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The Story of Post-It™ Notes

by Christine Plummer

Some products, such as the personal computer or microwave oven, become a way of life. They change the way we live or work, and they quickly become so pervasive that we can't remember what we did before they existed. Such a product is the Post-it™ note. The little squares of yellow paper with the tacky strip exist only because several chemists persisted in looking for a use for the adhesive that makes them work.

In 1968 Dr. Spencer Silver, an organic chemist with 3M Company, was assigned to study the addition of new monomers to polymers that were used for making pressure-sensitive adhesives. Polymers are extremely large molecules that are assembled from thousands of small molecules (monomers) linked together like a chain (see "Polymers" *Chem Matters*, April 1986).

Some types of polymers are adhesives. Natural adhesives go back a long way and include glue, paste, and cement—anything that can be used to physically join other materials. Not surprisingly, chemists are constantly looking for adhesives with greater bonding power.

Pressure-sensitive adhesives (PSAs) are polymers that more or less instantly bond with a substrate and, usually, can be removed without destroying the substrate. An example is mending tape used to hold fabric firmly together. In the case of PSAs, researchers try to develop greater peel and shear strength (see box *Strong Two Ways)*.

Silver refers to what happened in his lab in 1968 as "serendipity—the discovery of things for which you aren't looking." He was looking for a high-performance adhesive; what he found was one that didn't have those performance characteristics.

According to Silver, "The materials used to make these adhesives are rubbery (elastomeric) polymers that retain their rubbery properties to very low temperatures. The polymers generally fall into three groups: (1) polyisoprene from natural or synthetic sources, and copolymers containing isoprene or butadiene (the 'natural' sources include rubber trees); (2) polyolefins, such as polyisobutylene; and (3) polyacrylates.

"Groups 1 and, generally, 2 require the addition of tackifying resins. These may be derived from natural sources such as pine tree stumps, or they may be synthesized from mixtures of compounds distilled from petroleum. The resins are generally hard, glassy materials (like the rosin used for violin bows).

"Group 3 polyacrylates are derived from free-radical polymerization of acrylic acid esters with long side chains; examples include *n*-butyl or 2-ethylhexyl." (See Figure 1.)

Often a second monomer, such as acrylic acid, is included in the polymer backbone. In this case, the molar ratio of ester monomers to acid monomers could be 10:1 or 50:1. The acid monomers improve the elastic properties of the polymer.

"We are considering very large molecules, with molecular weights in the millions as opposed to several hundred, which one would normally encounter in organic chemistry or chemistry in general. And the fascinating thing is that you can add a small amount of another monomer with much different properties and modify the properties of the big molecule. And by adding a small amount (I mean you might substitute, say, one in ten, or even less than that, say one in twenty of the monomers in the backbone by something quite different) that small a change makes a huge difference in the way it performs. This is true of nearly all polymer chemistry. All polymers are generally modified; very few are used in their pristine state."

Silver continues, "I was a synthetic organic chemist at the time and the result of this particular experiment looked so different and interesting I asked a polymer chemist if he had ever seen anything like it. It had a special property that I try to look for, a natural combination. It gave its characteristic properties without any forcing, and polymerized exactly the same over and over again."

For years, Silver continued to play with the new polymer. It was definitely a PSA, but it was a weak PSA in a company that prided itself on strong adhesives. What's more, it was nonselective. You could apply it to a surface and, when that surface was pressed to a second surface, the polymer might transfer completely to the second surface.

At the same time, Arthur Fry, a chemical engineer with 3M, was thinking about one of those frustrating everyday problems. Fry sang in his church choir and kept track of the various pages in his hymnal with little pieces of paper. Sometimes he lost his place when the pieces fell on the floor. At 3M, Fry's job was to examine new chemicals and try to find a use for them and, while contemplating the problem of his hymnal, he remembered the novel adhesive. Silver had developed. But a temporary note attached with the weak PSA still had a problem. Instead of cleanly removing the sticky note, you would end up with a sticky hymnal page.

