A Research Powerhouse

It's no secret that in today's business world, innovation breeds success and with more than a century of research and development expertise, 3M is flourishing. Known worldwide as a leading innovative company, 3M is truly a new product powerhouse. "The Corporate Laboratory is continuously thinking about how to best bring technology forward," said Al Pocius, corporate scientist, 3M. "Our most important job is to consider what 3M can be doing with new technologies – not just now, but five years from now."

Research at 3M is conducted at two different levels and its global technical community consists of more than 6,500 scientists and engineers. 3M's Corporate Research Laboratory is dedicated to developing new technologies and sharing them with the divisional teams. Division scientists then take those technologies, combine them with customer needs, and engineer specific products for their industry.

"Division scientists have been talking directly to customers for years and years," said Pocius. "They understand the challenges – as well as the wants and needs – of their customers, so, the R&D at this level is tightly focused on groundbreaking ideas that meet customer needs today and into the future."

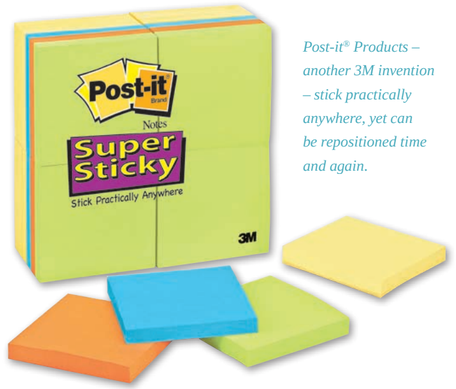
The Many Dimensions of Adhesives

3M leverages more than 40 technology platforms, and its reputation for innovation stems from its propensity to combine these diverse technologies to engineer products for a wide range of applications. Half the world's population today enjoys experiencing at least one of 3M's 55,000 products, either directly or indirectly, every day.

If any single technology has made 3M a household name, its adhesives. As the world's leading adhesives manufacturer, 3M's understanding of adhesives dates back to 1902 when the company introduced its first product, sandpaper, which consisted of abrasive minerals and paper held together by an adhesive developed by 3M scientists.

Seemingly mundane in purpose – to join materials – adhesives actually comprise one of 3M's most sophisticated technology platforms. This platform has generated thousands of innovative and useful products that span the full spectrum of stickiness, with applications in countless markets. In fact, 3M uses this technology in approximately 40 percent of its products, from Post-it® Notes to Adper™ Scotchbond™ Multi-Purpose Adhesive.

3M ESPE has successfully leveraged these platforms to respond to the unique needs of the dental industry with innovative solutions in dental adhesives and delivery systems under such well-known brand names as Scotchbond and Single Bond.



Post-it® Products – another 3M invention – stick practically anywhere, yet can be repositioned time and again.

The Next Generation of Dental Adhesives

Global adhesive trends show that self-etch adhesives are gaining popularity and growing at a faster rate than total-etch adhesives. More customers today want products that offer reduced post-operative sensitivity, fewer steps and easier procedure. In response to this, 3M ESPE is announcing two new options in self-etch dental adhesives: Adper™ Easy Bond Self-Etch Adhesive and Adper™ Scotchbond SE Self-Etch Adhesive.

Advancing upon the chemistry of Adper Single Bond Plus adhesive and Adper Scotchbond Multi-Purpose Plus adhesive, Adper Easy Bond self-etch adhesive incorporates 25 years of 3M ESPE adhesive experience in a single bottle that provides fast and easy application along with the reduced risk of post-operative sensitivity offered by a self-etch adhesive. Additionally, Adper Easy Bond self-etch adhesive is available in an easy to use unit dose delivery system that offers convenience and speed, leaving minimal time for contamination during procedures. Performance in independent tests has equaled that of one-bottle and even two-bottle self-etch systems.

The improved adhesive is used in combination with light-curing composite or compomer filling materials, cements and core build-up materials, and can be polymerized using halogen, LED or plasma curing lights.

