New developments prompt a rethink on self-etching adhesives

The focus of the development of dental adhesives for the recent past has been squarely fixed on perfecting the ability to self-etch. Self-etch adhesives (SEAs) now abound with many products enduring, but a limited release onto the market, with significantly more never leaving laboratory testing.

Using adhesives has traditionally been a complex, labor intensive process since their inception. The common goal with the new self-etch systems continues to reduce the number of steps and the overall complexity of their use, allowing dentists to concentrate on aesthetics rather than undue process.

3M™ ESPE™ Adper™ Prompt™ Self-Etch Adhesive, now in its third stage of evolution, is one of the few SEAs with long-term clinical evidence under its belt. The system allows the dentist to etch, prime and bond in a single step in an average time, according to the latest CRA study, of around 54 seconds.

The unique “L-Pop” delivery system also offers a hygienic, convenient and consistent unit-dose delivery of the adhesive material, further diminishing the chance of incorrect application (a bottle form is also available).

Why Self-Etch Adhesives?

“Self-etching primers have a number of advantages,” says Dr Harald O. Heymann, Professor and Graduate Program Director, Operative Dentistry, University of North Carolina School of Dentistry. “They’re very simple to use and eliminate the variables of wet bonding. The depth of the etch is also self-limiting owing to the buffering capacity of the dentin, so you cannot over-etch. The biggest advantage overall, however, is a profound lack of sensitivity post-operatively.”

“Etching with phosphoric acid as part of conventional bonding completely removes the smear layer and smear plugs resulting in dentinal tubules. This is like having a “super-highway” to the pulp. You then must apply the primer in a sufficient quantity to seal these open tubules, or risk post-op sensitivity.”

“With self-etching systems, the smear plugs are effectively infused with resin primer forming a very effective seal. Also, if a dentist fails to cover all of the prepared dentin in the cavity preparation with primer, no problem, because the smear plugs are still intact. In fact, Dr David Pashley has demonstrated in studies that the smear plugs themselves reduce dentin permeability and fluid flow by 82%. With conventional bonding after acid etching, if one fails to place sufficient primer to seal all open tubules, sensitivity can clearly occur. Not so with self-etching systems. They are much more forgiving. Dr. Heymann pointed out that current self-etch systems, including Adper Prompt, were also not without their disadvantages.

“The bond strengths to dentine and enamel are lower than for most total-etch systems,” he said, “but still sufficient for clinical success, in my opinion, with most self-etching systems whose pH is low enough to etch both cut and uncut enamel. The pH for Prompt appears to be...
sufficiently low to produce adequate bonds to both. In fact, even in our early clinical trials with the original version of Prompt-L-Pop, we observed retention levels in non-carious Class V’s that were very acceptable at 18 months. We also know now that with the improved version of Prompt, and using two coats, performance should be even better.” Dr Heymann goes on to note, however, “The bond strength to self-curing composites is virtually zero for most self-etch systems. The bond durability in the long-term may also be questionable owing to susceptibility to hydrolysis.

“Having said that, the clinical advantages far outweigh the disadvantages and I am convinced self-etching systems are here to stay. I am sure ever improving versions will address concerns of long-term bond durability.”

As Dr Heymann highlighted, Adper Prompt, as well as most other single component adhesives, will not bond effectively with self-cured resin cements. In the case of Adper Prompt, it is contraindicated to use with self-cured and dual-cured resin cements. Because resin cements come into contact with the adhesive in an uncured state, the low pH of self-etching adhesives interferes with the self-cure initiator system of the resin cement or composite causing possible bonding failures (the acid in the self-etching systems scavenges the tertiary amines needed for polymerization of self-cured resins).

Adper Prompt can, however, successfully be used as a bonding layer between light-cured resin-modified Glass Ionomer and Composite. In-house testing by 3M ESPE showed that the dentin bond strength of Adper Prompt on 3M™ ESPE™ Vitreobond™ Liner/Base, together with a composite, produced identical results as those achieved with a conventional, total-etch adhesive.

As Adper Prompt is applied to the tooth surface, its special composition enables it to dissolve the smear layer produced during preparation and thus optimally adapt to the surface structure. Bonding to the enamel surface is by means of micro-mechanical retention due to the etch pattern achieved. Bonding to dentin is carried out by the formation of a hybrid layer and the creation of micro tags, as in the case with conventional bonding systems. In addition to the mechanical bond between adhesive and dentin, a chemical bond between the calcium hydroxylapatite and the matrix can also be postulated for the phosphoric esters. The phosphoric esters attach to the calcium ions of the apatite, therefore the structure of the bond can be either covalent or ionic.

“We did evaluations for ESPE pre-release five years ago and have been using it ever since,” said Dr Richard Trustkowsky, A Staten Island, New York, GP running a solo practice with a mix of everything from cosmetic and C&B to root canal and period surgery.

