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Gail Gallessich

Tiny Glass Nanostructures Revealed In Nature Cover Story -- Potential Applications Abound

Delving into the world of the very, very small, the nano-world, scientists have created and "viewed," in three dimensions, materials that may help to solve macro-level problems of technology and the environment.

The cover story in this week's international journal Nature reports the direct three-dimensional imaging of highly-structured, porous glass, at the nano scale, that has potential applications for lasers, optical fibers, coatings for computer chips, containers for the storage and slow release of plant nutrients, packaging to protect and enhance desired biological processes, and a variety of highly sensitive detectors including sensors for finding biotoxins in the environment.

As intriguing as ice crystals, but vastly smaller, the dimensions of these glassy pores, cages and channels are from one to 50 nanometers in size, a nanometer being equal to one-thousandth the thickness of a human hair.

How does one see into such a tiny realm?

Scientists used an electron microscope that is two stories high, according to co-author Galen Stucky, at the University of California, Santa Barbara.

Three labs in three different countries cooperated on the research. In addition to Stucky's lab at UC Santa Barbara, which fabricated the material, researchers at Tohoku University in Sendai, Japan and the Korea Research Institute of Chemical Technology in Taejon, Korea worked on the problem. The electron microscope is located at Tohoku University.

"I like to call it three-dimensional etched glass," said Stucky, who created the glassy material with his research group in 1994 and published the discovery in Nature. In 1998, Stucky's research group and those of Brad Chmelka and Glenn Frederickson (both faculty members in chemical engineering at UC Santa Barbara), created and published, in the journal Science, a better way to make these materials.

"Essentially, we take soap (a surfactant or emulsifier) and sand (silica) along with whatever other optical or electronic component that we might wish to incorporate, then we put them together to make materials which are beautifully structured and easily processed," he said. "The materials can be used to make all sorts of things -- from fibers to films, to lasers and sensors. They can be used to create nanostructured, highly organized three-dimensional biochemical enzyme factories, to sense biotoxins and for the removal of toxic heavy metals from the environment."

The nanotechnology, the chemistry, and the processing make possible many different three-dimensional patterns, shapes and forms that can be organized at multiple-length scales in numerous ways, said Stucky.

According to the article, "The three-dimensional structural solution makes clear, at the nanoscale level, the sizes and shapes of the pores and cages, their arrangements and their connectivity, including sizes of openings."

In essence the article reports the methodology for directly observing the structured glass. Imaging and characterizing the material are challenging. Going beyond the usual two-dimensional projected image of a structure that

researchers see using the electron microscope, the researchers developed a new general approach for the direct determination of the three-dimensional pores, cages and channels that are present in the material.

This requires several series of mathematical conversions. With this new knowledge of the material, these "topographic" maps, applications can proceed. Biotechnology applications are of particular interest and are being developed with colleagues Brad

Chemlka; Dan Morse, in molecular genetics and biochemistry at UCSB; and, Alison Butler in chemistry and biochemistry, also at UCSB.

"We can make pores as big as any protein," said Stucky. "So we can separate or selectively package biomolecules, such as proteins, or DNA, in a way that makes them

readily accessible for use."

Stucky, professor of chemistry and materials, is known internationally for his work. His overall research goal is the design, synthesis and application of new multi-component material systems. He has received many honors and awards, and has published extensively.

Stucky received his Ph.D. in 1962 from Iowa State University. After postdoctoral study at MIT, he held positions at the University of Illinois, Sandia National Laboratory, and DuPont Central Research and Development Department before joining the chemistry faculty at UC Santa Barbara in 1985. He is now a professor in the Materials and Chemistry Departments and a member of the Biochemistry and Molecular Biology faculty. Stucky has been active in the American Chemical Society, serving as associate editor of the Journal of Inorganic Chemistry

and as chairman of the Inorganic Division.

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