# Waterproof and Germ Proof

What if all you needed to pack for your summer vacation was a comfortable T-shirt that kept you dry if it rained, and fought off germs, too? Nanotechnology could lead to lightweight clothing that's waterproof and germ proof.

### Stronger than Dirt

In some Eastern religions, the lotus plant is a symbol of purity. Although lotuses prefer to grow in muddy rivers and lakes, the leaves remain clean. Botanists who have studied lotus leaves have found that they have a natural cleaning mechanism: Their structure and surface chemistry mean that the leaves never get wet. Rather, water droplets roll off a leaf's surface like mercury, taking mud, tiny insects, and contaminants with them.

Some nanotechnologists are working on ways to make paints, roof tiles, and other surfaces that can stay dry and clean themselves, just as the lotus leaf does. To come up with new materials with what they call the "lotus effect," researchers are working from the molecular level up.

At Massachusetts Institute of Technology (MIT), chemical engineer Karen Gleason is particularly interested in copying the lotus leaf to make waterproof clothing that is not stiff or hot like rubber coated oil cloth, but lightweight and comfortable to wear. Along with other researchers from MIT's Institute for Soldier Nanotechnologies who are working on the military uniform of the future, Gleason has spent time with soldiers in the field in rural Louisiana. During training exercises there, their uniforms quickly became soaking wet and muddy, and they asked the MIT team to work on "waterproofed everything." Since soldiers going into combat usually carry at least 75 pounds in armor and equipment, they wanted lighter loads.

The lotus leaf was Gleason's model.

Collaborating with MIT chemist Alexander Klibanov, Gleason is combining two separate nanoscale coatings to make military clothing and blankets that would repel microbes as well as water, but would look and feel like untreated fabric. To make ordinary cotton waterproof, Gleason has patented a process that she developed called hot filament chemical vapor deposition. She starts with plastic molecules in gas form. When the gas is heated by filaments, or wires, inside a metal vacuum chamber that resembles a toaster, a chemical reaction causes the gas molecules to change shape.

On fabric, this change forms waterproofing that leaves it lightweight and comfortable to wear. "The coating is very thin," Gleason explains, "so that you physically cannot feel that it's different from uncoated fabric. That's because the process allows you to coat the entire thickness of the fabric. It goes around each individual textile fiber that makes up the weave, rather than just forming a layer on the top of the surface. It keeps the open areas in the weave, so that the fabric can breath."

So far, Gleason and her team have coated cotton T-shirts, and have found that the coating lasts through laundering. They've also used their process to waterproof silk and foam, and even money: "We've actually made dollar bills waterproof."

Now Gleason is combining her waterproofing with an extremely thin anti-microbial coating developed by Klibanov. So far, cotton treated with the combination produces far fewer bacteria than untreated cotton does. The two researchers hope to be able to use their combination coating to make soldiers' bulletproof body armor, which deteriorates when exposed to water, both waterproof and germ-free.

Most recently, Gleason's process has been described in the *Journal of Fluorine Chemistry* (2003) and *Chemistry of Materials* (2000).

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**by Ann Marie Cunningham**