Universal Adhesives

The Evolution Continues for the Ideal Adhesive

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INTRODUCTION OF UNIVERSAL ADHESIVES

In 2012, dental manufacturers started introducing new "universal" adhesives, which could be used as a total-etch (TE) and self-etch (SE) adhesive, and claimed it could replace all previous generations of adhesives. Ideally, the dream adhesive would satisfy the following criteria:

1. 1-layer, 1-component (1-bottle)
2. TE and SE adhesive
3. Usable in indirect procedures without the need for additional activator
4. Bonds to all indirect substrates, including zirconia and silica-containing ceramics

Recently, several 1-bottle universal adhesives became available for direct procedures, including: All-Bond Universal (ABU) (BISCO), Clearfil Universal Bond (CUB) (Kuraray), Prime & Bond Elect (PBE) (Dentsply) and Scotchbond Universal (SBU) (3M ESPE). For indirect procedures, however, an additional SC/DC Activator is required for CUB, PBE & SBU. This activator is required to make the adhesive compatible with DC/ SC luting resin cements. The newest universal adhesive on the market is Futurabond U (FBU) (Voco), which is a two-component adhesive only available in a SingleDose package, with the DC/SC Activator as one of the two-components, eliminating the need for a separate activator component. Do the products currently available meet the criteria for the ideal/dream adhesive eliminating the need for a separate activator?

In general, all of the new universal adhesives are more hydrophobic than previous self-etch adhesives in order to address the permeability issue of adhesives. The bond strengths to dentin in both TE & SE modes are very good, and bond strengths to enamel are reasonable, but not high enough to depend on for long term durability (Table 1). Hence, the selective-etch (etching of enamel only) technique is recommended, especially for MDP containing universal adhesives. Yoshida et al. reported that MDP can chemically bond to Ca++ ions and form stable MDPCa salts, according to the 'adhesiondecalcification' concept.[1] The salt deposits at the adhesive interface form 'self-assembled nano-layers', which may be responsible for the good longterm performance of MDP-containing adhesives, both in-vivo and in-vitro.[1]

THE PH OF UNIVERSAL ADHESIVES INFLUENCES INDIRECT BONDING

As noted in Table 2, the adhesives with a pH of less than 3.0 require a separate component called a "DC or SC Activator" to be used when cementing indirect restorations adhesively. DC luting resins, which are usually polymerized by free radicals generated by mixing two parts (catalyst & base), are based on a peroxide-amine redox system, unless they are an amine-free DC resin system, such as RelyX Ultimate (3M ESPE) or NX3 (Kerr). However, the use of an adhesive with a pH above 3 allows the clinician to use any DC luting resin, as it will be compatible with all SC/DC luting resins.

BONDING TO CERAMICS (PORCELAIN, LITHIUM DISILICATE, ZIRCONIA) WITH UNIVERSAL ADHESIVES

Two of the universal adhesives (CUB & SBU) (Table 2) are formulated with a silane monomer (porcelain primer) in the adhesive, with the hope that the silane will be stable in the acidic adhesive and will bond chemically to silica-containing ceramics. In theory, a universal adhesive with silane would make it very convenient for users. However, the water contact angle (CA) and shear bond strength (SBS) studies by Chen[2] at al. demonstrated that a silane primer does not function when it is mixed with other resin monomers (Table 3). As seen in Table 3, the CA's of CUB and SBU adhesives are statistically similar to the CA of no primer (negative control), and much lower value than the CA of a pure silane primer (positive control), indicating that silane in a universal adhesives is not effective in forming a chemical bond to silica-based ceramics. The SBS to a HF etched surface is reasonably high due to mechanical bonding, but the SBS from mechanical bonding without an effective silane primer will not be durable over time. The SBS of SBU to a HF-etched surface was measured after aging the specimens in water for 6 months and thermocycled 10,000 times. The SBS of SBU was very low (~5 MPa), which was the same as no primer, and much lower than a

All-Bond Universal® is a single-bottle dental bonding agent that combines etching, priming and bonding.

5 KEY TAKE AWAYS

1. All new universal adhesives result in good dentin bonding, in TE or SE mode. The selective-etch technique is recommended for enamel bonding.
2. CUB, PBE & SBU require a DC/SC Activator when used with a DC/SC resin composite/cement.
3. ABU does not require a separate DC/SC Activator due to its higher pH (=3.2). FBU does not require a separate DC/SC Activator because it is built into the SingleDose system (2-component).
4. Universal adhesives chemically bond to zirconia because they contain MDP (or an organo-phosphate) but light-curing is required. Universal adhesives function as a zirconia primer.
5. Universal adhesives do not chemically bond to silica-containing ceramics, even when silane is added to the adhesive formula (CUB & SBU). Universal adhesives do not function as a porcelain primer.

