Tiny domain expands into mega-nanotechnology

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says.

Richardson businessman James Von Ehr agrees.

"Seven years ago, people didn't want to talk to me about nanotechnology," said Mr. Von Ehr. The next year, he founded Zyvex, the first molecular nanotechnology company. Now he's selling $150,000 machines to other companies who want to manipulate matter on the molecular level.

Stimulated by the competition, new discoveries are flooding out of university labs. For instance, the NanoTech Institute at the University of Texas at Dallas produces at least 20 papers a year in major scientific journals, says its director, Ray Baughman.

The artificial muscle discovery appeared in one such paper, in the May issue of *Nature Materials*.

In it, scientists from UTD, Germany and New Jersey describe making tiny fibers of vanadium oxide that measure up to 10,000 nanometers long and 10 nanometers wide. They clump together in sheets, creating a tangle like a nano-sized plate of spaghetti.

But apply an electrical current to the nanofiber sheets, and they curl up in unison. Turning off the electrical current allows them to relax. The process can be repeated many times, mimicking flexing and unflexing of muscle, says Dr. Baughman.

Similar nanofibers might be used in robotic muscles or in optical switches. Other researchers have made nanomuscles out of carbon nanotubes — long, rolled-up tubes of carbon that are today's extension of buckyballs.

Carbon nanotubes appear to be the toughest muscles yet — even better than vanadium oxide, says Dr. Baughman. "We can have 100 times the stress generation of natural muscles," he says.

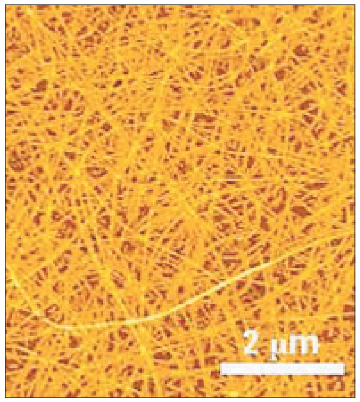
Gold's prospects

When natural muscles get sick, nanotechnology can help them in another way. Gold "nanoshells" under development could be used in a host of medical applications, says Naomi Halas, an electrical engineer at Rice.

Nanoshells are tiny balls of sand surrounded by a layer of gold. By varying the thicknesses of the sand center and the gold layering, researchers can change the optical properties of the nanoshells, making them absorb light of a chosen wavelength. (Renaissance artists knew enough of this phenomenon to mix metal particles into molten glass to produce vivid ruby colors in cathedral windows.)

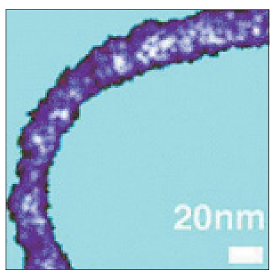
With new manufacturing tricks, "we can tune the color to virtually any wavelength we want," says Dr. Halas.

And that's most useful in medical applications, where there are few materials that absorb light in the near-infrared wavelengths. For instance, Dr. Halas and her colleagues are working to develop new blood tests that use nanoshells to skip the time-consuming process of purifying blood to make it transparent.



RAY BAUGHMAN/UT-Dallas

A tangle of vanadium oxide nanofibers, as seen through an atomic force microscope, could be used to develop artificial muscles.



ANGELA BELCHER/MIT

A microscope image shows a nanowire assembled by the natural organizational ability of viruses.

Even more dramatically, Dr. Halas says, doctors might one day inject nanoshells into a patient, where they would escape through leaky blood vessels and accumulate in a tumor. Shining a laser of a particular wavelength on the skin could heat up the nanoshell-impregnated area, essentially cooking the tumor while leaving the rest of the tissue intact.

In Dr. Halas' lab, graduate student Lee Hirsch recently demonstrated the approach, injecting an inky solution of nanoshells into uncooked chicken breast and then directing a laser at it. After a few seconds, a plume of smoke appeared, although the surface of the chicken breast remained uncooked.

The scientists are now testing the concept in mice.

Making connections

Nanomaterials don't just come in the shape of fibers and shells. Researchers have recently branched out to create many-pronged nanocrystals.

Last month, in the online version of *Nature Materials*, Paul Alivisatos of the University of California, Berkeley and colleagues reported success at growing nanocrystals with four arms of roughly the same length. Until now, scientists had been able to make only more rudimentary rods, spheres and disks.

