Leading the way to a new standard

G2-BOND Universal from GC

The new standard of 2-bottle Universal Bonding

COMPREHENSIVE GUIDE


G2-BOND
Universal
Bottle Kit

G2-BOND Universal from GC

1 Introduction

With over 1 billion composite restorations and a century of competence in dental materials, GC is leading the way to new standards in adhesive dentistry.

Focusing on continuous improvement, GC took the challenge to improve on the existing 2-bottle benchmarks. In this regard, achieving bond stability to dentin with its high inorganic content and complex morphology has always been the most challenging part. An ideal adhesive would be resistant to hydrolytic degradation, yet able to completely infiltrate and chemically adhere to the dentin.

This search has resulted in the development of G2-BOND Universal: with its proprietary Dual H-Technology, an advanced optimisation of the bonding both to the tooth and the composite, G2-BOND Universal is an all-round universal 2-bottle system combining what clinicians would expect from existing self-etch and etch-and-rinse (also referred to as total etch) gold standards. G2-BOND Universal creates a thick bonding layer that is resistant to hydrolytic degradation due to decreased water uptake and strong mechanical properties. As a result, a tight seal with better long-term marginal quality, less degradation potential and less discoloration can be expected, resulting in a durable interface that also remains invisible over time.

2 Product description

G2-BOND Universal is an all-round universal 2-bottle system that can be used in all etching modes.

- A separate primer **(1-PRIMER)**
  - Acting as the adhesion promoter; etching with phosphoric acid is optional
  - With chemical bond ability based on MDP working in synergy with 4-MET
  - Containing also photo-initiators to ensure a high degree of resin polymerization, even in the deeper parts of the hybrid layer.
  - HEMA-free to minimise water uptake and enhance long-term durability

- A separate bonding agent **(2-BOND)**
  - HEMA-free hydrophobic resin to reduce water uptake
  - Displaying a sufficiently thick bonding layer with high mechanical properties and stress-absorbing potential.
  - Providing a tight, reinforced seal of the interface

3 Indications for use

- Direct bonding of light-cured composites and compomers to tooth structure
- Bonding of dual-cured core build up composites to tooth structure as long as these materials are light-cured
- Intraoral repair of composite, metal-based and zirconia / alumina-based restorations
- Intraoral repair of ceramic restorations in combination with a silane coupling agent
- Treatment of hypersensitive teeth
- Sealing of tooth preparation (cavity or abutment) for indirect restorations
- Treatment of exposed root surfaces
- Cementation of all types of all ceramic, resin and metal-based inlays, onlays, crowns and bridges and veneers
- Post cementation

4 Technology

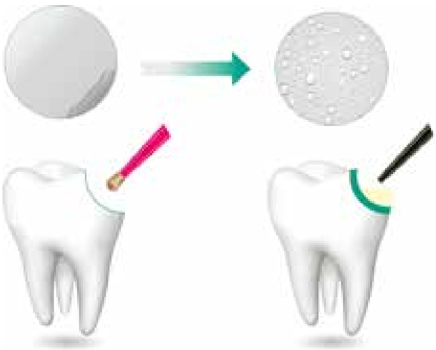
4.1 Dual H-Technology

GC researchers focused considerably on strengthening the adhesive layer and significantly reducing the potential for water degradation over time. The new GC proprietary Dual H-Technology provides **a smooth transition from hydrophilic to hydrophobic characteristics** in the primed surface, which is then further strengthened by a truly hydrophobic protective bond layer.

Hydrophilic primer wets and self-etches the tooth surface effectively.

Without hydrophilicity?

- Insufficient resin infiltration to dentin surface
- Higher risk for gap formation



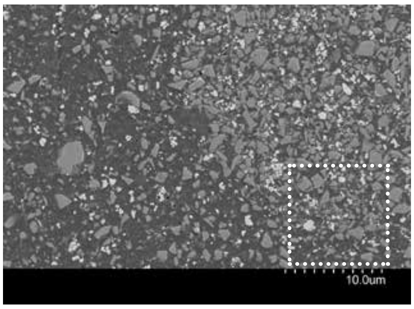
Highly hydrophobic bond layer results in strong bonding to composite.

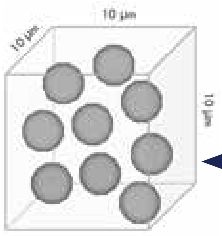
Without hydrophobicity?

- Hydrolytic degradation of bond layer
- Increased risk for debonding.

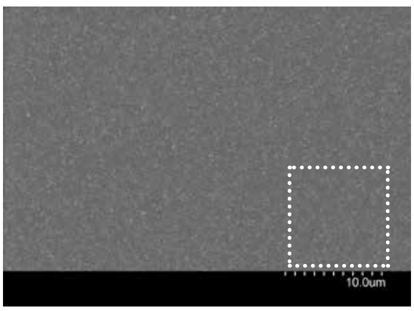
4.2 Single dispersion nanofiller

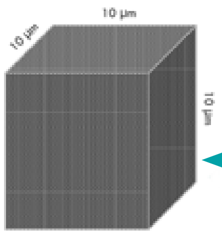
One of GC's established filler technology is used in G2-BOND Universal to achieve a strong and resistant bond layer. All filler particles are below 100nm in size and silane treated which enables them to bond to resin matrix, and to be individually and uniformly dispersed in resin. The illustration shows it in comparison to the product which has higher filler loading but with much bigger and aggregated particles.





In this hypothetical 1000 µm³ space,
OptiBond FL has
approx. **2,000 filler particles**





In this hypothetical 1000 µm³ space,
G2-BOND Universal has
appox. 12,000,000 filler particles
High density, minimal interparticle space

5 Composition

In the development of G2-BOND Universal, considerable care has been given to optimize the composition of both primer and bond, taking in mind the following elements

- The composition of 1-PRIMER is based on the technological knowledge of GC in self-adhesive bonding agents, which has been showing very favorable clinical results in randomized controlled clinical trials with follow-up data up to 9 years*.
- For the composition of 2-BOND, the development has been focusing on the search for a hydrophobic and strong layer capable of creating a perfect, long-lasting seal
  * Nine-year Clinical Performance of a HEMA-free One-step Self-etch Adhesive in Noncarious Cervical Lesions. Peumans *et al*, J Adhes Dent 2018;20(3):195-203.

5.1 A unique formulation

The following table describes the components of G2-BOND Universal and their clinical relevance.

1-PRIMER	
Component	Function
4-MET	Functional monomers: etching agents: • dissolve smear layer & demineralize • wetting agents: infiltrate the demineralized surface • promote chemical adhesion between tooth and monomers Promotes reliable adhesion to enamel and dentin
MDP	Functional monomer: • promotes excellent adhesion to tooth structure, zirconia, alumina and non-precious metals and monomers
MDTP	Functional monomer: • promotes chemical adhesion to precious metals
Dimethacrylate monomers	Resin monomers: • linking agents with hydrophobic composite resin • networking agents promoting monomer cross-linking
Distilled water	• Promotes etching • Solvent (takes in residues from etching)
Acetone	• Solvent (evaporates water from interface)
Silicon dioxide	• Adjusts the viscosity • Reinforcing material
Photo-initiator	• Triggers the polymerization of monomers upon light activation • Ensures sufficient polymerization of the deepest parts of the hybrid layer

2-BOND	
Component	Function
Dimethacrylate monomers	Resin monomers: • linking agents with hydrophobic composite resin • networking agents promoting monomer cross-linking
Silicon dioxide	• Adjusts the viscosity • Reinforcing material
Photo-initiator	• Triggers the polymerization of monomers upon light activation

Further information on the role of some main components

Fillers: the 2-BOND of G2-BOND Universal contains silicon dioxide homogeneously dispersed thanks to a proprietary GC technology. This helps to reinforce the bonding layer.