“When it first came out, we used it extensively and back then there were some questions in research about its longevity. Research can be good and bad – what happens in research can be a lot different. We’ve been using the product for a long time and so far there are no problems with any of the restorations we placed.

“We use Adper Prompt extensively for Class I, II, III, V, direct composites and to increase the efficacy of sealants. Because the resin is penetrating at the same time as the etch, I haven’t noticed any sensitivity. It has lot of advantages, for example, in a pedo practice there’s no etching so you don’t need the rubber dam and it’s easier to maintain a dry field. In treating children, if you don’t use a rubber dam, the increased time with a separate acid etch step and the taste of the etch may cause the child to move, with resultant saliva contamination possible. Adper Prompt etches the tooth, but a separate step isn’t required and the material isn’t rinsed off.

“The main limitation is you are using it with direct restorations only, there’s no dual cure. You need to use another material for indirect restorations, but that’s a drawback with most self-etch materials.”

That was then, this is now
The latest release of Adper Prompt was developed jointly by 3M ESPE division scientists Steve Aasen in St Paul and Thomas Luchterhandt in Seefeld.

“There were a number of limitations with the original version of Prompt developed by ESPE,” said Dr Aasen, “and we have worked to address these to the point where Adper Prompt is a significantly improved adhesive. It is very different from the original.

“The original Prompt, for example, was designed for compomers. It wouldn’t work with LED curing lights. The latest version uses camphorquinone photoinitiator, overcoming this limitation.

“The original formulation also required several applications to achieve optimal effectiveness. We have since added BIS-GMA, among other things, to reduce this application to what amounts to a single coat, although we recommend two coats to ensure optimal bond strength.”

Delivery System
As mentioned, Adper Prompt was originally developed in Seefeld, Germany by ESPE prior to the merger with 3M and known simply as Prompt-L-POP. Apart from the development of innovative materials, ESPE invested considerably in creating delivery systems to make its products easier to use and less susceptible to operator error. Enduring examples of the foresight include the Pentamix system for mixing impression materials, capsule systems and of course, the award-winning designed L-POP “LollIPOP”.
“The original design of the L-POP was truly innovative,” said Dr Aasen, “and essentially the concept has not changed with the latest version. We have, however, made a number of improvements.

“For instance, the Adper Prompt ‘L-POP’ unit-dose is physically easier to activate, requiring less physical force to compress the blisters. This is due, in part, to modifying the design of the middle blister.

“When you depress the magenta blister, forcing the contents into the adjacent yellow blister, the latter pops up. This feature minimizes pressure and at the same time, indicates that adhesive transfer has been successful.”

In addition, there is also now a color change. If the brush on removal is not yellow, then this indicates the adhesive has not mixed properly.

The blister system keeps the acidic methacrylated phosphates and BIS-GMA contained in the magenta compartment separate from the water, HEMA-hydroxyethylmethacrylate and polyalkenoic acid contained in the yellow. Keeping the two components separate ensures a long shelf life for the product.

**Two coats vs. single coat**

“The original instructions were to apply one coat,” said Dr Rolf Halvorson, 3M ESPE Technical Service in St Paul, “then check if there was a glossy shine. Often, you have to apply multiple coats to observe that glossy shine. Now, typically you really can achieve that glossy appearance with one coat but we recommend a second coat for extra strength and enhanced consistency.”

As Dr Halvorson points out, there are more variables to overcome in the oral environment than the laboratory, so the second coat is recommended.

“The BIS-GMA gives the adhesive a more hydrophobic quality that allows it to bond better with the restorative material,” said Dr Aasen. “It’s a nice balance between hydrophilic to wet the tooth with hydrophobic properties to bond with restorative material.”

**Clinical evidence**

“I’ve been using Adper Prompt since before it was released,” said Dr Carlos Muñoz-Viveros, Director, Biomaterials Research Laboratory at Loma Linda University School of Dentistry. “We have a clinical trial currently in progress with over three years of data involving anterior restorations. Of twenty-six restorations we are monitoring, there has been one failure in that time. Adper Prompt is on par with other adhesives and the data so far is excellent.

“Dr. Muñoz-Viveros explained that unlike total etch systems, the pH of SEAs is very low. When you put the adhesive on the tooth, you have to ‘scrub’ it over the surface of the tooth to maintain the low pH, otherwise it rises very fast. With Adper Prompt, you leave it on for 15 seconds. It will only etch effectively if the pH remains low. You get a much better result if you do this.

“SEAs traditionally do a very poor job at etching the apismatic enamel. You need to use a bur to remove 15-20 microns first, then use the SEA. I generally do this with Total Etch as well, but it is critical with SEAs.”

Dr. Muñoz-Viveros said Self Etch Adhesives make it more difficult to misuse the material and there is no chance of over etching the dentine.

