

# Basic technical properties of CLEARFIL SE BOND

Authors\_Dr Toshimoto Yamada & Dr Junpei Sugizaki, Japan



Fig. 1

Since Dr Raphael Bowen developed the Bis-GMA oligomer in the early 1960s and Dr Michael Buonocore introduced the phosphoric-acid etching technique for enamel cavity walls, followed by the development of dentine bonding, aesthetic adhesive resin composite restorations—in areas such as the occlusal surfaces

of posterior teeth—were widely performed in Japan before any other country in the world. These aesthetic adhesive restorations have contributed greatly to the improvement of the oral health of the Japanese population.

About 30 years ago, Kuraray developed CLEARFIL BOND, which was the first generation of a clinically successful resin bonding containing phenyl-P monomer as an adhesion-promoting monomer. Thereafter, light-cure technology was introduced to resin bonding, leading to the development of the light-cured resin bonding agent CLEARFIL PHOTO BOND. As a next step, Kuraray began developing an easier-to-use and more biocompatible resin bonding agent, resulting in the introduction of the world's first self-etching resin bonding agent—CLEARFIL LINER BOND 2—which does not require water rinsing after priming. This type of resin bonding is known as two-step simplified bonding in the US.

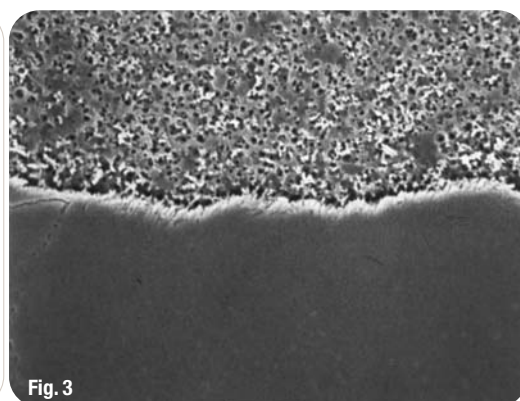
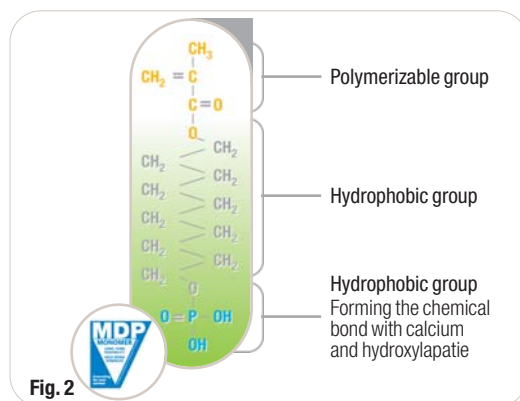
Based on CLEARFIL LINER BOND 2, Kuraray further improved and simplified the system. The result was CLEARFIL SE BOND, which consists of a one-bottle primer and one-bottle bond. With CLEARFIL SE BOND, a truly two-step, self-etching primer resin bonding system was launched, that creates strong adhesion to both enamel and dentine.

## Composition of CLEARFIL SE BOND

The CLEARFIL SE BOND kit consists of a single liquid primer, a single liquid bonding agent and accessories. The primer has a self-etching effect, and comprises HEMA (2-hydroxyethyl methacrylate), hydrophilic dimethacrylate, MDP (10-methacryloyloxydecyl dihydrogen phosphate, adhesion-promoting monomer), N,N-diethanol-p-toluidine, D,L-camphor-quinone, and water. The bonding agent comprises silanated colloidal silica, bisphenol A diglycidyl-methacrylate, HEMA, hydrophobic dimethacrylate, MDP, N,N-diethanol-p-toluidine and D,L-camphor-quinone.

