Scientists Create Multifunctional Brushes From Carbon Nanotubes

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The nanobrushes could benefit the electronic, biomedical, and other industries

Researchers at Rensselaer Polytechnic Institute have created a line of brushes whose bristles, made from carbon nanotubes, are so small that a thousand of them could fit inside a strand of hair.

The carbon nanotube brushes already have been tested in a variety of tasks that range from cleaning microscopic surfaces to serving as electrical contacts. The brushes eventually could be used in a whole host of electronic, biomedical, and environmental applications, says Pulickel Ajayan, the Henry Burlage Professor of Materials Science and Engineering at Rensselaer, who is heading the research.

The research, in collaboration with the University of Hawaii at Manoa, will be published in the July issue of the journal *Nature Materials*. Rensselaer postdoctoral associate Anyuan Cao, working with Ajayan, is the lead author of the paper.

The brushes look like microscopic toothbrushes, brooms, and paintbrushes, with handles the diameter of a human hair. Each brush is composed of millions of carbon nanotubes, each about 30 nanometers in diameter. The brushes have been tested manually and with rotating electric motors.

The researchers have used the brushes to remove nanoparticles in

microscopic grooves on various substrates. They also have cleaned and coated the inside of a 300-micrometer-wide capillary tube (a few times as wide as the diameter of a hair). In addition, because carbon nanotubes conduct electricity, the brushes have been successfully used as electromechanical switches in micromotors and as electrical contacts.

The brushes could be used to sweep away tiny particles and dust that cause static electricity, particularly nanosize particles that are difficult to remove by other means, according to Ajayan. Static electricity due to particulate attraction is a bane to the electronics industry. At the nanoscale level, even the smallest amount of particulate contamination can cause machines to malfunction.

From a biomedical perspective, the brushes are small enough to be used to clean up unwanted deposits in arteries and other blood vessels, Ajayan adds. The researchers also have shown that, when dipped in absorbent materials, the brushes will soak up toxic silver ions from contaminated water. The researchers plan to apply the brushes to more specific microelectronic and biomedical applications.

The materials typically used for making conventional brushes for electronics and other industries include animal hairs, synthetic polymer fibers, and metal wires. But metals corrode, hair is not very strong, and synthetic fibers degrade easily, according to Ajayan.

“Because of their small size, strength, light weight, pliability, and resistance to heat, carbon nanotubes may be a better option,” Ajayan says.

Using a gas-phase delivery technique, the researchers grew the carbon nantubes onto brush handles, made from silicon carbide fibers, by exposing the handles into a furnace of vaporized hydrocarbons. To control the shape of the brushes, the researchers wrapped the fibers in

gold except where they wanted the bristles to attach.

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Source: Rensselaer Polytechnic Institute