News

Dec 1, 2003

U-M researchers take giant leap toward fulfilling nanotech's promise

By Mark Puls
Michigansmalltech.com Correspondent

Nanotechnology is taking on a life of its own, and soon self-assembly with almost no human help could become more than just a dream of scientists.

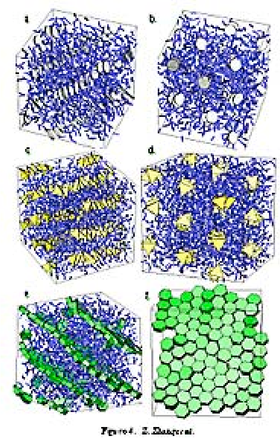

Illustration courtesy of University of Michigan
Shown are examples of self assembled structures formed from tethered nanoparticles. By changing the nanoparticle shape and position of the tethers different kinds of structures, such as wires or sheets, can be formed.

Scientists at the University of Michigan recently used virtual models to demonstrate how microscopic structures can build themselves almost automatically. Tiny tethers were attached to simulated nanoparticles causing them to arrange themselves according to a mysterious blue print.

"Future materials and devices for photonics, molecular electronics, nanomedicines and sensors require the self-assembly of synthetic nanostructures with the precision, reliability, and speed of biological self-assembly," said Sharon C. Glotzer, professor of chemical engineering at U-M.

She unveiled her group's discoveries about nanotethers in an article authored with graduate student Mark Horsch and post doctoral researchers Zhenli Zhang and Monica Lamm in the October issue of the scientific journal Nano Letters. Glotzer's work to develop self-assembly technology is funded through grants from the U.S. Department of Energy and the National Science Foundation. The work is being presented today at the annual Materials Research Society Meeting in Boston.

Scientists at the Ann Arbor university envision this technology eventually improving parts used in computers, cars, aircraft, sensors, fuel-storage cells and any other products with nano-components and micro-machines.

It promises to make electronic circuits smaller and faster, which could help develop even smaller cell phones and supercomputers the size of sugar cubes. Some of the far-reaching benefits may be difficult to predict.

"Self-assembly doesn't just provide the possibility of improving parts of existing devices - it provides the possibility of inventing entirely new materials, devices and technologies that aren't possible with traditional concepts."

So far, much of the practical application of the technology is still in the theoretical stage. But within two to five years, self-constructing nanostructures in products might be introduced, and widespread use is perhaps a decade away, Glotzer said. If nanoparticles can be made to cooperate in an orderly fashion, the daunting obstacle of arranging millions of tiny jigsaw pieces can be solved.

"Next generation materials and devices comprised of molecular and nanoscopic building blocks tailor-made for specific applications will not be fabricated via traditional methods," Glotzer said. "Mechanical positioning of millions to trillions of nano bulding blocks into specific arrangements is simply not feasible."

Both academic and industrial researchers are trying to find economical ways to make novel materials made possible by nanotechnology, said John Kieffer, U-M professor of materials science and engineering.

“You have to work at a very small scale,” he said. “So it's crucial to make the production of them economically viable. Self-assembly is requisite. Just imagine you had to purposely manipulate millions of millions of nano-sized particles. The sheer number indicates that if it doesn't happen autonomously, the process would be astronomically costly.”

The alternative is self-assembly. This strategy is based on harnessing the forces of nature that cause nanoparticles to either flock together or fly apart. These tendencies can be manipulated, at least in theory, by placing tethers on them in strategic spots, causing the nanoparticles to pack in unusual ways.

"When you have particles that are only a few nanometers or tens of nanometers in size, it becomes possible, in principle, to consider attaching a small, countable number of short polymer 'tethers' to the particle that are similar in size to the particle," Glotzer said.

Self-assembly occurs naturally with certain proteins in the body that can rapidly organize themselves into viruses, either pill-shaped, cylindrical or many sided. Scientists at U-M and elsewhere have already observed some self-assembly occurring in man-made nanoparticles such as semiconductor "quantum dots" and silica cubes.

"Our simulations predict that nanoparticles could spontaneously self-assemble into sheets, wires, tubes, shells and other useful structures when conditions are such that the tethers and nanoparticles repel each other," Glotzer said.

The thesis proffered by Glotzer and her students is that if small tethers can be attached to nanoparticles in just the right place, predictable, self-assembled patterns (or shapes) can be obtained.

"If the tethers and nanoparticles either repel each other or prefer their own kind more strongly than they prefer each other, either directly or via the solvent in which they may be suspended, then thermodynamics can be exploited to organize the nanoparticles into structures that begin to approach the intricacy of self-assembled biological structures," Glotzer said.

"Our simulations predict that this may indeed be possible. Experiments testing our predictions are now needed."

But just how these natural forces work together to produce one structure versus another is not known.

"The rulebook for self-assembly needs to be developed," Glotzer said. “There is no theory that can predict, even generally, let alone for a specific system, what structures might be assembled and how to do it. This is the motivation for our work on this problem."