Resin matrix: G2-BOND Universal contains only **hydrophobic** dimethacrylates

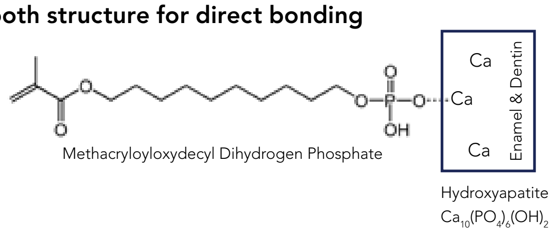
Functional Monomers: G2-BOND Universal 1-PRIMER contains both MDP & 4-MET in its formulation, as well as MDTP. This results in an improved adhesion to enamel & dentin (MDP and 4-MET), to zirconia, alumina, non-precious metals (MDP) and precious metals (MDTP).

MDP: 1-PRIMER contains MDP (10-Methacryloyloxydecyl dihydrogen phosphate), which is a functional monomer that enables a very efficient chemical adhesion to enamel, dentin, metal alloys and zirconia/alumina. However, MDP is NOT present in 2-BOND, in order to reduce the hydrophilicity of the BOND. Research has shown that the incorporation of MDP in 2-BOND could decrease the performance of the bonding agent.

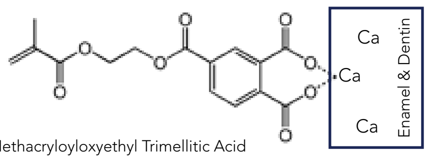
MDTP: G2-BOND Universal contains MDTP (Methacryloyloxydecyl dihydrogen thiophosphate), which is a functional monomer promoting adhesion to precious metals.
Most competitors do not contain MDTP, which is why they cannot bond to precious metals.

Bond to tooth structure for direct bonding

MDP

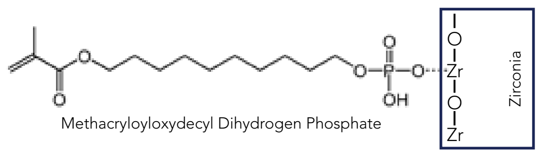


4-MET

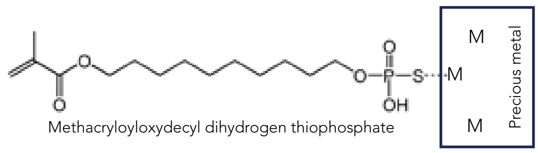


Bond to indirect substrates in repair cases

MDP



MDTP

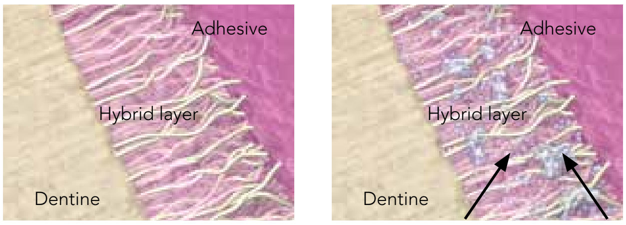


5.2 The HEMA-free principle

Like all GC adhesives, G2-BOND Universal is HEMA (2-hydroxyethyl methylmethacrylate) -free. Developing a HEMA-free adhesive is technically more difficult to achieve which is why the majority of adhesive manufacturers choose to include HEMA, which is water soluble, despite some clear disadvantages:

- HEMA enhances water uptake from the tooth and the intra-oral environment, rendering the bond more prone to degradation over time
  - Van Meerbeek, Bart *et al*. From Buonocore's Pioneering Acid-Etch Technique to Self-Adhering Restoratives. A Status Perspective of Rapidly Advancing Dental Adhesive Technology. DOI: 10.3290/j.jad.a43994
- The presence of HEMA, a hydrophilic monomer, will strongly affect water sorption
  - Ito S *et al*. Dentin bond durability and water sorption/solubility of one step self etch adhesives. Dent Mater J 2010; 29(5): 623 630
- Hydrolysis of HEMA leads to the release of some small alcohol molecules which have substantial water solubility, such as ethylen glycol.
  - Cohen Setal. Water sorption, binding and solubility of polyols. J Chem Soc, Faraday Trans 1993;89:3271-3275.
- From a chemical perspective, HEMA has only one polymerizable group, reducing its polymerization efficiency (only linear polymerization without cross-linking), thus resulting in a weaker interface
- HEMA has been shown to reduce the effectiveness of MDP chemical interaction with hydroxyapatite
- HEMA has been reported in the literature as being able to induce contact allergic reactions and can also quickly penetrate through dental gloves.

HEMA poly-gel



HEMA attracts water | Collagen fibers degrade over time

Figure 1: HEMA is prone to water degradation

By excluding HEMA from G2-BOND Universal, the application technique for 1-PRIMER is slightly different to the application of a typical HEMA-containing primer/adhesive. In an aqueous environment, 1-PRIMER has a pH of around 1.5, enabling the creation of a nano interaction zone in self-etch mode or a defined hybrid zone in etch-and-rinse mode. This zone of chemical bonding is formed very quickly (during the 10s application of 1-PRIMER). However, once formed, the water needs to be removed; otherwise it is a source of degradation over time.

A HEMA-containing adhesive would simply absorb this water (hence you gently air-dry after application). A HEMA-free adhesive is not absorbing water, which makes it possible to remove the hydrophilic elements by air-drying under maximum air pressure for 5 seconds. This step is critical for the removal of water from the adhesive interface.

The combination of MDP and 4-MET functional monomers ensure simultaneous demineralization and complete infiltration of resin monomers into the collagen network; ensuring the risk of voids at the dentin/bond interface is averted. As a result, the risk of nano-leakage is decreased and the long-term durability of the adhesive is increased.

After application of the adhesive, water is separated from the other ingredients upon acetone evaporation. The HEMA-free formulation of G2-BOND Universal 1-PRIMER evades substantial water retention in the adhesive layer. As mentioned above, residual water along with the presence of HEMA would lead to greater water sorption, and thus a less stable bond (Figure 1). In contrast, the long-term hydrolytic resistance and stability of the bond are improved when using the HEMA-free G2-BOND Universal 2-bottle adhesive. In addition, the risk of allergic reactions associated with HEMA is prevented with G2-BOND Universal.

5.2.1 Impact of MDP and HEMA on 2-BOND formulation

Not only is 1-PRIMER HEMA free, but the composition of 2-BOND was also optimized to make it free of hydrophilic components and solvents.

The impact of MDP and HEMA on the formulation of 2-BOND was analyzed in the following test

Method: Three trial 2-Step self-etch Bonding agents, Control (G2-BOND Universal which consists of primer and adhesive free of HEMA and MDP, GC), +HEMA (including 30% of HEMA in Control) and +MDP (including 20% of MDP in Control) were examined. Bovine dentin surface was with 400-grit SiC paper. Each primer and adhesive were applied on prepared dentin surface, then composite resin was applied to prepare bonding specimen according to ISO29022. After storage in water at 37°C for 24 hrs., bonding specimen were subjected to shear bond strength (SBS) test. Flexural strength specimens of each adhesive were prepared, stored in water at 37°C for 1 week. Flexural strength tests were according to ISO4049. Data were statistically analyzed (ANOVA, $p<0.05$)($n=5$).