"Adper Easy Bond self-etch adhesive offers 3M ESPE quality in a fast and easy one-bottle, one-coat self-etch adhesive," said Jon Fundingsland, scientific affairs manager, 3M ESPE. "This results in confidence and maximum convenience for the clinician and reduced risk of post-operative sensitivity for the patient."

3M ESPE's second new addition to its full-line of Adper™ adhesive products, Adper Scotchbond SE Self-Etch adhesive offers a unique combination of confidence-inspiring features and total-etch performance in a self-etch system for reduced post-operative sensitivity.

In addition to long-term bond performance, Adper Scotchbond SE self-etch adhesive features a color change indicator to ensure proper placement and activation. The pink wetting solution is a visual indicator of coverage. When the resin is applied, the resulting solution becomes clear, illustrating activation of the system.

One benefit of this unique approach is the stability of the adhesive. Unlike traditional self-etch systems that require refrigeration, Adper Scotchbond SE self-etch adhesive's unique formulation offers good stability without requiring refrigeration or shaking. The aqueous component is kept separate from the acidic resin until being combined on the tooth to prevent hydrolysis during storage and assure stability.

Incorporating nanotechnology developed first for Filtek Supreme universal restorative, the improved adhesive is also radiopaque to prevent misdiagnosis of cured adhesive film as secondary decay.

"Adper Scotchbond SE self-etch adhesive's unique color change placement indicator and radiopacity properties provide additional confidence in its efficacy to the clinician." said Fundingsland.

A Future Built on Strong Bonds

The dental industry is an ever-changing landscape with new products being created faster than most dental professionals have time to take note of them, meaning manufacturers must consistently innovate to create relevant products for their customers. During the past five years, 3M ESPE has led the dental industry with an average of 45 innovations per year, and now manufactures and markets more than 2,000 products for use in the dental industry to improve the oral health of people around the world.

3M continues to be recognized as a pioneer in developing and applying technologies in new and groundbreaking ways, including being hailed in Business Week as the third most innovative company in the world in 2006. In addition, 3M ESPE Dental Products division was recently ranked as the most innovative company in the worldwide dental industry, according to the 2006 Dental Industry Review conducted by the Anaheim Group. With its own base of proprietary technologies and global regulatory expertise – including many in the realm of adhesives – quality, innovation and relevance are a given at 3M ESPE. And when the company is looking for that next impact product, it need only turn to its own employees for the answers.

"Innovation is entwined within the 3M organization and that extends to every Division," finished Pocius. "When 3M ESPE creates a new dental adhesive, every scientist and every researcher is behind that product 100 percent."

The Scotchbond™ Story

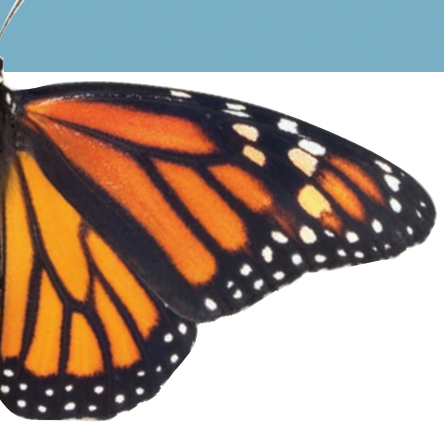
Scotchbond™ Dual Cure Adhesive, 3M ESPE's original two-component, dual-cured dental adhesive was actually the third in a series of the "original." Scotchbond™ Adhesive was initially introduced as a two-part, chemically-cured adhesive and the first dentin bonding material available in North America. In response to interest in a light-cured system, 3M ESPE introduced Light Cure Scotchbond™ Adhesive the following year. Shortly thereafter, it was discovered that the chemistry employed in Light Cure Scotchbond adhesive also cured chemically, and Scotchbond Dual Cure adhesive was born.

Although the 2nd generation products proved reasonably effective both in terms of bond strength and prevention of microleakage, researchers hoped to create adhesive systems that could actually rival bonds to etched enamel. In the following years, 3M ESPE's commitment to innovation would become increasingly evident with the introduction of several breakthrough, commercial products including Scotchbond™ 2 Adhesive, which was the first adhesive to employ an acidic primer material as the first step of the bonding procedure.

