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U-M scientists unveil findings on self-assembling particles

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ANN ARBOR, Mich., Sept. 13, 2004 - **University of Michigan** (U-M) researchers are a quantum leap closer to discovering how nanodevices can build themselves. Scientists at the Ann Arbor campus have used virtual computer models to show how sticky patches can make nanoparticles group together in programmed ways to create a variety of shapes and structures such as wires, sheets and shells.

The discovery could be used to make futuristic materials and devices in industries such as medical and automotive.

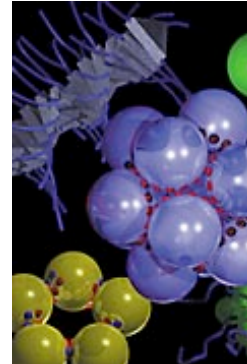


Photo courtesy of U-M
Computer-simulated
assemblies

U-M researchers unveiled their findings in the scientific journal **Nano Letters** in August with a paper, "**Self Assembly of Patchy Particles**," co-authored by Zhenli Zhang, U-M research fellow in chemical engineering, and **Sharon C. Glotzer**, U-M professor in **chemical engineering**.

"Today, the extent to which materials building blocks can be engineered has undergone a quantum leap," Glotzer said. "We are on the verge of a materials revolution in which entirely new classes of molecules and particles will be designed and fabricated with desired features, including programmable instructions for assembly."

The paper by Glotzer's **group** expands the findings from its published report in the same journal last year. The previous article focused on using 'tethers' that made nanoparticles form into shapes by either repelling or attracting them. The latest work focuses on using sticky patches, which allow for greater possibilities for self-assembly.

The new technology opens a host of possibilities and challenges, Glotzer said.

"These new building blocks will be the 'atoms' and 'molecules' of tomorrow's materials, self-assembling into novel structures made possible solely by their unique design."

But the rubric presents several questions.

"What happens when we replace traditional atoms and molecules with these new, improved building blocks?" Glotzer asked. "What types of ordered structures are possible, and what unique properties do they have? These are the questions my students and I are trying to answer using computer simulations of model building blocks."

The patches use tiny molecular adhesives that make particles bind according to a

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blueprint. The charged patches either attract or repel parts of other particles, much like proteins do. This discovery is helping to unlock the riddle of nanotechnology: building minutely small structures invisible to the naked eye. Obviously, a factory assembly line is not where this process can occur.

Fortunately, self-assembly occurs naturally with certain proteins in the body that are capable of rapidly organizing themselves into pill-shaped, cylindrical or many-sided viruses. Scientists at U-M and elsewhere have already observed the self-assembly process in manmade nanoparticles such as semiconductor "quantum dots" and silica cubes. But understanding these rules and then engineering and using them have remained a mystery.

Glotzer's group has tested its theories on computer models. Doing the tests in a lab would create a need to work out an infinite amount of possibilities; options that would be too expensive in time, money and scientists.

"That's why computer simulation is so important; it allows us to simulate many possibilities rapidly, to find the most promising designs, and see what they do," Glotzer said.

"We are working with several laboratories at U-M that have the capability to make the kinds of 'patterned' building blocks we can design; and we are in the process of establishing a center at U-M devoted to this activity of 'bottom-up assembly' of engineered materials and structures."

Glotzer's work to develop self-assembly technology is funded through grants from the U.S. **Department of Energy** and the **National Science Foundation**.

Scientists at U-M envision that this technology will eventually improve parts used in computers, cars, aircraft, sensors, fuel-storage cells and any other products with nano-components and micro-machines. Self-assembly also 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 more difficult to predict.

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

Both academic and industrial researchers are trying to find economical ways to make novel materials 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 production economically viable. Self-assembly is requisite. Just imagine you have 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."