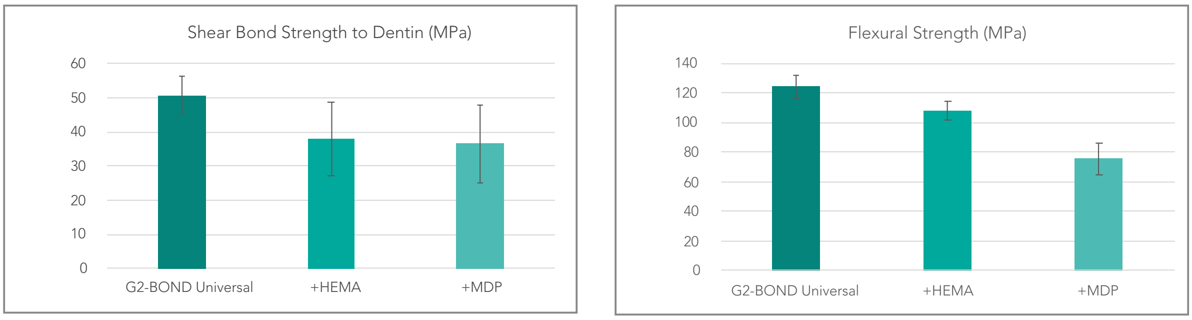


Figure 2: Shear bond strength and Flexural Strength of G2-BOND Universal 2-BOND compared to same formulation with either added HEMA or added MDP. *Source: GCC R&D, Japan. Data on file.*

Result: Mean(±SD) SBS values were 50.7(±5.5), 38.0(±10.6) and 36.6(±11.4) MPa for Control, +HEMA and +MDP respectively. Mean(±SD) flexural strength values were 124.1(±7.8), 108.3(±6.3) and 75.6(±10.8) MPa for Control, +HEMA and +MDP respectively. +HEMA and +MDP showed significantly reduction of both bond strength and flexural strength compared with Control.

Conclusions: Formulation of HEMA and MDP had negative impact on material performance and this might indicate HEMA and MDP free adhesive may result in high durability and clinical performance.

5.2.2 Impact of HEMA free formulation on the performance of G2-BOND Universal 2-BOND

Another test was conducted to assess the impact of HEMA at different concentration on the performance of G2-BOND Universal.

Shear bond strength test against bovine dentin and Vickers hardness tests were performed to evaluate the impact of HEMA on the performance the of 2-step self-etch bonding agents.

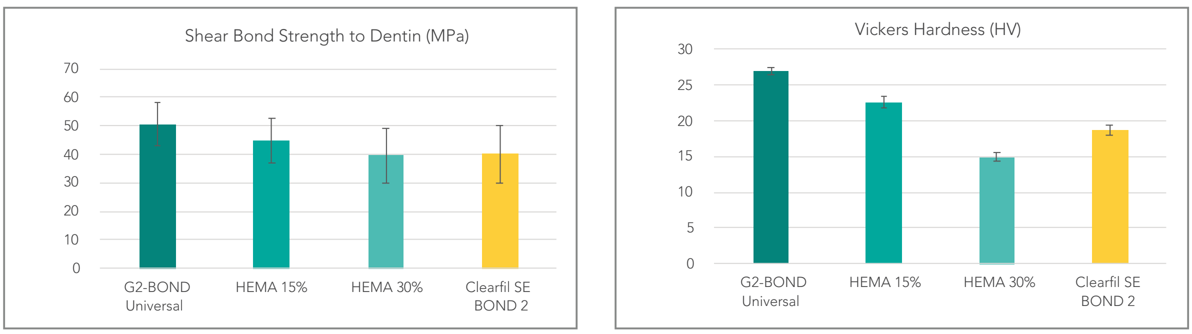


Figure 3: Shear bond strength and Vickers Hardness of G2-BOND Universal 2-BOND compared to the same formulation with increased HEMA concentration and Clearfil SE BOND 2 (Kuraray Noritake). *Source: GCC R&D, Japan. Data on file.*

The results show that both Bond Strength and Vickers hardness were negatively affected by the presence of HEMA. Furthermore, the values were also higher than leading competitor Clearfil SE BOND containing HEMA. These results suggest that the HEMA Free composition of G2-BOND Universal 2-BOND may result in high durability clinical performance.

6 Physical properties – *in vitro* studies

6.1 Bond strength and durability

G2-BOND Universal was designed to create a physically stronger, more durable adhesive layer as the Dual-H Technology ensures a higher bond strength immediately after placement, with lower water sorption which decreases the risk of degradation for superior durability.

G2-BOND Universal is a bonding system that can be adapted to all clinical situations, offering flexibility and the option to select the most clinically appropriate technique:
The self-etch technique: for all clinical indications where adhesion is mainly to dentin; avoids the risk of nano-leakage and hypersensitivity.
The selective etching technique: acid etching the enamel only for 10 seconds before applying G2-BOND Universal. This is indicated for uncut and cut enamel surfaces.
Using selective etching offers the benefits of both techniques and avoids their respective disadvantages.
The etch-and-rinse technique: for all clinical situations where there is contact only with the enamel and hence acid etching only for 10 seconds will increase micromechanical retention.

6.1.1 Shear bond strength in two etching modes

A. Shear bond strength to enamel and dentin in self-etch mode

Method: The bond strength was tested with a notched-edge shear bond strength (SBS) test in accordance with ISO29022:2013 (Figure 4). Bovine enamel or dentin surfaces were ground with 400-grit SiC paper. Adhesives were applied in accordance with the respective manufacturer's instructions. The bonded specimens were subjected the SBS test at 1 mm/min after storage in water at 37°C for 24h, before (TC 0) and after thermocycling for 20000 cycles (TC 20k; 5-5°C, 30 s dwell time).

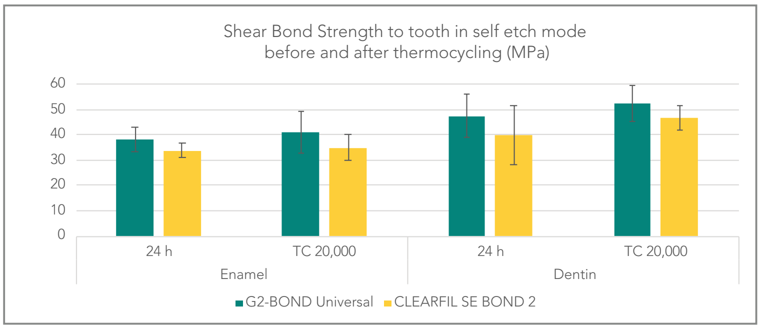


Figure 4: Shear bond strength of G2-BOND in self-etch mode compared to Clearfil SE BOND (Kuraray Noritake) before and after thermocycling.
Source: GCC R&D, Japan. Data on file.

B. Shear bond strength in etch-and-rinse mode

Method: The bond strength was tested with a notched-edge shear bond strength (SBS) test in accordance with ISO29022:2013 (Figure 5) as described in 5.1.1. However, prior to the adhesive application, the tooth surfaces were etched with phosphoric acid gel in accordance with the manufacturer's instructions.

