help us in giving the best treatment to our patients and eventually contributing to successful practice.

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