“With phosphoric acid on the Total Etch Systems, you get a much deeper layer of demineralized dentin,” he said. “When you apply the primer/adhesive, it cannot infiltrate as far – the deeper layers don’t get infiltrated. The deeper layers of collagen that did not get infiltrated will degrade with time (hydrolyse) and the restoration will fail.

“With SEAs they infiltrate as they etch. Very seldom would you get layers of collagen that have not been infiltrated.

“SEAs also are not sensitive to moisture. With Total etch, the dentin has to be moist, otherwise you will not get good infiltration.”

Dr. Muñoz-Viveros recommends SEAs in pediatric dentistry because it cuts the number of steps. “It works well with the primary dentin and enamel; for anterior restorations routinely and in situations where you need to work fast – we do a lot of dentistry for handicapped patients – we need to do a large number of restorations very
The “Acid” Test

Dr Heymann said that one of the key factors to look for when choosing a self-etch adhesive is the acidity of the product.

“Importantly, Adper Prompt’s pH of 1.05 allows bonding to both cut and uncut enamel. This prevents marginal leakage and discoloration in situations where preparing the enamel is impossible or impractical. With some systems, the acidity is not sufficient to predictably bond to uncut enamel and problems may occur long term.”

Dr Heymann highlighted research by Dr Ted Croll from Doylestown who has published a study detailing the use of Adper Prompt for applying sealants.

“Dr Croll discovered the residual hydrophilic resin displaces all moisture in the grooves and simultaneously etches the enamel. When you place sealant on top of Adper Prompt you achieve an extremely good bond. Dr Croll’s results are very good and it also looks very promising in the long term.”

According to internal laboratory testing by Dr Halvorson at 3M ESPE, the pH of Adper Prompt measures at 0.8, while the pH of the original Prompt was as low as 0.6 since the formula contained 100% acidic monomer. Dr Halvorson reconciled the difference between the pH of 1.05 quoted by Dr Heymann as an example of the inherent differences often found when testing pH in different laboratories.

Post-operative sensitivity

“Self-etch adhesives in general are great because there is no post-op sensitivity as you have combined the etchant and the primer in one,” said Dr Charles Wakefield, a private practitioner based in Dallas, Texas and also Director of the Advanced Education in General Dentistry Residency Program at Baylor College of Dentistry in Dallas, Texas.

“There are only two self-etch systems that combine etchant, primer and adhesive in one step, and Adper Prompt is one of these.”

“I even find that it’s excellent as a cervical desensitizer — but it can be a bit expensive to use it for that. I take a cotton swab and I use Consensus scrub (Ultradent) — which is a mix of 2% Chlorhexidine with fine flour of pumice — and I scrub off the salivary glycol-protein and rinse it. You don’t completely dry it, then apply multiple coats of Adper Prompt, dry it and repeat the process until the sensitivity goes away. Then you light cure it. The bottle system is good for a single tooth to save waste or the unit-dose will do a whole quadrant.

“The reason SEAs eliminate sensitivity is because the prime and etch is in one step and you’re not washing it off. It’s not removing the whole smear layer — you selectively remove it but leave the plugs in the tubules.”

Dr Wakefield said that in his experience, the difference between the bond to dentin strength of a self-etch and a total-etch is clinically insignificant.

“With enamel, it’s different. In these cases, I usually etch with phosphoric acid first, then wash it off and apply the self-etch system as per the instructions.

“The pH of phosphoric acid is down around 0.5, so the new Adper Prompt at 1.05 is getting there but I still wouldn’t trust it on the margins on a large Class III with a big facial margin. For example, I would not be surprised to see yellowing around the enamel margin eventually so I would use phosphoric acid first on enamel, then the self-etch just to ensure I will get longevity. I place the phosphoric acid on the enamel only and leave it on for 15 seconds and then wash it off, then I use Adper Prompt. In this way, I get a good bond without any sensitivity.”

Technique Sensitivity

“The point to emphasize with the latest version of Adper Prompt is that it mixes much more easily than it did,” said Dr Trushkowsky. “Even with the original, however, it’s very easy because it’s all together in one system. It’s impossible to mix-up the components.

“With bottle systems, some clinicians I know mix the primer from one system with the bond from another, simply because they don’t want to waste them when there is some left over. The problem, of course, is that every system is different and most likely incompatible. With Adper Prompt, it’s all-in-one so there can’t be any of these kinds of mistakes.

“The Adper Prompt ‘L-POP’ unit-dose is very easy to use, but having said that, you still have to be careful using it. You have to do it right.”

One of the chief catalysts for unpredictable results is a failure to adhere to the manufacturer’s instructions for use. Despite its simplicity of use, Adper Prompt unit-dose is not immune to operator error.