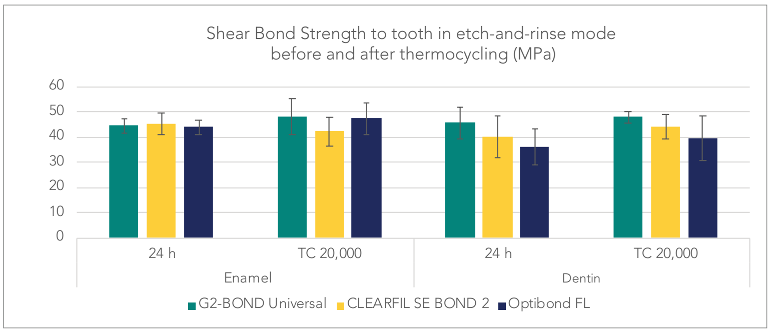


Figure 5: Shear bond strength of G2-BOND in etch-and-rinse mode as compared to Clearfil SE BOND (Kuraray Noritake) and Optibond FL (Kerr) before and after thermocycling. *Source: GCC R&D, Japan. Data on file.*

The bond strength of G2-BOND Universal remains stable before and after thermocycling in both self-etch and etch-and-rinse modes, suggesting that a long term clinical performance could be achieved in both etching modes.

6.1.2 Shear bond strength compared to other two-bottle adhesive systems

The University of Paris V (JP Attal and P François) tested the shear bond strength (SBS) to dentin of G2-Bond Universal when used in self-etch (SE) and total etch (E&R) modes comparing to different multi-mode adhesive systems.

Method: A total of 40 extracted sound molars were embedded in acrylic resin blocks. Then, the middle part of the dentin was exposed on a flat surface after polishing until 800 grits. For each group (n=10), cylinders of resin composite (Z100, 3M ESPE) were bonded to dentin, with the following two-bottles adhesives according to manufacturer's instructions: G2-Bond Universal in E&R mode (control group), G2-Bond Universal in SE mode, ClearfilSE Bond 2 (Kuraray-Noritake) in SE mode and the E&R OptibondFL (Kerr). For each group: 10 samples were tested for SBS. A one-way ANOVA followed by Tukey's post hoc test was performed to analyze SBS results.

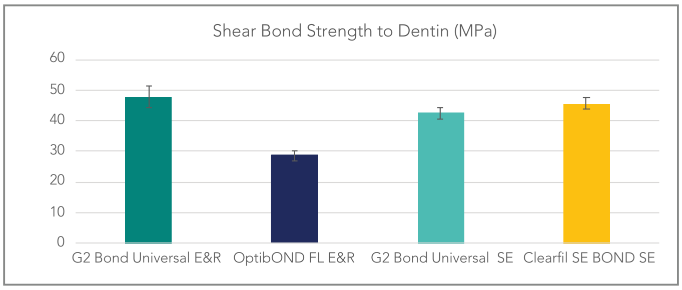


Figure 6: Francois P, *et al.*, Dentin Shear Bond Strength of Novel Two-Bottle Multimode Adhesive:

G2-BOND Universal showed satisfactory dentin SBS in both E&R and SE modes. G2-Bond Universal in E&R mode showed the highest SBS values (47,49 MPa) and statistically different from other groups whereas OptibondFL showed the lowest SBS values (28,95 MPa).

6.1.3 Microtensile Bond strength

Microtensile bond strength to human dentin was evaluated after 24 hours, 3 months and 6 months water storage. Fracture surface was analyzed.

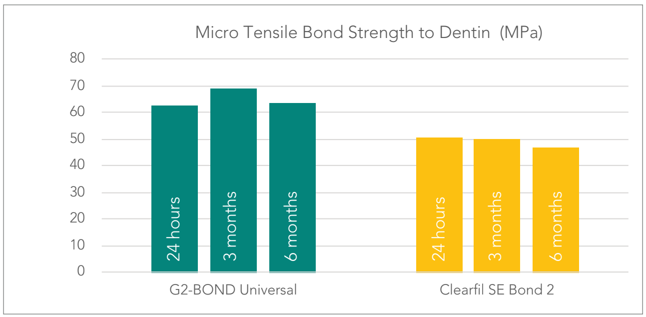


Figure 7: Micro-tensile bond strength of G2-BOND Universal in comparison to Clearfil SE BOND (Kuraray Noritake) at 24h, 3 months and 6 months after water storage. *Source: Dr. Mine, Osaka University, Japan*

After 6 months, the Bond Strength of G2-BOND Universal was 28% higher than the one of Clearfil SE Bond 2. Zero% Interface failure was observed for G2-BOND Universal.

The initial adhesive performance of G2-BOND Universal was maintained over time. The hydrophobic property of the bond has played an important role in improving the durability of 2-step bonding agent.

6.1.4 Water sorption

Water sorption is a source of bond deterioration over time. The water sorption was tested in accordance with ISO 4049:2019 (Figure 8).

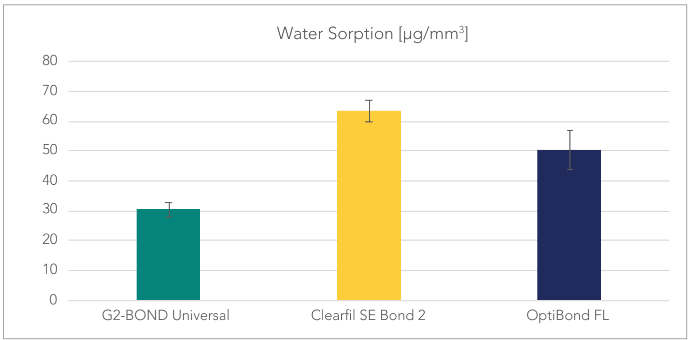


Figure 8: Water sorption of G2-BOND Universal in comparison to Clearfil SE BOND 2 (Kuraray Noritake) and Optibond FL (Kerr). *Source: Prof. Van Meerbeek, KU Leuven, Belgium*

Water absorption was significantly higher in HEMA-containing group in comparison to G2-BOND Universal. This feature is also expected to an effect on the durability and lower incidence of discoloration of G2-BOND Universal in time.

6.2 Marginal quality

G2-BOND Universal was designed to provide a strong bond layer that assists the aesthetic transition from the composite to the tooth, avoid gap formation and microleakage to maintain marginal quality over the time.

6.2.1 Micro-leakage

Method: The marginal seal of relocated cervical margins of MOD Overlays was evaluated using different bonding systems.
Standardized MOD cavities were prepared in human molars. The proximal margins in mesial side were located 1 mm below cement-enamel junction (CEJ), whereas on the distal side of the tooth the margins were located 1 mm above CEJ. Three adhesive systems were combined with an injectable resin composite (G-ænial Universal Injectable). An incremental technique was followed to restore the cavities.

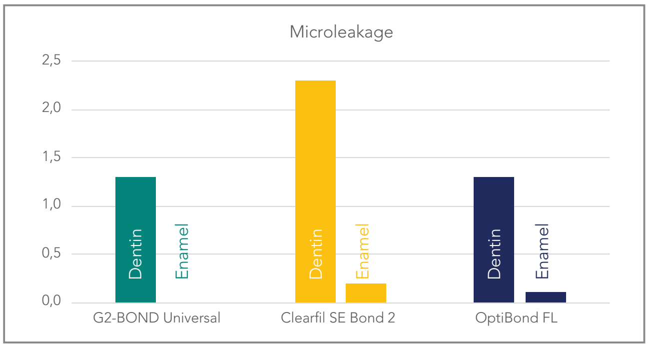


Figure 9: Microleakage of G2-BOND Universal in comparison to Clearfil SE BOND (Kuraray Noritake) and Optibond FL (Kerr) *Source: Prof. Ferrari, University of Siena, Italy, 2020*

Differences were observed in nanoleakage along the dentin-bonding interfaces among 3 groups, showing a better performance of G2-BOND Universal and Optibond FL on dentin and better performance of G2-BOND Universal on enamel.