pure silane primer. Therefore, the shear bond strength (SBS) to polished silicacontaining ceramic surface was tested with CUB & SBU adhesives to determine the chemical bond. The reason silane is not effective when combined into a universal adhesive is most likely due to the MDP (acidic) and BisGMA resins in the adhesive. A silane monomer in an acidic condition (MDP + water) may be unstable due to the self-condensation reaction of the silanol groups in silane. Additionally the BisGMA resin may interfere with the silane-coupling condensation reaction between the silane and the hydroxyl (-OH) group of a silica-containing ceramic surface.[2,3] Thus, silane added to a universal adhesive cannot be effective. Therefore, a pure silane primer should be used for a durable chemical bond to porcelain. In addition, the CA of an experimental adhesive (ABU + silane primer) was measured to test the efficacy of the addition of silane, which, as expected, was low (~12). The SBS to a polished surface of silica-containing ceramic was also measured and resulted in low SBS (~6 MPa). The presence of an MDP (or other organophosphate) monomer makes a universal adhesive bondable to zirconia (Zr) and other metallic substrates. Chen et al. proved that MDP chemically bonds to Zr.[4] However, MDP-containing universal adhesives must be light-cured to be used as a Zr primer, due to the presence of other resins (BisGMA, HEMA, etc.) which may not cure when placed under a self-cured resin cement. However, light curing the universal adhesive on the restoration may cause film thickness issues. To avoid light-curing the adhesive on Zr/metal, a pure Zr Primer (AZ Primer (Shofu), Z-Prime™ Plus (Bisco), Ceramic Primer (Kuraray), Monobond Plus (Ivoclar) should be utilized.

CONCLUSION

None of the new universal adhesives completely meet the conditions of the ideal adhesive. SBU, PBE and CBU require a DC/SC activator for indirect procedures, while ABU (pH>3.0) and FBU (two component adhesive with a built-in activator) do not. ABU is the only single-bottle adhesive, that does not require a SC/DC Activator but like all the other universal adhesives, it requires a separate silane primer for chemically bonding to silica-containing ceramics. All universal adhesives, with or without silane incorporated into the adhesive formula (CUB & SBU) are not as effective as pure silane primers. Therefore, it is recommended to use a separate silane primer on silica-containing ceramics (porcelain & lithium disilicate) when using any universal adhesive.

Current universal adhesives are almost "universal", but not yet the "ideal" adhesive. However, some are closer to ideal than others. Regardless, the current universal adhesives are superior to any previous generation of adhesives, and are here to stay, and will continue to improve.

Table 1. Shear Bond Strength in MPa (SD) on Tooth Structure Using Universal Adhesives in Total-etch (TE) and Self-etch (SE) modes

Adhesive Name	Enamel (TE)	Enamel (SE)	Dentin (TE)	Dentin (SE)
All-Bond Universal®	38.0* (7.8)a	26.2 (4.5)a	42.5 (4.6)a	36.9 (6.7) a
Scotchbond™ Universal	37.0* (4.7)a	27.1 (5.9)a	36.0 (3.3)b	34.7 (10.8)a
Prime&Bond Elect™	31.9* (4.2)ab	24.6 (3.7)a	29.5 (5.1)c	34.7 (11.2)a
Clearfil™ Universal Bond	33.0* (2.9)ab	23.7 (0.6)a	37.2 (4.0)ab	32.2 (5.3)
Futurabond U	28.4 (4.9)b	28.0 (7.8)a	30.9 (5.1)bc	36.0 (7.1) a

*Mean values followed by different letters in the same column are statistically different (p<0.05). For the same adhesive, mean values followed by * (for enamel bonding) or are significantly higher than that of the other etching mode (p<0.05). SD = Standard Deviation. Shear bond strength was tested using Ultradent jig method, bonding area 4.5mm2, water storage 24hrs/37ºC, n=5. Aelite™ All-Purpose Body was used as composite. Trademarks are property of their respective owners.*

Table 2. Universal Adhesives

Adhesive Name	#Componen	PH	Activator Required?	+Silane?	AFM*
All-Bond Universal®	1	3.2	No		MDP
Scotchbond™ Universal	1	2.7	Yes	+Silane	MDP
Prime&Bond Elect™	1	2.5	Yes		PENTA-P
Clearfil™ Universal Bond	1	2.3	Yes	+Silane	MDP
Futurabond U	2	2.3	BUILT-IN		Not Disclosed

**AFM=Adhesive Functional Monomer.*
Data compiled from respective manufacturer's instructions for use.

Table 3. Evaluation of Silane-Priming Efficacy of Silane-Containing Universal Adhesives

Primer/Adhesive	No Primer (Neg. Cont.)	Scotchbond Universal	Clearfil Universal	Porcelain Primer (Pos.Cont.)
Water Contact Angle (º)n=10	12.2 (1.6)a	12.0 (2.2)a	10.0 (2.6)a	82.3 (8.3)b
SBS-polished (MPa)n=10	2.4 (0.4)a	5.2 (2.1)b	-	23.5 (3.5)c
SBS-etched (MPa)n=16	17.5 (4.2)a	24.6 (5.8)b	-	38.5 (7.7)c
SBS-etched-aging (MPa)n=16	7.2 (2.0)a	5.6 (3.7)a	-	25.8 (4.2)c

SBS = Shear bond strength; SBS-polished = SBS on polished lithium disilicate; SBS-etched = SBS on etched lithium disilicate; SBS-etched-aging = SBS on etched lithium disilicate after aging for 6 months/37ºC and 10,000 times of thermocycling (5ºC-55ºC). Mean (Standard Deviation) values followed by different letters in the same row are statistically different (p<0.05). Shear bond strength was tested using ultradent jig method, bonding area 4.5mm2. Contact angle was tested on primed etched lithium disilicate after ultrasonication in ethanol.

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