For example, in a published CRA study, Adper Prompt caused a color change in Filtek Supreme when not air dried sufficiently. The overlying Filtek Supreme resin darkened an average of 0.5 shades (Vitapan 3-D Master Shade Guide) within 5 days. The color change was not observed when the adhesive was air dried thoroughly as directed by the instructions. The color change did not occur with any other restorative material used in the study.

“The technology is very interesting because it is very simple,” said Dr Muñoz-Viveros. But because it is simple, it has lead to some problems. If you do not mix it properly, you will end up with reduced bond strength. The packaging makes it very simple to use and this is what dentists are looking for. But it doesn’t mean you can make mistakes and get away with it.
“One of the problems is that dentists don’t read instructions. They open the box and put the instructions aside and start using the product. When I lecture, I tell dentists they must start by reading the instructions. Adper Prompt is no different. There are no two SEAs that work the same.

“To some extent, manufacturers portray self-etch materials in general as very simple to use solutions, but the more I use them, the more I find that if you are careful, you get much better results.”

Joseph Allbeury is the editor of Australasian Dental Practice magazine. Interviews for this article were conducted between December 2003 and February 2004.

References

About the dentists interviewed

Harold O. Haymann, DDS, Med
Dr Haymann is Professor and Graduate Program Director in the Department of Operative Dentistry at the University of North Carolina. He is active in clinical research and participates in a dental practice devoted largely to aesthetic dentistry. Dr Haymann is a Fellow in the International College of Dentists, the American College of Dentists, the Academy of Dental Materials, and is a Fellow and President of the prestigious American Academy of Esthetic Dentistry. He is the author of over 175 scientific publications, co-editor of The Art and Science of Operative Dentistry, editor-in-chief of the Journal of Esthetic and Restorative Dentistry, and is on the editorial boards of nine dental journals. He has given over 700 lectures on various aspects of aesthetic dentistry worldwide and has received the Gordon J. Christensen Award for excellent as a CE speaker.

Carlos A. Muñoz-Viveros, DDS, MSD, FACD
Dr Muñoz-Viveros Professor and Director, Biomaterials Research Center, Department of Restorative Dentistry, Loma Linda University School of Dentistry. He is a Fellow of the American College of Dentists and at Loma Linda is Director of the Biomaterials Research Facility; Coordinator of the visiting research scholars program and fellowships in Biomaterials; and Director of the Center for Dental Research. He is on the Editorial Review board for Reality and the Board of Directors for the Journal of Contemporary Dental Practice. Dr Muñoz-Viveros has lectured extensively worldwide in the US, Mexico, Brazil, Colombia, Nicaragua, El Salvador, Philippines, Japan, Singapore, Thailand, Dominican Republic, Spain and Lichtenstein and has published over 80 research abstracts and over 50 refereed studies and articles. He has received over 15 fellowships and awards for dental research.

Richard D. Trushkowsky, DDS, FAGD, FICD, FADM, FPFA
Dr Trushkowsky completed a BA in Chemistry prior to completing his dental degree in 1971. He then completed military service with the Army as a dentist with rotations in Endodontics, fixed Prosthetic dentistry and Oral Surgery. He currently works in private practice in Staten Island, New York and was Director of Operative Dentistry, Staten Island University Hospital from 1992-2003. Dr Trushkowsky has lectured extensively throughout the United States and has published over 75 articles in peer-reviewed journals. He also completed a chapter on direct composites in Esthetic Dentistry 2nd Edition (Mosby 2001: 69-96) and a chapter on Complex single-tooth restorations in Dental Clinics of North America. Dr Trushkowsky holds a patent on the Trimax™ device he invented for placing and curing posterior composites. He is a clinical evaluator for several dental manufacturers and a Clinical Research Associates (CRA) Evaluator and a senior consultant for the Dental Advisor Plus. He has been on the Editorial Board of Contemporary Esthetic Dentistry and Restorative Practice since 1999 and on the Editorial Board of Collaborative Techniques for one year.

Charles W. Wakefield, DDS, MAGD, ABGD, FICD, FACD
Born and raised in California, Dr Wakefield attended the UCLA School of Dentistry. During his career in the U.S. Army Dental Corps, he completed a two-year Advanced General Dentistry Residency at Fort Knox, Kentucky. Other military assignments included time in West Germany and Alaska and also served a two year tour as an Exchange Officer with the British Army, Royal Army Dental Corps, London, England. He is a diplomat of both the Federal Services Board of General Dentistry and the American Board of General Dentistry and has also served as an Examiner for both. Having been awarded a Mastership in the Academy of General Dentistry, he is also a Fellow in the American and International Colleges of Dentists and holds the Surgeon General’s “A” designator. He is currently a Consultant to the Commission on Dental Accreditation, American Dental Association. He is currently a Professor in the Department of General Dentistry and Director of the Advanced Education in General Dentistry Residency Program at Baylor College of Dentistry, Texas A & M Health Science Center, Dallas, Texas.