6.2.2 Gap formation

The bonding performance of one-step self-etch adhesives was reported to be improved with a hydrophobic coating layer. Based on this result, a novel two-step self-etch adhesive (2-SEA) was designed, interfacial gap formation was evaluated and compared to a clinically well-proven 2-SEA.

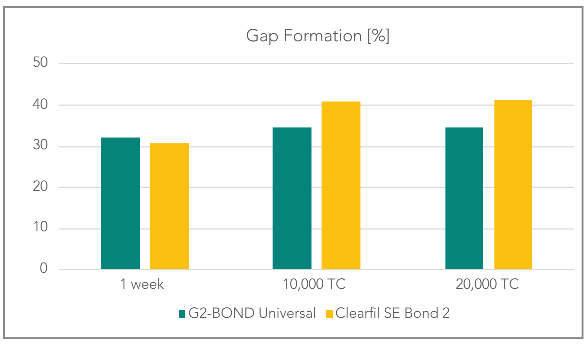


Figure 10: Gap formation of G2-BOND Universal compared to Clearfil SE Bond 2 (Kuraray Noritake) at 1 week and after 10k and 20k thermocycling. *Source: Prof. Tagami, Tokyo Medical and Dental University, Japan*

The interfacial gap formation was similar for both adhesives after 1 week ($p>0.05$), but G2-BOND Universal exhibited a significantly lower gap formation than Clearfil SE BOND 2 after TC ($p<0.05$)

6.2.3 Color stability

The color stability is important for the aesthetic outcome over time (marginal discoloration). It was measured after water immersion at 37°C using a calorimeter.

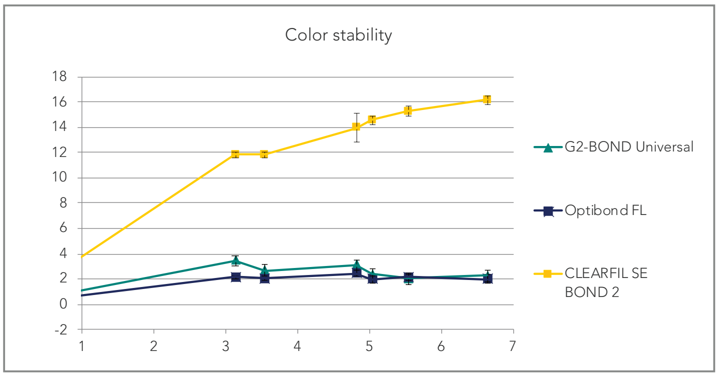
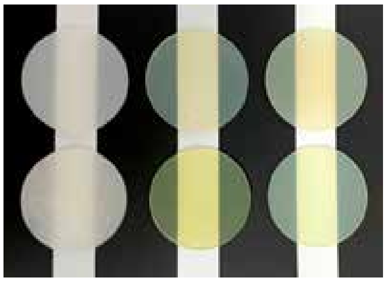


Figure 11: Color stability of G2-BOND as compared to Clearfil SE BOND (Kuraray Noritake) and Optibond FL (Kerr). *Source: GCC R&D, Japan. Data on file.*

G2-BOND showed very little discoloration, avoiding the appearance of ungraceful restoration margins over time.

0 day

6 months



Optibond FL Clearfil SE BOND 2 G2-BOND Universal

Picture 1: Color stability of G2-BOND as compared to Clearfil SE BOND (Kuraray Noritake) and Optibond FL (Kerr). *Source: GCC R&D, Japan. Data on file.*

6.2.4 Wear resistance

Good wear resistance is important to avoid marginal gap formation over time. All tested specimens were polished up to high gloss following a standardized protocol and subjected to a toothbrush with a toothpaste slurry (toothpaste:water at ratio 1:2) and a toothbrush at 200 g load, 12000 times. After the test, the specimens were thoroughly rinsed with water and the depth of loss was measured using 3D laser microscope (Figure 12).

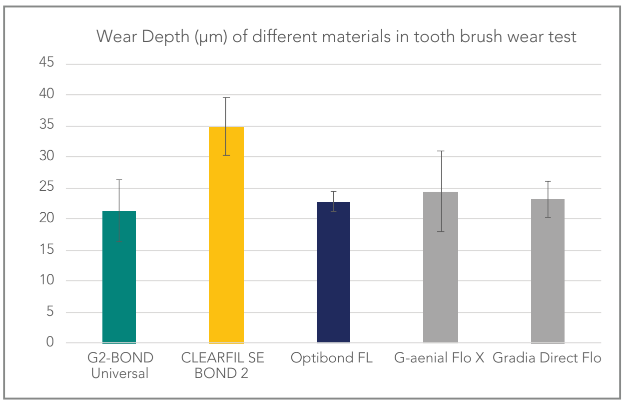


Figure 12: Tooth brush wear test of G2-BOND as compared to Clearfil SE BOND (Kuraray Noritake) and Optibond FL (Kerr). *Source: GCC R&D, Japan. Data on file.*

G2-BOND showed excellent wear resistance, which is beneficial to maintain the marginal integrity of the restoration. Within the given test, the wear resistance was also comparable to flowable composites.

6.3 G2-BOND Universal as a shock absorber

The layer thickness of G2-BOND is optimized to act as a shock absorber.
Method: Bovine dentin surfaces with ground with #400 SiC paper. Primer and adhesive were applied in accordance with the manufacturer's instructions. The air pressure was standardized at 0.05 MPa with a distance from surface to tip of 30 mm. Specimens were covered with composite. After cross-section, the film thickness was measured on SEM images (Picture 2).

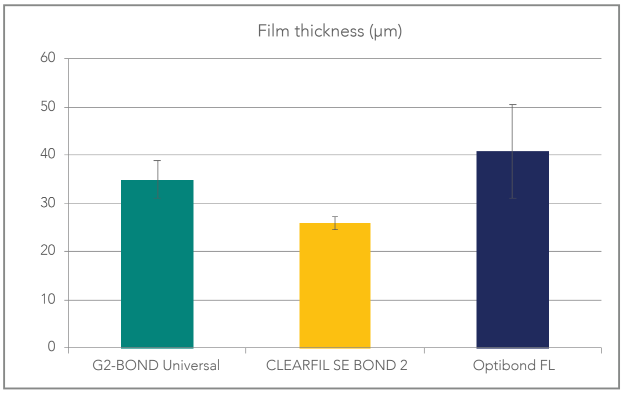
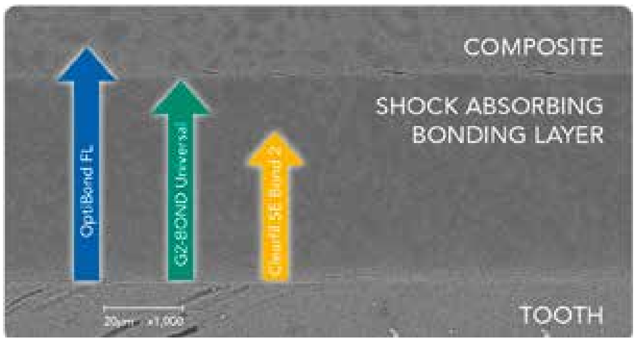


Figure 13: Film thickness of G2-BOND as compared to Clearfil SE BOND (Kuraray Noritake) and Optibond FL (Kerr). *Source: GCC R&D, Japan. Data on file.*

The optimal thickness G2-BOND Universal was designed act as a shock absorbing layer, capable of preventing debonding. The bonding will function as a base in large cavities and can overcome the polymerisation shrinkage, compensating for the stress caused by the over layered composite.