One significant feature of CLEARFIL SE BOND is that it saves time, since it is not necessary to rinse the primer with water or to evaporate the solvent with light airflow. As soon as the cavity surface has been treated with the primer, MDP is able to penetrate the cavity wall, self-etching mineral components of the tooth tissue and dissolving the smear layer created on the cavity walls during tissue reduction in 20 seconds. The subsequently applied bonding agent is able to strengthen the adhesion between the tooth tissue

Fig. 3\_FE-SEM (argon ion beam etched surface; x 10,000) of the resin-enamel interface. The upper half is the set bonding layer and the lower half is the enamel layer. The superficial enamel was finely and densely etched.



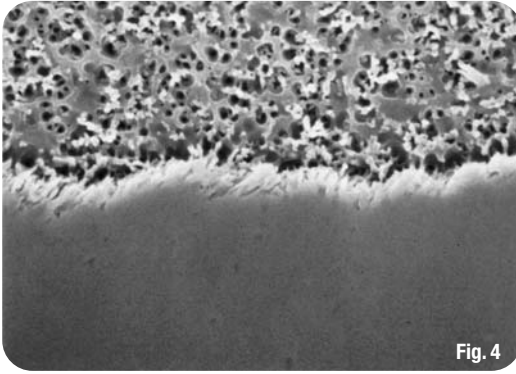


Fig. 4

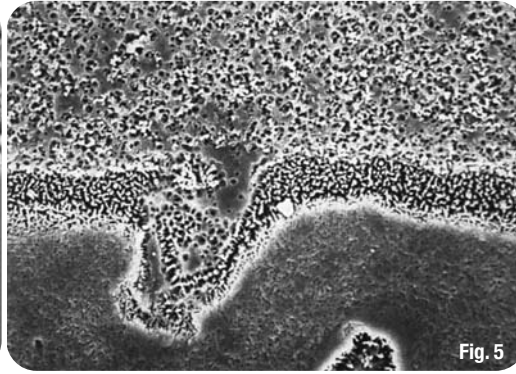


Fig. 5

and the placed resin composite paste after light irradiation for ten seconds.

Another important feature of CLEARFIL SE BOND is that the acidity of the primer is optimised to allow simultaneous treatment of both enamel and dentine layers. It is able to etch the enamel cavity wall enough to ensure good bonding, while not damaging the collagen structure of the dentine cavity wall excessively. Additionally, the primer remains diffused throughout the dentine tissue after treatment, since there is no rinsing away with water. Therefore, the collagen network structure in the dentine cavity wall prevents the structure from collapsing, and thus allows excellent penetration of the bond component throughout the supported dentine structure. The primer reverts to a neutral pH during treatment and demineralisation. The primer and bond are able to produce a strong and stable bonding layer with excellent dentinal sealing, which could contribute to much-reduced sensitivity.

Up until now, it was believed that self-etching primers were unsuitable for performing veneer restorations on discoloured teeth with a large enamel surface area in the cavity owing to the low etching effect of most primers. It has also been reported that marginal brown lines appeared along enamel margins when the existing self-etching primers were used to perform adhesive restorations. However, Kuraray has overcome this problem with other self-etching

primers by enhancing and improving the mixture rate of MDP and other agents in CLEARFIL SE BOND.

### Adhesion of CLEARFIL SE BOND

The tensile bond strength of CLEARFIL SE BOND to tooth tissue was determined using extracted bovine teeth from the jaws of cattle freshly slaughtered on the morning of the test day and kept frozen until the afternoon. Because the dental pulps had not been removed, the adhesion tests were conducted under tough conditions.

The adhesion area was regulated at 3 mm in diameter and the tensile stress (cross-head speed) was set at 1 mm per minute. CLEARFIL AP-X resin paste was used as a restorative resin and 10 minutes after bonding, the bonded assemblies were stored in 37°C tap water. The tensile bond strength of CLEARFIL SE BOND was higher than 20MPa to both bovine enamel and dentine.

The thermo-cycling test of 4,000 cycles (4~60°C) produced similar results in both the enamel and dentine. Since the resin is able to bond to enamel and dentine tissues at comparable strengths, the present system could be an ideal bonding system, and its bond strength is one of the highest amongst the resin bonding systems currently available. Additionally, since resins generally adhere to human teeth much more strongly than to bovine teeth, this would be true of CLEARFIL SE BOND too.