"Prior to Scotchbond 2 adhesive, bond strengths to dentin were quite low," said Steve Aasen, division scientist, 3M ESPE. "With this product, we succeeded in developing a dentin primer that improved bond strengths by a factor of three to four."

Scotchbond™ Multi-Purpose Plus Adhesive essentially put dentin bonding agents on the map as clinically proven materials in the dental industry and is considered the "gold standard" in bond performance.

Innovation breeds success



Every year, thousands of Monarch butterflies are tagged with tiny labels that feature a gentle, yet firm, 3M adhesive that helps researchers learn the secret of the butterflies migration pattern.

Innovation at 3M ESPE certainly didn't stop with Scotchbond 2 adhesive. Scientists reached their goal of developing an adhesive that offered more consistent, solid performance without sacrificing ease of use when Adper™ Scotchbond™

Multi-Purpose Adhesive was introduced in 1992. 3M ESPE's first offering in the 4th generation, this product consisted of an etchant, a primer and an adhesive and while it appeared similar to Scotchbond 2 adhesive, there were several differences. The etchant in Scotchbond Multi-Purpose was used on both enamel and dentin. "This was extremely exciting for us as we had unlocked the secret to good performance on all conditions," said Aasen. The improved adhesive's primer also contained a polymer developed for Vitrebond™ Resin Modified Glass Ionomer (RMGI) Liner/Base, which helped solve the variable dentin bond strengths seen with Scotchbond 2 adhesive.

"One of the things noticed in our lab was that bond values for Scotchbond 2 adhesive and other adhesives varied considerably depending upon when the products were tested," said Jon Fundingsland, scientific affairs manager, 3M ESPE. Typically, the lower bonds occurred in the summer, leading to a correlation between bonding and humidity. High humidity reduced the bond values, especially to dentin.

However, over the same time period 3M ESPE was also using Vitrebond RMGI liner/base in lab studies. "We noticed that this material did not vary as much between the high humidity summer months and the low humidity winter months," said Fundingsland. By adding one of the key ingredients of Vitrebond liner/base, the unique "Vitrebond copolymer" 3M ESPE was able to make the Scotchbond Multi-Purpose adhesive system very resistant to changes in humidity.

commitment to innovation

This improvement had direct clinical implications, as the oral environment is a humid environment. Additionally, a new initiator system allowed for a 10-second light exposure when other light-cured adhesive on the market required at least a 20-second light exposure.

"Scotchbond Multi-Purpose adhesive was a statement to the industry – from 3M, and even from me and my personal values as the 'adhesives guy' at 3M," said Aasen. "The vastly successful clinical performance of this product was very gratifying, especially because of the dramatic improvements it showcased over 2nd and 3rd generation adhesives."

One success lead to another when Adper™ Scotchbond™ Multi-Purpose Plus Adhesive was developed to give Scotchbond Multi-Purpose adhesive the capability to do indirect applications. Because indirect restorations require a chemical cure component, 3M scientists developed additional components that could be added to the Scotchbond Multi-Purpose adhesive system. Scotchbond Multi-Purpose adhesive components were labeled as 1 (the etchant), 2 (the primer) and 3 (the light cured bonding agent). Three new components – an accelerator, a catalyst and a ceramic primer to be used to prime the indirect device – were then added to the system to create Scotchbond Multi-Purpose Plus adhesive "This product essentially put dentin bonding agents on the map as clinically proven materials," said Aasen.

3M™ Scotch-Weld™ Structural Adhesives are so strong, they're used instead of metal fasteners in the production of airplanes, helping make aircraft lighter and more fuel-efficient.

Collaborating for Success

A prime example of how researchers and developers have worked collaboratively to transform an idea explored in the laboratory into a product is 3M's investment in nanotechnology. "The Corporate Research Laboratory has long been focused on research and development of practical applications for nanotechnology," said Pocius. "When we first started working with it, we didn't have a specific product in mind, but we were sure of its potential."