Picture 2: Film thickness of G2-BOND Universal *Source: (SEM picture) Prof. Miyazaki, Nihon University, Japan*

6.3.1 Flexural strength

In high-stress clinical situations, adequate flexural strength is mandatory. The flexural strength was tested in accordance with ISO4049 after storage in water at 37°C for 24 h, 3 months and 6 months, respectively (Figure 14).

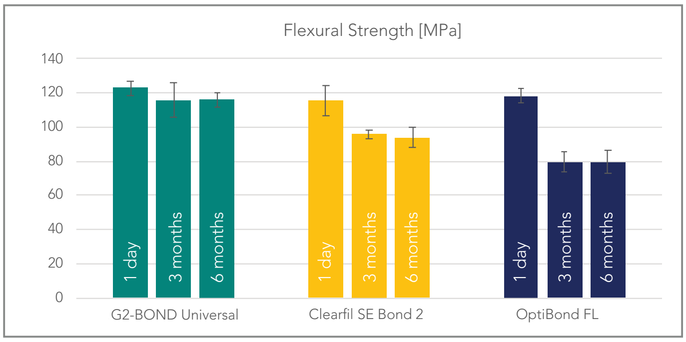


Figure 14: Flexural strength of G2-BOND over time as compared to Clearfil SE BOND (Kuraray Noritake) and Optibond FL (Kerr). *Source: GCC R&D, Japan. Data on file.*

The HEMA free and hydrophobic composition of G2-BOND Universal led to a lower degradation of bond layer by reducing the water uptake. Long term durability of the restoration could be expected.
Due to the high flexural strength, G2-BOND Universal will be able to better resist the strains from polymerization of the overlying composite.

6.4 Technique sensitivity

6.4.1 Influence of air pressure on shear bond strength

After application of 2-BOND, a gentle air blow is recommended to spread the bonding layer evenly. Interestingly, R&D data demonstrates that the application is less sensitive to air pressure than some leading competitors as can be seen in Figure 15.

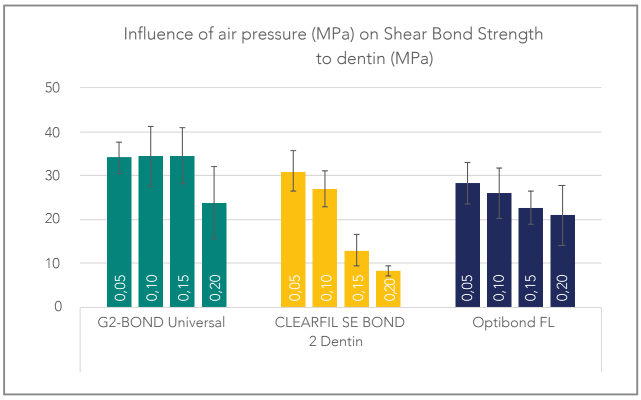


Figure 15: Influence of air pressure on shear bond strength of G2-BOND to dentin as compared to Clearfil SE BOND 2 (Kuraray Noritake) and Optibond FL (Kerr). *Source: GCC R&D, Japan. Data on file.*

The force of the air pressure does not seem to influence the bond strength of G2-BOND Universal a lot, whereas for the other tested adhesives, more variation is shown.

7 Clinical Procedure

Although the main purpose of bonding agents is to be used in direct restorations, they have shown to be of interest in other clinical indications, such as immediate dentin sealing & intra-oral repairs.

For extended explanation on the procedures, please refer to the instructions for use.

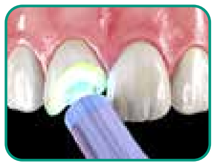
7.1 Direct bonding

Apply 1-PRIMER and wait 10 sec.

Dry.


Apply 2-BOND.

Make a uniform bond film.


Light cure.

GC recommends that 1-PRIMER is dried with maxium air pressure after application. This will allow the acetone & residues of water to evaporate and improve the quality of the bond. The primer contains photo-initiator in order to ensure a good polymerisation in the depth of the hybrid layer. Care should be taken to respect the working time of the product.
Light-curing time will be influenced by the power output of the device & the distance to the cavity. This is translated in the recommendations below:

	Distance from light guide tip <10 mm	Distance from light guide tip >10 mm
Halogen/LED (700-1200 mW/cm^2)	10 seconds	20 seconds
High power LED (>1200 mW/cm^2)	5 seconds	10 seconds

7.2 Immediate dentin sealing (IDS)

With a bond thickness of 35 μm, G2-BOND Universal possesses the ideal characteristics to be used in the IDS technique.

IMMEDIATE DENTIN SEALING (IDS) with G2-BOND Universal / TECHNIQUE GUIDE

Courtesy of
Dr Jean Meyer, France

Benefits of the IDS technique

- Resin infiltration is more effective on freshly cut dentin because it is uncontaminated and clean.
- IDS protects dentin against contamination with bacteria or remnants of temporary cements.
- It increases bond strength of the final indirect restoration to the tooth
- It avoids post-operative sensitivity by sealing dentin tubules.
- It often eliminates the need for anesthesia during the cementation procedure (2nd appointment).

1st Appointment

1. Clean the tooth surfaces, rinse thoroughly and dry.
2. Apply 1-PRIMER.
3. Dry.
4. Apply 2-BOND.
5. Air blow to make a uniform bonding layer.

6. Light cure. See table 1 on the next page.

Optional: Apply glycerin gel and light cure it again to prevent oxygen inhibition layer.

7. Remove unpolymerized layer. Expose enamel covered with adhesive with a fine-grit diamond bur.

Apply GC Cocoa Butter or vaseline to avoid interaction with impression and temporary materials.

8. Isolate

Continue with impression taking and temporary restoration using your usual protocol.

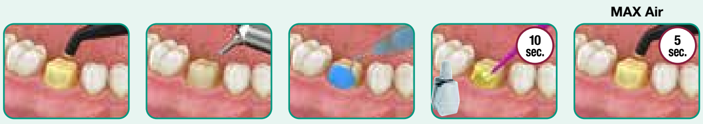
9. Impression and temporary restoration

Clinical Tips - 1st appointment

- Placing a rubber dam and isolating neighbouring teeth with Teflon tape are always recommended.
- Selective etching of enamel is recommended.
- 1-PRIMER should be kept out of light as it contains photoinitiators.
- Use maximum air pressure to dry 1-PRIMER to remove the solvent & residues of water.
- Applying 2 layers of 2-BOND can help to achieve a thicker layer.
- A flowable composite can be used to block undercuts and eliminate irregularities.
- Avoid the use of polyether impression material.

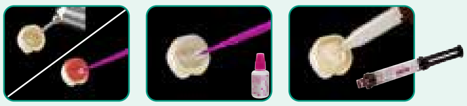
2nd Appointment

In case of cementation with G-CEM LinkForce + G2-BOND Universal



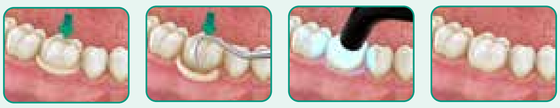
1. Remove the temporary restoration & clean the preparation.
2. Sandblast with Al_2O_3 30 μm with low pressure.
3. Selective etch the enamel
4. Apply 1-PRIMER
5. Dry

6. Light cure. See table 1.



7 & 8. Pre-treat the restoration.