**Fig. 4** FE-SEM (argon ion beam etched surface; x 20,000) of the resin-enamel interface. The upper half is the set bonding agent loaded with micro-filler particles and the lower half is the enamel layer. The fine etching pattern of the superficial enamel layer is very clear.  
**Fig. 5** FE-SEM (argon ion beam etched surface; x 10,000) of the resin-intact dentine interface. The upper half is the set bonding agent and the lower half is the dentine layer. The junction between the resin and dentine was very tight through the hybrid layer of 1 µm in thickness.

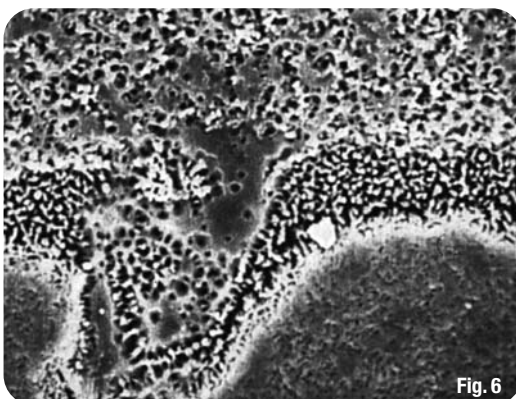


Fig. 6

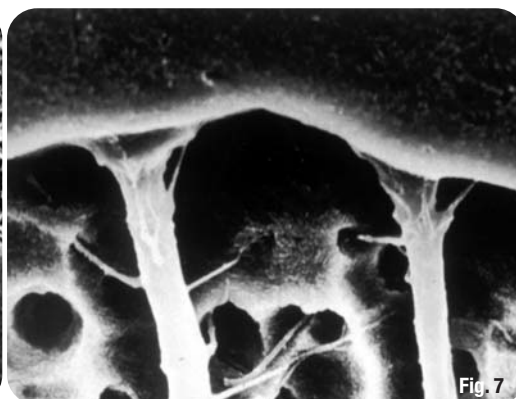
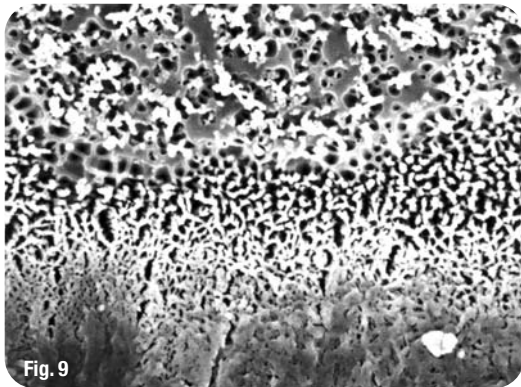
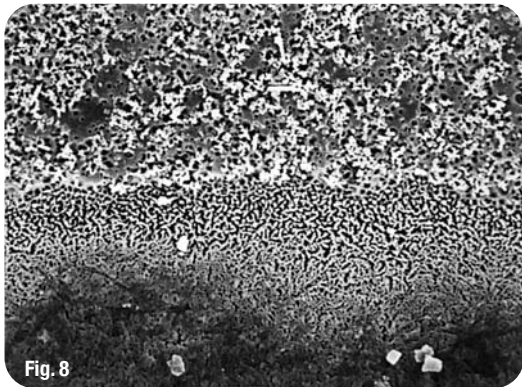


Fig. 7

**Fig. 6** FE-SEM (argon ion beam etched surface; x 20,000) of the resin-intact dentine interface. When subjected to the argon ion beam etching, the hybrid layer was clearly demonstrated.  
**Fig. 7** SEM (hypochlorite treatment following phosphoric acid treatment; x 5,000) of the resin-intact dentine interface. The resin tags penetrated the dentinal tubules and penetrated lateral branches are presented. This demonstrates that the CLEARFIL SE BOND primer has a good treatment effect.



