Researchers make nanosheets that mimic protein formation

October 12 2006

How to direct and control the self-assembly of nanoparticles is a fundamental question in nanotechnology. University of Michigan researchers have discovered a way to make nanocrystals in a fluid assemble into free-floating sheets the same way some protein structures form in living organisms.

"This establishes an important connection between two basic building blocks in biology and nanotechnology, that is, proteins and nanoparticles, and this is very exciting for assembling materials from the bottom up for a whole slew of applications ranging from drug delivery to energy," said Sharon Glotzer, professor of chemical engineering and materials science and engineering.

Glotzer and Nicholas Kotov, associate professor of chemical engineering, and their graduate students and post doctoral researchers have co-authored a paper scheduled to appear Oct. 13 in the journal *Science*.

"The importance of this work is in making a key connection between the world of proteins and the world of nanotechnology" Kotov said. "Once we know how to manipulate the forces between the nanoparticles and their ability to self-organize, it will help us in a variety of practical applications from light-harvesting nanoparticle devices to new drugs which can act like proteins, but are actually nanoparticles."

The sheets, which can appear colored under UV illumination from bright

green to dark red depending on the nanoparticle size, are made from cadmium telluride crystals, a material used in solar cells. The sheets are about 2 microns in width, about 1/5 the thickness of a human hair.

Scientists have long known how to coax nanoparticles into forming sheets, Glotzer said. But those sheets have only been achieved when the particles were on a surface or at an interface between two fluids, never while suspended in a single fluid.

The work started in Kotov's lab three years ago, when he and his team observed the sheets in experiments. Though they created them, they weren't sure how.

"We were aware of certain proteins in living organisms that self-assemble into layers, called S-layers," Kotov said. S-layer proteins comprise the outermost cell envelope of a wide variety of bacteria and other single-celled, prokaryotic organisms called archaea, and they are able to form 2-d sheets with square, hexagonal, and other packings at surfaces and interfaces, as well as suspended in fluid. The group sought to make the connection between the forces governing S-layer protein assembly and the forces governing the nanoparticle assembly. That's when Glotzer's group, whose expertise is in computer modeling and simulation, became involved.

"It's likely that the forces between S-layer proteins are highly anisotropic, and we suspected this was also a feature of the nanoparticles," Glotzer said. "Computer simulations allowed us to further develop and test this hypothesis."

Post doctoral researcher Zhenli Zhang of Glotzer's group tried various combinations of forces based on information gleaned from experiments performed by post doctoral Zhiyong Tang of Kotov's group. The team discovered that the unique shape of the CdTe nanocrystals gave rise to a

combination of forces that conspired to produce the unusual two-dimensional packing. Subsequent experiments by Kotov's group showed that if any of the forces were missing, the sheets would not form, confirming the simulation predictions.

"Self-assembly is nature's basic building principle for producing organized arrays of biomolecules with controlled geometrical and physicochemical surface properties," Glotzer said. "In the fabrication of functional nanoscale materials and devices, self-assembly offers substantial advantages over traditional manufacturing approaches, if we can design the building blocks appropriately. This is what we're trying to do."

Source: University of Michigan College of Engineering