9. Dispense G-CEM LinkForce into the restoration.



10. Seat the restoration.
11. Remove excess.
12. Light cure each surfaces/margins for 20 seconds (Halogen/ LED 700mW/cm²)
13. Finish and polish.

Consult Instructions for Use

Clinical Tips - 2nd appointment

- Placing a rubber dam and isolating neighbouring teeth with Teflon tape are always recommended.
- Always protect patient's eyes, specially while sandblasting.
- Sandblasting should be done carefully (low pressure, short time) to avoid removing the bonding layer on dentin.
- In case of luting procedure, use of 1-PRIMER alone is sufficient and recommended.
- Remove any pooling of 1-PRIMER on corners or irregularities of the preparation before light curing it to assure a perfect sitting of the restoration.

TABLE 1. LIGHT-CURING TIME OF G2-BOND UNIVERSAL

Light curing unit	Distance from light guide tip	
	<10mm	>10mm
Halogen/LED (700-1200 mW/cm²)	10 sec.	20 sec.
High power LED (more than 1200 mW/cm²)	5 sec.	10 sec.

7.3 Intraoral Repair

As the 1-PRIMER contains MDP and MDTP, G2 BOND Universal can be used directly on zirconia and metal-based indirect restorations without extra primers.
In case of ceramic restorations (feldspathic or lithium disilicate), the use of a silane-containing primer such as G-Multi PRIMER is recommended.

1. Roughen the surface; rinse & dry.

2. If there is a ceramic surface, apply G-Multi PRIMER & dry.

3. Apply 1-PRIMER to all surfaces to be repaired and leave for 10s.

4. Dry 5 s at MAX air pressure.

5. Apply 2- BOND to all surfaces.

6. Make a uniform bond film.

7. Light-cure for 10 s.

8. Proceed with placement of composite resin.

8 Clinicians evaluation

8.1 In-vivo data

Postoperative sensitivity evaluation of a new two-step bonding
A clinical study was conducted with 120 patients in need to restore at least one class II and one Class V non carious lesion to evaluate the clinical effectiveness of G2-BOND Universal. The patients were divided in four groups according to the adhesive system and resin composite; Group 1- G2-BOND Universal and G-ænial Universal Injectable, Group 2 – G2-BOND Universal and Clearfil Majesty ES Flow Low (Kuraray Noritake), Group 3 – Clearfil SE Bond 2 (Kuraray Noritake) and Clearfil Majesty ES Flow Low, Group 4 – Clearfil SE Bond 2 and G-ænial Universal Injectable. Recalls were made at 1 and 3 months.
The retention rate for all restorations was 100% after 3 months. Group 1 and group 2 in which G2-BOND Universal was used did not show any postoperative sensitivity.

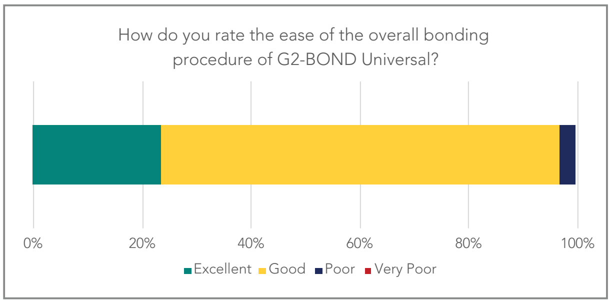
Source: Dr. EF Cagidiaco, University of Siena, Italy

8.2 Clinicians' feedback

Evaluations by clinicians worldwide resulted in over 1,500 restorations performed with G2-BOND Universal. We have compiled the most interesting feedback from the practitioners below.

8.2.1 Handling

97% of the respondents rated the ease of use of G2-BOND Universal good or excellent. This result includes the dentists who normally use the single-component bonding in their practices.

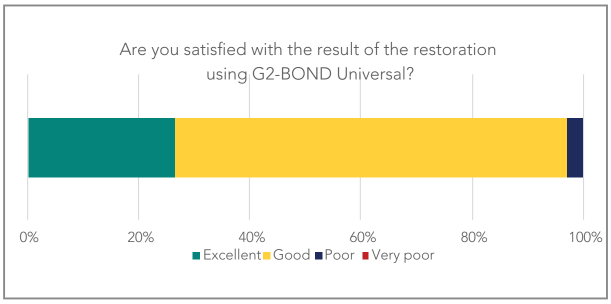


8.2.2 Post-operative sensitivity

97% of the respondents had no patient reporting the post-operative sensitivity.

8.2.3 Overall Evaluation

Overall experience using G2-BOND Universal was also very positively rated.



9 Packaging

9.1 Volume and application drops

G2-BOND Universal Bottle Kit contains:

- 1-PRIMER 5 mL liquid,
- 2-BOND 5 mL liquid

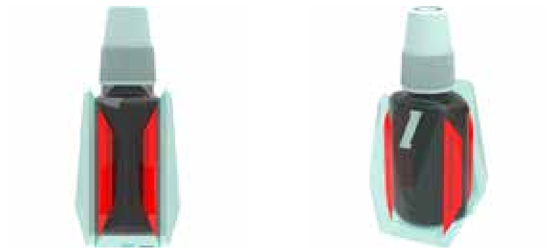
The nozzles have been designed so that both bottles of G2-BOND Universal primer and bond contain 300 drops, respectively.

9.2 Design

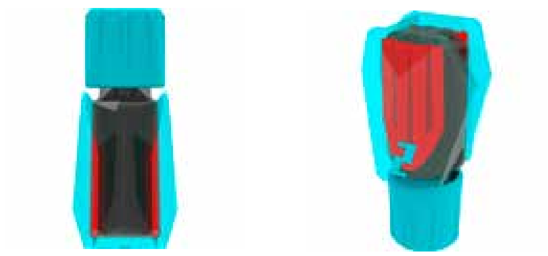
Use of G2-BOND Universal bottle covers is highly recommended. Bottle covers are designed to protect product from body heat, which might impact product working time.

Note:
Bottle covers marked 1 and 2 are for 1-PRIMER and 2-BOND respectively. Be careful not to switch the bottle covers. The covers are specifically designed to adapt the dispensing pressure to the viscosity of the product (Picture 3).

The bottle covers may be reused with subsequent refills. The bottle covers can be cleaned with water or wipe with alcohol (ethanol). Do not sterilize, autoclave, or clean with chemical disinfectants.



Reduced contact point between cover and bottle



Rib designed to effectively press the bottle.

