Smart materials investigated on space station

November 27 2013, by Dr. Tony Phillips

If you have a smartphone, take it out and run your fingers along the glass surface. It's cool to the touch, incredibly thin and strong, and almost impervious to scratching. You're now in contact with a "smart material."

Smart materials don't occur naturally. Instead, they are designed by human engineers working at the molecular level to produce substances made-to-order for futuristic applications. The Corning Gorilla Glass that overlays the displays of many smartphones is a great example. It gets it toughness, in part, from "fat" potassium ions stuffed into the empty spaces between old-fashioned glass molecules. When the molten glass cools during manufacturing, dense-packed molecules solidify into a transparent armor that gives Gorilla Glass its extraordinary properties.

Around the world, designers are working on other smart materials such as alloys that can change shape on demand, plastics that heal themselves when ruptured, and fluids that obey magnetic commands to flow or stiffen under computer control.

"One of the great challenges in creating a smart material is arranging the molecules," says Eric Furst of the University of Delaware. "They're so small!"

Furst wants to create a new class of materials, beyond smart. "We need 'genius materials'—materials that arrange themselves," he says.

The research to accomplish this is already underway on the International Space Station.

Furst is the principal investigator of an experiment called InSPACE-3. In the microgravity of Earth orbit, vials of fluid mixed with very small 'colloidal' particles (about a millionth of a meter in diameter) are exposed to magnetic fields. Magnetism is switched on and off again very rapidly. This jostles the particles, causing them to bump together and self-assemble into microscopic structures that currently no supercomputer can predict.

"Astronauts enjoy watching this process in action through microscopes," says Furst. "Because the samples are backlit by a green lamp, they sometimes call it the 'green blob experiment.'"

Furst recently won an award from the American Astronautical Society for his work on InSPACE-3.

"I'm excited," he continues. "Just by toggling a magnetic field, we're learning how to take any kind of microscopic building blocks and get them to spontaneously form interesting structures."

Recently, observers have seen the colloidal particles forming long fibrous chains. Furst speculates that these could lead to materials that conduct heat or electricity in one direction only. The experiment has also yielded crystalline structures that the team is just beginning to investigate.

The fluids underlying these tests are themselves very smart. They are called magnetorheological or "MR" fluids because they harden or change shape when they feel a magnetic field.

If you own a sports car or a Cadillac, you might have MR fluids in your shock absorbers. The stiffness of magnetic shocks can be electronically adjusted thousands of times per second, providing a remarkably smooth ride. Similar but more powerful devices have been installed at Japan's

National Museum of Emerging Science and China's Dong Ting Lake Bridge. They're there to counteract vibrations caused by earthquakes and gusts of wind. Some researchers have speculated that MR fluids might one day flow through the veins of robots, moving artificial joints and limbs in lifelike fashion.

Furst and colleagues are using these fluids as a laboratory for studying self-assembly. MR fluids are, by definition, responsive to the magnetic nudging that sets self-assembly in motion. Furthermore, in space the particles don't sediment out due to gravity. "We can study the full 3D evolution of the material," he adds.

Varying the shape of the colloidal particles, the cadence of magnetic toggling, the temperature of the fluid and other factors will allow researchers and astronauts to further explore the frontiers of self-assembly.

Touch the surface of your smartphone again. Maybe that's just the beginning.

Provided by NASA

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