Liquid Bandages—The Future Suture

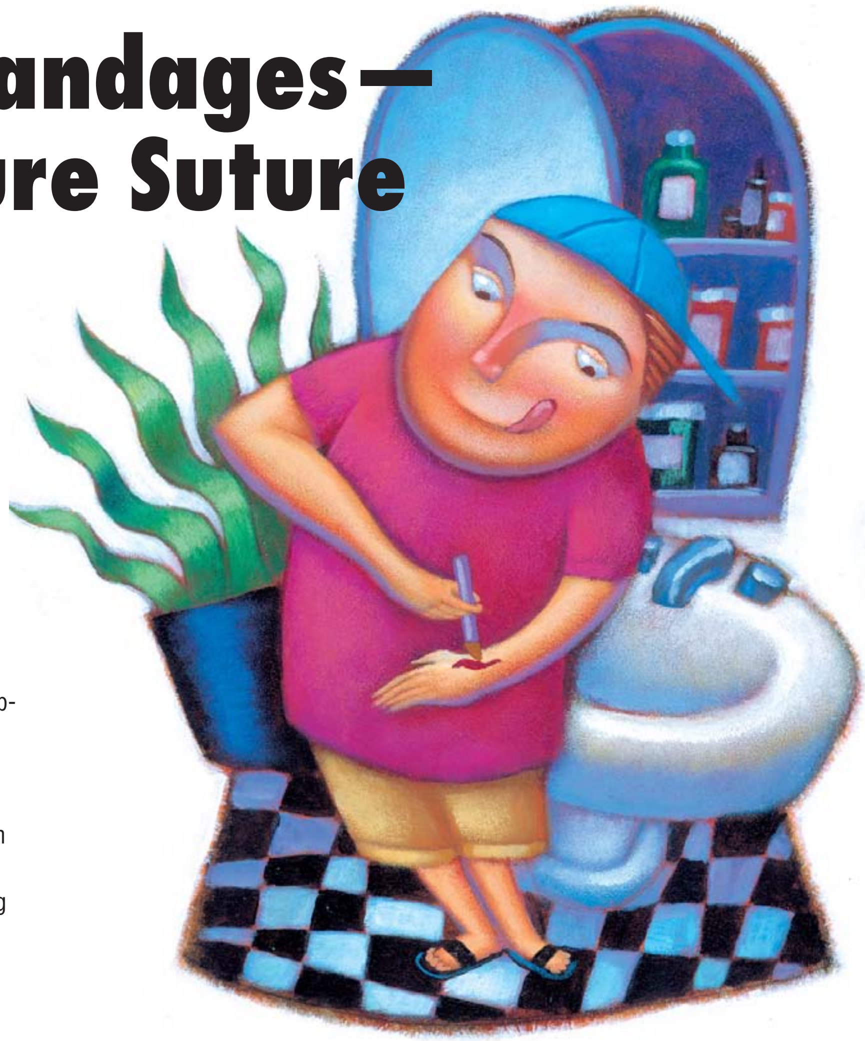


ILLUSTRATION BY WILL TERRY

By Bruce Goldfarb

It worked for Dr. Carter on the popular television drama *ER*. In a November 1999 episode, Carter glued together the sides of a surface wound while Dr. Benton watched with rapt interest. With a sure hand, he painted on the clear liquid, even being careful to match the details of his patient's tattoo. "Something new. It's called Dermabond." An older doctor passing by overheard the remark and disputed the new part of the description. "Been around since Vietnam. Just took the Feds this long to approve it!"

Science fiction or fact? Dr. James Penoff—not a character on *ER*—but a plastic surgeon at Straub Clinic and Hospital in Honolulu assures that it's real. "When you have a child come to the emergency room with a superficial laceration, you don't have to poke them with a bunch of needles anymore. You can put the wound together with cyanoacrylate. It sticks together, sealed and waterproof, almost immediately."

In 1998, the U.S. Food and Drug Administration (FDA) granted approval to Dermabond, a cyanoacrylate tissue adhesive marketed by Ethicon, a subsidiary of health products manufacturer Johnson & Johnson. Dermabond can be used to close a variety of skin wounds, from common lacerations to the inch-long incisions of endoscopic (minimally invasive) surgery. Several other formulations of cyanoacrylate adhesives, including one that remedies painful mouth ulcers, are expected to be approved by the FDA this year.

A version of cyanoacrylate skin adhesive for home use—"Liquid Band-Aid"—may be available without a prescription in your local supermarket or drug store by 2001, according to Jeff Clark, director of research and development at Closure Medical Corp., which produces Dermabond for Ethicon.

Pretty impressive for something that was discovered by accident! Twice.