10 References

Bond strength & Durability

1. **Impact of HEMA Formulation on 2-Step Self-etch Bonding Agent Performance.**
Hirano K, Yamashita M, Fujimori K, Arita A, Kumagai T. 2020. 98th General Session & Exhibition of the IADR. 0188.
2. **Effect of HEMA blending ratio on bonding performance of novel 2-step adhesive.**
Yamashita M, Arita A, Kumagai T. 2020. The 152nd Meeting of the Japanese Society of Conservative Dentistry. P20. (available only in Japanese)
3. **Improvement of bonding property using a newly developed hydrophobic bonding material.**
Yamanaka A, Mine A, Higashi M, Yamada-Tajiri Y, Yumitate M, Ban S, Hagino R, Nakatani H, Yatani H. 2020. Ann Jpn Prosthodont Soc. 12 129th Special Issue: 102. (available only in Japanese)
4. **Improvement of dentin bonding effectiveness using the next generation 2-step system with a newly developed hydrophobic bonding agent.**
Yamanaka A, Mine A, Hagino R, Matsumoto M, Yamada-Tajiri Y, Ishida M, Higashi M, Ishigaki S, Van Meerbeek B, Yatani H. 2020. Adhes Dent. 38(3):112. (available only in Japanese)
5. **Microtensile bond strength of novel two-step bonding agent to dentin.**
Ohara N, Ono S, Shibuya K, Yoshiyama M. 2020. Adhes Dent. 38(3):113. (available only in Japanese)
6. **Evaluation of bonding layer durability on 2-step self-etch adhesive.** Fujimori K, Hirano K, Fusejima F. 2020. The 68th Annual Meeting of Japanese Association for Dental Research. Poster 002.
7. **Water Sorption and Solubility of an Experimental Bonding Resin.**
Islam M, Alam A, Yamauti M, Chowdhury A, Sano H. 2020. 31st SEAADE & 34th IADR-SEA Scientific Meeting. P022.
8. **Influence of a Primer Resembling Universal Adhesive on the Bonding Effectiveness of an Experimental Two-step Self-etch Adhesive.**
Tamura T, Takamizawa T, Ishii R, Hirokane E, Tsujimoto A, Barkmeier WW, Latta MA, Miyazaki M. 2020. J Adhes Dent. 22(6):635-646.
9. **High-resolution mechanical mapping of the adhesive–dentin interface: The effect of co-monomers in 10-methacryloyloxydecyl dihydrogen phosphate.**
Takahashi S, Zhou J, Wurihan, Shimomura N, Kataoka Y, Watanabe C, Shibata Y, Funatsu T, Gao P, Miyazaki T. 2021. J Mech Behav Biomed Mater. 117:104389.
10. **Characterization of an Experimental Two-Step Self-Etch Adhesive's Bonding Performance and Resin-Dentin Interfacial Properties.**
Chowdhury AFMA, Alam A, Yamauti M, Álvarez Lloret P, Saikaew P, Carvalho RM, Sano H. 2021. Polymers. 13:1009.
11. **Back to the multi-step adhesive system: A next-generation two-step system with hydrophobic bonding agent improves bonding effectiveness.** Yamanaka A, Mine A, Matsumoto M, Hagino R, Yumitate M, Ban S, Ishida M, Miura J, Van Meerbeek B, Yatani H. 2021. Dent Mater J. In press. doi: 10.4012/dmj.2020-272.
12. **High-resolution Modulus Mapping of the Adhesive-dentin Interface.**
Shibata Y, Takahashi S, Zhou J, Shimomura N, Watanabe C, Kataoka Y. 2021. 99th General Session & Exhibition of the IADR. 0727.
13. **Evaluation of bond strength of multi-step adhesives.** Minamisawa H, Fujimori K, Hirano K, Fusejima F. 2021. 99th General Session & Exhibition of the IADR. 0729.
14. **Bonding effectiveness of the multi-step self-etching adhesive to dentin.**
Suyama Y, Mizukami H, Yamada T, Sugizaki J. 2021. 99th General Session & Exhibition of the IADR. 0730.
15. **Dentin Shear Bond Strength of Novel Two-Bottle Multimode Adhesive.**
Abdel-Gawad S, Francois P, Le-Goff S, Dursun E, Attal JP. 2021. 99th General Session & Exhibition of the IADR. 1256.
16. **Bond strength of different adhesive systems to indirect restorative materials.**
Khandelwal P, Hirano K, Fusejima F. 2021. 99th General Session & Exhibition of the IADR. 1969.
17. **A Multifaceted Evaluation of a Novel HEMA-Free Two-Step Self-Etch Adhesive.**

Tichy A, Hosaka K, Yang Y, Motoyama Y, Sumi Y, Nakajima M, Tagami J. 2021. 99th General Session & Exhibition of the IADR. 1971.

18. **Push-out Bond Strength of a New Two Steps Adhesive.**
Verniani G, Karafili D, Zucca G, Ferrari M. 2021. 99th General Session & Exhibition of the IADR. 2304.
19. **Bond durability of a novel two-step bonding agent to dentin.**
Ohara N, Ono S, Shibuya K, Yokoyama A, Matsuazaki K, Yamaji K, Yoshiyama M. 2021. The 154th Meeting of the Japanese Society of the Japanese Society of Conservative Dentistry. P18.
20. **Bond strength to dentin of novel HEMA-free two-step bonding agent.**
Someji Y, Kobayashi M, Niizuma Y, Sugai R, Hasegawa M, Manabe A. 2021. The 154th Meeting of the Japanese Society of the Japanese Society of Conservative Dentistry. P22.
21. **Changes in Initial Bond Strength of Two-step Bonding System Over Time.**
Yabe A, Irie A, Okada M, Takayoshi N, Taketa H, Torii Y, Matsumoto T. 2021. The 154th Meeting of the Japanese Society of the Japanese Society of Conservative Dentistry. P26.
22. **Influence of a Primer Resembling Universal Adhesive on the Bonding Effectiveness of an Experimental Two-step Self-etch Adhesive.**
Tamura T, Takamizawa T, Ishii R, Hirokane E, Tsujimoto A, Barkmeier W, Latta M, Miyazaki M. 2020.J Adhes Dent. 2020;22(6):635-646.
23. **Effect of Adhesive Application Method on the Enamel Bond Durability of a Two-Step Adhesive System Utilizing a Universal Adhesive-Derived Primer.**
Takamizawa, T. Yokoyama, M.; Sai, K.; Shibasaki, S.; Barkmeier, W.W.; Latta, M.A.; Tsujimoto, A.; Miyazaki, M. 2021. Appl. Sci. 2021, 11, 7675. https://doi.org/10.3390/app11167675

Marginal quality

1. **A comprehensive evaluation of dentin bonding durability of a novel two-step self-etch adhesive.**
Tichy A, Hosaka K, Nakajima M, Tagami J. 2020. Adhes Dent. 38(3):109.

Technique sensitivity

1. **Adhesion performance of novel 2-step adhesive.**
Ohara Y, Arita A, Kumagai T. 2019. The 151st Meeting of the Japanese Society of Conservative Dentistry. P17. (available only in Japanese). 0729.
2. **Effect of Air Blow Pressure at Multi-step Adhesive Application on Bond Strength.**
Yamashita M, Hrano K, Fusejima F.2021. Abstracts of the 10th Virtual Conseuro 2021 Congress. Clin Oral Invest 25, 4185–4238 (2021). EP-027.

Clinical Performance

1. **Postoperative sensitivity evaluation of a new two-step bonding system.**
Ferrari Cagidiaco E, Corsentino G, Ferrari M. 2021. 99th General Session & Exhibition of the IADR. 2304.

Notes

Notes

Optibond FL, Clearfil SE BOND,
Clearfil SE BOND 2
are not trademark of GC.

GC EUROPE N.V.
Head Office
Researchpark
Haasrode-Leuven 1240
Interleuvenlaan 33
B-3001 Leuven
Tel. +32.16.74.10.00
Fax. +32.16.40.48.32
info.gce@gc.dental
https://europe.gc.dental

GC UNITED KINGDOM Ltd.
Coopers Court Newport Pagnell
Buckinghamshire MK16 8JS
United Kingdom
Tel. +44.1908.218.999
Fax. +44.1908.218.900
info.uk@gc.dental
https://europe.gc.dental/en-GB

z O MA EN 8 90 01/22