Dr. Alivisatos' crystals, of cadmium telluride, could act as building blocks for more complicated nanostructures built from scratch. When dropped on a surface, the crystals almost always land with one end pointing up — suggesting they could naturally self-align as connectors for miniature wiring, the scientists wrote in their paper.

Some day, "such multi-branched structures might serve as building blocks for three-dimensionally interconnected computing structures, not unlike the neural connections found in the brain," write Harvard researchers Deli Wang and Charles Lieber in an accompanying commentary.

Intricate wiring

Nanotechnology and biology are already coming together in the new field of nanobiotechnology. One of its leading practitioners, Angela Belcher of the Massachusetts Institute of Technology, devised the new method to create nanowires using ordinary viruses.

Viruses create a naturally organized, crystalline coat for themselves. Scientists want to use that ability to force inorganic material, like the stuff that makes up nanowires, into a regular structure.

In the new experiments, Dr. Belcher's team fused the virus coat with protein fragments that can attract inorganic material such as zinc sulfide or cadmium sulfide. When the virus tried to assemble its coat, it also created an organized strand of inorganic nanocrystals: a naturally assembled nanowire.

"Our results demonstrate the potential application of engineered viruses to serve as the template to assemble nanocrystals along a nanowire," the scientists wrote last week in the *Proceedings of the National Academy of Sciences*.

The marriage of biology, chemistry and physics is just one reason that nanotechnology is so compelling these days, says UTD's Dr. Baughman. He foresees the explosion of nanotech research continuing over the next few years, especially in his lab.

"As long as it's exciting, I don't care if it's nano or not," Dr. Baughman says. "But nano is one of the most exciting areas."

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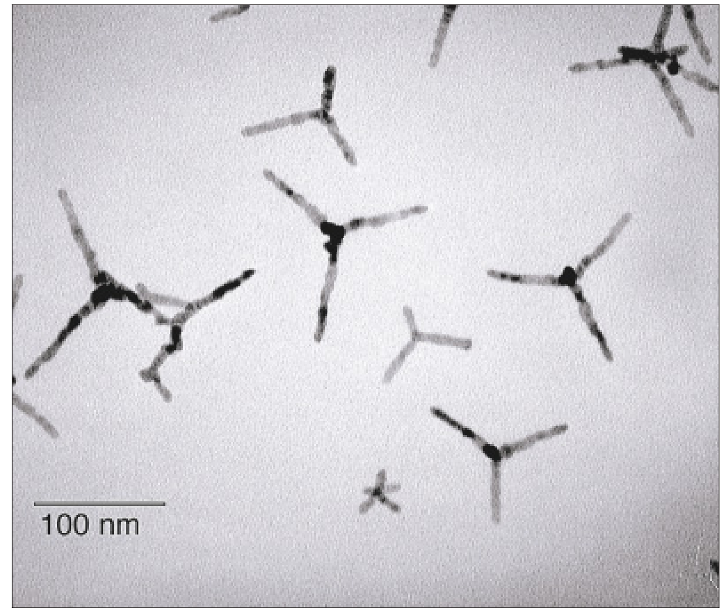

PAUL ALIVISATOS/University of California, Berkeley

Four-armed nanocrystals such as these made of cadmium telluride (viewed from above) could serve as natural wiring connectors for miniaturized electronics of the future, some scientists think.

C. MORAN AND C. RADLOFF/Courtesy NAOMI HALAS/Rice University

Vials of suspended "nanoshells" vary in color because varying the thickness of the shells affects their optical properties. The vial at far left contains only gold nanoparticles; the other vials have gold shells around a silica core.

On the Web

Discoveries looked at the emerging world of nanotechnology in October 2000. Read those stories on DallasNews.com/health

SCIENCE Q&A

Question: In raised garden beds using pressure-treated wood, is there danger that the arsenic in the wood will move through the soil and contaminate food crops?

Answer: Wood is often treated with chromated copper arsenate, applied under pressure to guard against dry rot, mold and insects. Studies of risks vary. Some experts suggest that the chief danger comes from handling the wood (like sawing and drilling it to build the gardens) or disposing of it by burning.

Most research has concluded that the variable amounts of chromated copper arsenate that leach slowly into the soil are small and do not significantly penetrate more than six inches and that except in highly acidic soil, the components tend to stay bound to the soil rather than being absorbed by plants.

To be on the safe side, the Cornell University department of horticulture suggests putting a plastic barrier between the soil and the wood or using a long-lasting untreated wood like cedar.

The New York Times