Setting sights on polymer research

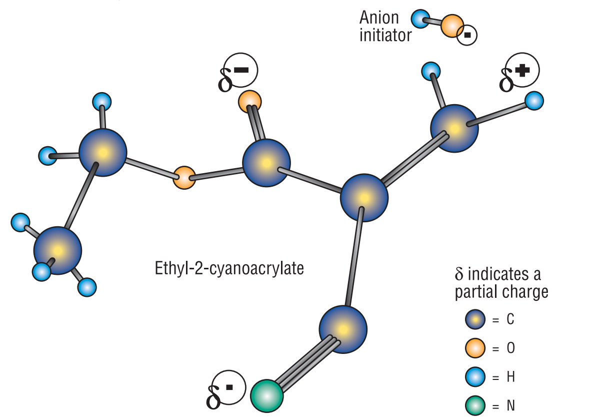
During World War II, Harry W. Coover, a polymer chemist at Eastman Kodak's research laboratory, was trying to come up with a material that could be cast into precise gunsights. He tested a variety of new polymers, including an ester of cyanoacrylic acid now known as cyanoacrylate. Although cyanoacrylate cast well and had high strength and heat resistance, it was very difficult to work with. "The problem was that it kept gumming up," recalls the retired chemist. "Every damned thing stuck together." Ultimately, the gunsight research was abandoned as other war-related projects took priority.

In 1951, Coover’s lab was searching for a plastic that could be molded into canopies for fighter jets that had better heat resistance than the methacrylate used at the time. He asked a young scientist, Frederick Joyner, to duplicate some of his earlier work—warning him to be careful with that cyanoacrylate. Joyner needed to measure the purity of several polymers. Using a refractometer to measure the density of the polymers, he placed a drop of cyanoacrylate between its two prisms. You can probably guess what happened. The prisms were immediately glued together, impossible to pry apart. Embarrassed about ruining an expensive scientific instrument, the aptly named Joyner went to show his boss what he'd done.

“Instantly, the light went on,” says Coover. “I immediately realized that this material is really an adhesive!”

To celebrate, the two delighted researchers ran around the lab gluing glassware, stoppers, samples of plastic, and any other material at hand. “We went around and stuck together everything in the laboratory,” says Coover.

Dermabond, the medical cyanoacrylate adhesive, eliminates needles and minimizes scarring.



The hydroxyl anions found on any wet surface are attracted by the partial positive charge on the cyanoacrylate monomer. The attraction initiates a rapid exothermic polymerization that results in an extraordinarily strong chain within seconds.

ILLUSTRATION BY CESAR CAMINERO

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Linear molecules

Cyanoacrylate was the first liquid adhesive that *cures* or hardens without the need for a solvent or catalyst. Most types of glues either involve two parts that are combined just before use, such as epoxies, or they are composed of polymers suspended in a solvent. Common white glue, for example, contains casein proteins derived from milk that polymerize and cross-link as the solvent evaporates.

Cyanoacrylates cure by *anionic polymerization*, a process triggered by the trace of OH^- anions present in the thin layer of moisture that coats essentially every surface outside of a vacuum. “Just about everything is covered with a layer of water a few molecules thick,” says Clark. “The moisture causes cyanoacrylate to polymerize.”

Individual molecules of cyanoacrylate snap together in linear chains 1–2 million molecules long—stretching from surface to surface like millions of small tethers. The resulting bond is so strong that one square inch of adhesive can support more than a ton of weight. However, an absence of cross-links between the polymer chains gives the adhesive one surprising weakness. The adhesive bond can be broken fairly easily with a sharp tap or sideways force.

One of the most important properties of cyanoacrylate is its ability to wet the surface that is being glued. Cyanoacrylate has a very low surface tension, allowing it to flow easily to wet the entire surface to which it is applied. As it flows into microscopic surface features, it locks the two surfaces intimately together. Its ability to enter all nooks and crannies is probably the most important contributor to its strength. The thinner the layer of cyanoacrylate, the stronger the resulting bond.

Beginning in 1966, cyanoacrylate spray was used by Medevac teams in Vietnam to staunch the bleeding of massive trauma suffered by soldiers. “We provided the military with small bottles that could be sprayed into a wound,” says Coover. “The other methods of stopping bleeding caused a lot of tissue damage, and consequently, they lost a lot of people. Our spray stopped the bleeding, so the victim could survive until they got to a field hospital.”

Although the commercial product Super Glue is readily available, adhesives chemists caution against using this household cyanoacrylate to treat your own cuts. Dermabond has a slightly different chemical composition than household glues. The consumer versions of the adhesives are typically ethyl- or methyl-cyanoacrylate, which is a stiff adhesive that is irritating to the skin. Dermabond is composed of octyl-cyanoacrylate, which is flexible and nonirritating to the skin. Perhaps more important, household cyanoacrylate has not been subjected to the same strict level of sterility and quality that is demanded of surgical-grade materials.

One of the major stumbling blocks to FDA approval was the need to prove that cyanoacrylate is harmless in the body. Some scientists suspected the adhesive may produce cyanide or formaldehyde as it cures, and even suggested that the material might cause cancer. “We did extensive work to demonstrate unequivocally that, when used properly, cyanoacrylate caused absolutely no problems,” says Coover.

Cyanoacrylate gradually depolymerizes, flakes off the skin, and is usually gone in a week to 10 days. In addition to sealing a wound, cyanoacrylate provides an added bonus. Its application gives almost immediate pain relief by protecting sensitive exposed nerve endings. We’ll probably be seeing more of it on *ER* and elsewhere. Something this effective is bound to stick around.

Bruce Goldfarb is a science and medical writer in Baltimore, MD. His article “Fascinating Fungi” appeared in the December 1998 issue of *ChemMatters*.

REFERENCE

Penoff, J. Skin Closures Using Cyanoacrylate Tissue Adhesives. *Plast. Reconstr. Surg.* **1999,** *103* (2), pp 730–731.