Weather

Today: *Foggy, showers. High 54, Low 44.*
Friday: *Foggy, drizzle. High 50, Low 38.*

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A Plastic That 'Heals' Itself

Innovation Could Extend Life of Everyday Items

By GUY GUGLIOTTA
Washington Post Staff Writer

For years, scientists have tried to find an easier way to repair plastic—to make a tennis racket that lasts longer, a surfboard that patches more easily or a fiber-glass auto body that could give a vintage Corvette a look as elegant as the day it rolled off the assembly line.

Yesterday, researchers reported they had taken a step toward finding a way to repair glass fiber and other composite materials without tedious drilling, plugging, patching and sanding. They have developed a "self-healing" form of plastic.

Using high-tech materials and a low-tech concept inspired by the human body, the scientists devised a process that can continuously repair and regenerate the chemical soup that makes up most plastics by activating special resin-filled capsules stored within the material itself.

"I wish I could say it was a case of waking up one morning, jumping out of bed and shouting, 'Eureka!'" said lead researcher Scott R. White, a materials and aerospace engineer at the University of Illinois at Champaign-Urbana. "But it wasn't. We took a detailed look at the problem and went from there."

White's process, with potential commercial applications ranging from increasing the life of an implanted prosthesis to creating more durable spacecraft, is one of many efforts underway to develop new types of plastics, metals and other "smart materials" that have been updated, using the latest technology, to have desirable properties.

See PLASTIC, *A12, Col. 1*

Researchers Work to Develop 'Smart Materials'

PLASTIC, *From A1*

Scientists are also experimenting with "shape-memory" polymers, which change shape depending on their temperature. These could have a wide range of uses, such as for expanding springs that would open or close a skylight or regulate a shower's temperature. Other research involves embedded sensors, such as fibers that would change the color of a mountaineer's rope in places it is frayed or weakened.

"If you can replace things like wood and metals, add extra toughness and longer lifespan, people are going to be interested in it," said University of Delaware chemical engineer Richard P. Wool, who is also president of a materials research firm. "Material sensing and healing itself gives you an enhanced safety factor for everything from aircraft to [Defense Department] applications and sports equipment."

Polymer composites, present in everything from Corvette fenders to cell phone circuit boards, tennis rackets and pole-vaulting poles, are made of reinforcing fibers—glass, carbon or Kevlar, or hemp, jute or flax, among others—surrounded by a resin matrix, such as epoxy or urethane.

The life of the composite is determined by fatigue. Each time a Corvette bounces in and out of a pothole, or a surfboard bangs into a coral shelf, or an aircraft wing vibrates when an engine starts, tiny "microcracks" radiate through the polymer. As time passes, the composite weakens to the point it needs to be discarded or repaired.

"The standard approaches are extremely complicated and time-consuming," White said. For years, repair techniques involved cutting out the bad part and patching. This process today has expanded to include injecting resin into holes drilled into damaged areas, but "that's about the state of the art," White said.

So, he added, "we looked at the human body" and decided that any polymer repair method had to marry two elements humans take for granted: Healing had to occur automatically, and it had to be site-specific—"if you cut your finger, only your finger is going to be healed."

The key was to spread the new resin through the matrix so it would be available everywhere, but at the same time activate it only in areas where microcracks appeared. The solution, described in today's issue of the journal Nature, turned out to be simple.

White and his team encased microscopic drops of monomer—the building blocks of polymers—in "microcapsules" and mixed the capsules into the original resin matrix. Then they added tiny crystals of catalyst, like sprinkling salt on mashed potatoes, and blended that in. The mixture was molded and set as a polymer composite.

The team then scored the specimen by tapping a razor blade into a precut groove. As the resulting cracks probed deeper into the original polymer, they encountered the capsules and pierced them, releasing the liquid monomer, which flowed into the crack.

When the monomer encountered the catalyst crystals, it activated the polymerization process, changing it into a fresh resin filler that hardened on site: "The beautiful thing about it is that it nips the damage in the bud," said Wool, who wrote a critique to accompany White's report. "That's when the healing gremlins go to work."

White said that the healing process in many materials would be almost constant. Scratches on a Corvette fender would be like abrasions on someone's knee. Pushing cell-phone buttons would bruise the keypad beneath them. Vibrations from an aircraft engine would create the aeronautical equivalent of deep muscle soreness.

The microcapsules would fix all of that as it happened, White said, and leave the composite stronger than it would have been had the microcapsules never been added. As a result, the longevity of a virtually endless list of polymer products could be easily doubled or quadrupled.

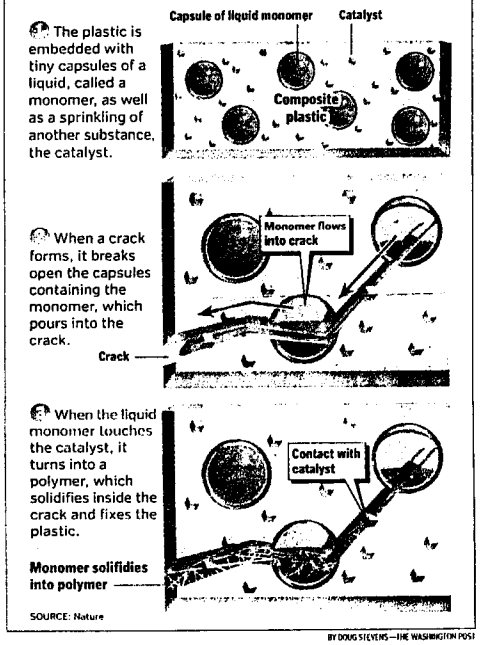
Despite the elegance of the concept, however, Wool noted that the research needed to make it happen was anything but simple. The crystalline catalyst is a recent invention, and although microcapsulization has existed for some time, the White team spent a great deal of time getting the capsules to work exactly right.

"It was a technical challenge, finding the [capsule] wall thickness, the size range and the properties," White said. The capsules had to be strong enough to survive the polymerization process without breaking, yet permeable enough so microcracks would pierce them and not go around them.

White said a commercial partnership with Motorola Inc. could produce self-healing microelectronic circuit boards within three to five years, but "something like airplane parts or aerospace applications is much further down the road."

Self-Healing Plastic

University of Illinois researchers have developed a type of composite plastic that heals itself when a crack forms.



SOURCE: Nature

BY DOUG STEVENS—THE WASHINGTON POST