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TECH

Sticky Science: Gecko Toes Key to Adhesive That Doesn't Lose Its Tackiness

U.C. Berkeley researchers are testing artificial microfibers that imitate those a gecko uses to cling to wet surfaces

- By Larry Greenemeier on October 1, 2008

Credit: Courtesy of Kellar Autumn, Lewis and Clark College

At first blush, it might seem that a wall-crawling robot and a gecko do not have much in common. That is, until you look closely at how each adheres to the surface it is climbing, with thousands of tiny hairs attaching and detaching to provide gravity-defying traction.

The biggest difference is that the diminutive lizards have been moving this way for millions of years, whereas researchers have for only the past decade been trying to emulate this natural phenomena in their mechanical creations. Researchers at the University of California, Berkeley, reported online last month in *Langmuir*, a journal of the American Chemical Society, the latest success in this area of bio-mimicking with the creation of an adhesive studded with hairlike microfibers that clean themselves of debris as they move along a surface.

Such an adhesive, when applied to the tires of an all-terrain robot, could allow it to scamper up walls and across ceilings, perhaps in the search for survivors after a disaster, says Ron Fearing, a U.C. Berkeley professor of electrical engineering and computer sciences and head of the research team developing the new material. "The gecko is one of the largest creatures that can stick to and move very quickly on a surface," he says. "It does this by turning its adhesive on and off."

Each gecko toe—they have five per foot—contains thousands of microhairs, which are generally 100 microns long and five microns in diameter, according to Fearing. (A micron is about four one hundred-thousandths of an inch.) The microhair's ability to adhere comes from touching, dragging against, and biting into a surface, rather than pressing down against it (as a piece of adhesive tape would). Because the hair is at an angle on the gecko's toe, it catches against a surface when moved in one direction, but can be freed from that surface when moved in the opposite direction. "In hindsight, it makes great sense," he adds. "Its feet should only stick when they want them to."

Whereas the hairs on a gecko's toe are made from the protein keratin (a major component of human hair, skin and nails), Fearing and his team made theirs from a polypropylene polymer. This gave them enough hardness to be packed together on a 0.4- by 0.8-inch (one- by two-centimeter) piece of white plastic they designed to simulate a gecko's toe. They attached the plastic strip to a piece of glass held in the vertical position, and then attached a small weight to the patch. After recording the maximum weight the patch can hold before slipping off, the researchers reattached the patch and added more weight. "After every test, there is a gradual increase in the load which can be sustained, showing that the contaminating particles are being removed," Fearing says. The goal is to create an adhesive that has similar adhesion to geckos, which can withstand a force of about 64.5 Newtons per square inch (10 Newtons per square centimeter).

The researchers raised the stakes during their experiments by scattering microscopic debris on the glass surface where the artificial gecko toe was stuck. This was done to study how well the synthetic hairs could shed dirt and retain their adhesion as they detached and reattached to the surface. With each simulated step, designed to provide a force similar to a gecko's step, an increasing number of particles fell away. After 30 simulated steps, the adhesive dropped about 60 percent of the particles it had collected while "walking".

Conventional adhesive tapes quickly become contaminated with the particles they touch and do not shed most of those particles when the tape is removed, which means there is less adhesive available if the tape is reused.

The work at U.C. Berkeley, funded over the past decade by $2 million from government organizations including the National Science Foundation and the Defense Advanced Research Projects Agency (DARPA), builds on research led by Kellar Autumn, an associate biology professor at Lewis & Clark College in Portland, Ore., who determined that a gecko keeps its feet sticky but clean by shedding dirt particles with every step. Other research in this area dates back to 2003 in England, when University of Manchester scientists created a prototype adhesive—0.155 square inch (one square centimeter)—with an array of microfabricated polyimide hairs attached to a flexible base.

The researchers are now looking to test their adhesive's ability to stick over rough surfaces, where fewer of the hairs are able to make contact. One possible solution to this would be to create synthetic hairs with even tinier fibers protruding from the hair tips in different directions, giving each hair more bite into the uneven surface. Fearing and his colleagues will be working on this through the end of the year.

In addition to providing traction for robots, reusable adhesives have a number of practical uses in office products, clothing and even wearable prosthetics. For example, picture frames could be fixed on a wall without nails or glue and later be moved without leaving holes or sticky residue on the wall. "Look at a shoe," Fearing adds. "What about something that keeps it from slipping on a wet tile? Geckos walk on wet leaves and can even stick to surfaces underwater."