**Fig. 8**\_FE-SEM (argon ion beam etched surface; x 10,000) of the resin–cariou dentine interface. The upper half is the set bonding agent and the lower half is the dentine layer. The junction between the resin and dentine was very tight, and the hybrid layer in the superficial dentine layer was clear. But the junction between the hybrid and underneath dentine layer was not distinctive.



**Fig. 9**\_FE-SEM (argon ion beam etched surface; x 20,000) of the resin–cariou dentine interface.

The junction between bonding, hybrid and dentine layer was tight and continuous.

**\_Electron microscopic examination of the interface between CLEARFIL SE BOND and human tooth tissue**

*FE-SEM of the resin–intact tooth tissue interface*

The FE-SEM picture of the resin–enamel interface is shown in Figures 3 and 4. Both images present the resin–enamel interface subjected to the argon ion beam etching. The upper half is the set bonding layer and the lower half is the enamel layer. The superficial enamel was finely and densely etched, and the hydroxyapatite crystals of the enamel prism were decalcified. Nonetheless, this demineralisation process is not as destructive as that of conventional phosphoric acid etching, yet the junction at the resin–enamel interface was extremely tight, producing small and dense resin tags. The micro-filler particles appear in the upper half of bonding layer.

resin paste. The resin–dentine interface is shown in Figures 8 and 9. The specimen was argon ion beam etched. The very clear hybrid layer was demonstrated in the superficial layer of dentine. The upper half is the set bonding layer, followed by the hybrid layer and dentine in the lower half. As shown in the FE-SEM pictures, CLEARFIL SE BOND showed tight adhesion to the carious dentine through the hybrid layer. These FE-SEM findings revealed that CLEARFIL SE BOND could adhere as well to the carious dentine as to the intact dentine.

**\_Conclusion**

It has been about 30 years since the resin bonding system was introduced to dental operations. Today, anterior and posterior cavities are restored with resin bonding. The history of Kuraray's resin bonding systems is synonymous with the 30-year history of resin bonding. Modern resin bonding is able to decrease the treatment time, patient's discomfort and operator's mental and physical labour.

The most modern system is two-step, self-etching primer resin bonding, and is indicated not only for caries treatment, but also for repairing restorations in combination with Kuraray's ALLOY PRIMER or CLEARFIL PORCELAIN BOND ACTIVATOR. The CLEARFIL SE BOND is able to create a strong and stable bond to hard tooth tissue, and the resin composite paste is able to adapt excellently to the cavity walls treated by CLEARFIL SE BOND. Furthermore, moulding and shaping it is extremely easy. We thus believe that the CLEARFIL SE BOND resin bonding system will greatly contribute to global oral health.

The FE-SEM picture of the resin–intact dentine interface is shown in Figures 5 and 6. The upper half is the set bonding agent and the lower half is the dentine layer. The junction between the resin and dentine was very tight and the hybrid layer of about 1 µm in thickness in the superficial dentine layer was very clear when subjected to the argon ion beam etching. The dentine was removed using 10% phosphoric acid and 5% hypochlorite (Fig. 7). The set resin tags penetrating the dentinal tubules were clearly demonstrated and small resin tags penetrating lateral branches of the dentinal tubules showed the improved treatment effect of the CLEARFIL SE BOND.

*FE-SEM of the resin–cariou dentine interface*

The carious lesion of the extracted third molar was removed by means of the CARIES DETECTOR according to the routine technique. The prepared cavity was restored using CLEARFIL SE BOND and CLEARFIL AP-X



**Fig. 10**

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<p><b>Kuraray Europe GmbH</b>                  Industriepark Höchst, Building F 821                  65926 Frankfurt/Main, Germany</p> <p>dental@kuraray.eu                  www.kuraray-dental.eu (EU)                  www.kuraraydental.com (USA)</p>	

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