Recognizing the opportunity to utilize nanotechnology for dental restoratives, 3M ESPE was the first organization to commercialize true nanotechnology with Filtek™ Supreme Plus Universal Restorative. "Prior to nanotechnology, companies were putting glass in restoratives and making it smaller and smaller to achieve better esthetics," said Pocius. "What this did was make the restorative too viscous, thus ruining the handling of the material."

"With Filtek Supreme Plus Universal restorative, 3M ESPE built the restorative from the ground up, utilizing proprietary nanoclusters and bonded nanofillers to create a restorative that achieved the desired esthetics without diminishing strength." Since its landmark introduction in 2002, Filtek Supreme Plus Universal restorative continues to be a leading restorative solution in the United States, and 3M ESPE has introduced nanotechnology. into other products such as Adper™ Single Bond Plus Adhesive to achieve additional desired characteristics.

Adhesive Performance Plus Convenience

Since first introducing Scotchbond™ Adhesive in 1983, 3M ESPE continued to respond to customer wants and needs by bringing new adhesive products to the market that deliver high quality performance and unique, confidence-inspiring characteristics – qualities the industry has come to expect from the industry's leading innovator.

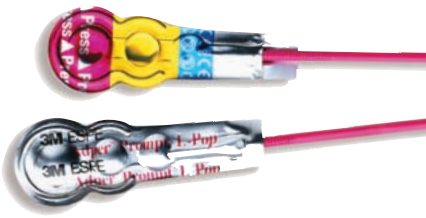
3M ESPE made its entry into the 5th generation of dentin adhesives in 1997 with Adper™ Single Bond Adhesive. Characterized as a two-component, total-etch bonding agent, this generation of products combined the primer and adhesive of the 4th generation product into a single composition. Removing the priming step simplified the procedure and reduced the application time, which means less chance for contamination during a procedure. "As is the case with all of our adhesives, we were not willing to sacrifice the product's robustness for convenience – we wanted both," said Aasen.

Proving its dedication to bringing the latest product technology into the dental office, 3M ESPE introduced a nanofilled version of Single Bond adhesive in 2004, Adper™ Single Bond Plus Adhesive. This product incorporated a patented nanofiller technology to provide better bond strengths and a more consistent mix with no shaking required as well as low post-operative sensitivity, leading to more successful procedures.

When focus of the development of dental adhesives shifted to perfecting the ability to self-etch, 3M ESPE continued to lead the way with the introduction of its Prompt™ Self-Etch Adhesive. First introduced in 1999, the original Prompt Self-Etch adhesive was one of the first self-etch adhesives on the market. With the new etch system, 3M ESPE researchers continued to reduce the number of steps and overall complexity of using an adhesive, allowing dentists to concentrate more on esthetics rather than undue process.

Additionally, Prompt Self-Etch adhesive was the first product available in the convenient, unit-dose, L-Pop™ delivery system, allowing the customer to etch, prime and bond in a single step.

"The design of the L-Pop delivery system was truly innovative," said Aasen. "The delivery system offered a hygienic, convenient and consistent unit-dose delivery of the adhesive material, further diminishing the chance of incorrect application."



Though the original Prompt Self-Etch adhesive performed well clinically, scientists were committed to providing even better adhesion to dentin and more reliable, consistent performance, and continued to evolve the product. "There were a number of limitations with the original version of Prompt and we worked to address those to the point that we developed a significantly improved adhesive," said Aasen.

Originally indicated for use with compomers only, a photoinitiator modification was made to Prompt Self-Etch adhesive in 2000 to allow the claim for all direct light cured restoratives. Following the combination of 3M Dental Products Division and ESPE Dental AG, scientists also made changes to the formulation and in 2002 the product was replaced with Adper™ Prompt™ Self-Etch Adhesive, which featured an improved bond performance, an activation control feature on the L-Pop delivery system, and improvements to the instructions for use.

3M™ Tegaderm™ Transparent Dressings cover and protect I.V. sites and wounds and are the No. 1 choice of health care professionals globally and are sold in more than 60 countries.