Fry developed a chemical primer that made Silver's weak PSA more selective. When the primer was applied, followed by the adhesive, Fry could pull the paper off and the adhesive would come with it. With this success, Fry's problems were just beginning. 3M has vast experience making and selling sticky tape, but tape is packaged in rolls whereas the note paper would have to be produced in pads. When pads are manufactured, the stack of sheets must be jogged to make the edges line up. "You cannot jog a stack of sheets that are coated with adhesive into alignment," Fry explains. Engineers would have to invent new machines, and they didn't believe it could be done. But Fry was not through being creative. He literally assembled a pilot manufacturing machine in his basement that would stack the sticky sheets of paper precisely—and then had to break through the side of his basement to get the machine out!

Now out of the lab, Fry began hounding the marketing department, trying to get them to sell this new product. Finally, test sales of the little note pads with the tacky adhesive began in four cities. The displays, near the cash register in office supply stores, described the notes, but few people bought them. After all, for years people had successfully used paper clips, staples, and "dog ears" to attach notes to papers and books. "Also," according to Fry, "new things often require new words to describe them. Without a sample of the notes, purchasers could not understand their usefulness." Try explaining to someone why they should spend money for sticky pieces of paper that don't really stick. The funny thing was that everyone who tried Post-it notes wanted more, but unless people actually *used* the notes, 3M couldn't sell them.

In 1973, Geoff Nicholson became technical manager of new ventures at 3M and agreed to make and market the Post-it notes. Nicholson was completely sold on Post-it notes, as was his boss, Joe Ramey. Ramey decided that the only way to *sell* the product was to *give it away*. The marketing team descended on Boise, Idaho, where a small army of employees handed out the new product in every office and business they could find. Ninety percent of those who used the product bought more. This unusual marketing effort has become known as "the Boise Bitz" and is usually recounted in business and marketing journals, not science magazines.

Chem Matters can't give you the exact formula for the Post-it notes adhesive because, unfortunately, many countries don't recognize the patent laws that protect the inventors of new products. This protection allows companies time to recoup the cost of research and make a profit on new products before they can be copied by other manufacturers. We can tell you that the tacky, quirky adhesive, created by Spencer Silver, quickly became one of 3M's most profitable products.

Clearly, Post-it notes would not have been a success without the insight of very creative people who worked well on their own. But, just as clearly, success depended on the same individuals' willingness to work as a team. Throughout, they gave new meaning to the old adage "stick to it."

SIDE BAR

Strong two ways

Adhesives must have two kinds of strength, shear strength and peel strength—named for the forces that tend to break the adhesive bond. Shear forces pull in a direction that is parallel to the surfaces that are joined by the adhesive (left arrow, below). A peel force is perpendicular to the surface and acts on one end of the joint (right arrow). The adhesives used on airplanes to hold the metal skin onto the control surfaces must be strong in both peel and shear. A temporary paper note, in contrast, should have moderate shear strength, so it won't fall off the refrigerator, and low peel strength, so it can be easily removed.

CAPTIONS

Figure 1. A typical pressure-sensitive adhesive, made in two steps. First the organic acid (A) (acrylic acid) and alcohol (B) (1-butanol) are combined to form the monomer (C) (butyl acrylate), which contains a reactive double bond between the first two carbon atoms (green). Second, countless identical monomers react with each other to form a long, sticky polymer, a portion of which is shown at D. The actual molecule extends, to the left and right, thousands of atoms beyond the fragment shown here. Also not shown in the molecules above are hydrogen atoms attached to the carbon atoms.

Chemists Spence Silver (left) and Art Fry invented the easy-on, easy-off adhesive that 3M now sells as the Post-it Notes line of products.

Scanning electron micrograph, 500 times magnification, of microsphere adhesive coated on paper (showing the cut edge of paper).

BIOGRAPHY

Christine Plummer is a freelance writer in Baltimore, Maryland, who specializes in science and engineering.

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