Nano compartments may aid drug delivery, fuel cell design

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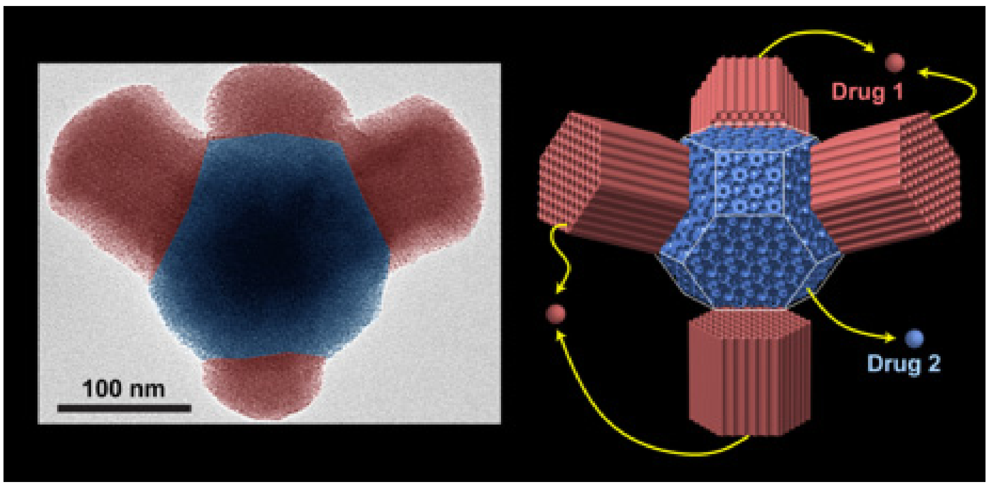

This false-color image (left) depicts the core lattice in blue, where drugs can be placed in compartment pores for targeting in the body. In the hexagon-shaped cylinder branches, other types of drugs may be place for delivery. Simultaneous delivery of pharmaceuticals can thus be optimized for each drug separately. The accompanying illustration (right) offers a clear vision of the left image. Credit: Wiesner Lab

(Phys.org) —In a scientific two-for-one deal, Cornell researchers have created compartment nanoparticles that may carry two or more different drugs to the same target. Meanwhile, the same technology gets applied to fuel cells, where catalysts may be formed into porous structures to expose more surface area.

Ulrich Wiesner, the Spencer T. Olin Professor of Materials Science and Engineering, has tweaked "sol-gel" chemistry used to self-assemble porous silica particles, making it shift gears partway through a reaction, and creating what amounts to two or more different nanoparticles joined together. The finding was reported in the April 19 issue of *Science*. Wiesner is senior author.

"It's the first time I'm aware of that the shapes of the particles have been controlled," Wiesner said. "The products so far are fairly simple particles with two or three compartments that look a bit like tiny versions of a space station with protruding habitats, but the methods might be extended to create much more complex structures," he said.

The discovery was partly serendipitous. While making ordinary nanoparticles, the scientists saw a small fraction with hexagonal arms growing out of the cubic faces. They sought to understand the controls.

Wiesner and his research team report their results in *Science* as "Multicompartment Mesoporous Silica Nanoparticles with Branched Shapes: An Epitaxial Growth Mechanism." The other researchers include first authors Teeraporn Suteewong, M.S. '09, Ph.D. '10, and graduate student Hiroaki Sai; graduate student Robert Hovden; David Muller, professor of applied and engineering physics; Sol M. Gruner, professor of physics; and Michelle Bradbury, M.D., Memorial Sloan-Kettering Cancer Center.

The starter for the process is a mixture of organosilanes, complex molecules built around carbon and silicon atoms. Organosilanes are surfactants, akin to soap, which means that one end of the molecule likes to get close to water, while the other end tries to stay away. So in water the molecules are pushed together and link up, just as soap molecules link to form the skin of a soap bubble. Here they assemble a three-dimensional lattice that grows to form particles a couple of hundred nanometers in diameter, filled with pores one or two nanometers in size that could be filled with other material. (A nanometer is a billionth of a meter, about the length of three atoms in a row.) The shape of the pores depends, among other things, on the pH, or acidity, of the solution.

The researchers added ethyl acetate, a chemical that breaks down in water, in the process making the solution more acidic. At first the organisilanes form a lattice of tiny cubes that join into somewhat cubical particles, with rounded corners. As acidity increases the lattice becomes hexagonal, building a rough cylinder, and hexagon-based cylinders begin to grow out of the faces of the cubes. The number of cylinders and their length can be controlled by the timing of the process and the concentration of ethyl acetate.

"Previous work was on how to control the pore structure," Wiesner said. "Here we use the pore structure to control the shape."

In a hint for the future, the researchers were able to connect two or three cubes with cylindrical bridges between them, perhaps the beginning of a nanoscale network of cubes and tubes. "We have learned to switch the growth conditions. If we can switch back we might be able to grow all sorts of funky architectures," Wiesner said.

More information: Paper: www.sciencemag.org/content/340/6130/337.abstract

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