Self-assembly generates more versatile scaffolds for crystal growth

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Self-organizing synthetic molecules originally used for gene therapy may have applications as templates and scaffolds for the production of inorganic materials. Using electrostatic interactions between oppositely charged molecules as the binding force, scientists are learning how to organize these synthetic molecules into more versatile complexes with large and controllable pore sizes.

"By investigating the fundamental design rules for the control of self-assembled supramolecular structures, we can now organize large functional molecules into nanoscopic arrays," said Gerard Wong, a professor of materials science and engineering and of physics at the University of Illinois. Wong and his colleagues report their latest experimental results in the September issue of the journal Nature Materials.

"We showed that the self-assembly of charged membranes and oppositely charged polymers into structures can be understood in terms of some simple rules," said Wong, senior author of the paper. "We then applied those rules and demonstrated that we could organize molecules into regular arrays with pore sizes ten times larger than in previous DNA-membrane complexes."

Early self-assembled DNA-membrane structures consisted of periodic stacks of alternating layers of negatively charged DNA "rods" and positively charged lipid membranes. The pores between the DNA rods could be used to package individual ions, which can in turn be crystallized. This work was published last year by Wong's group, and was featured as a "Chemistry Highlight of 2003" by Chemical & Engineering News.

But generalizing this idea to larger pores was difficult. In previous work, Wong and colleagues showed that actin, a protein found in muscle cells, also reacts with lipid membranes to create ordered structures. The actin-membrane assemblies, however, consisted of the membrane sandwiched between layers of actin, with little room to house or organize other molecules.

In the latest work, the researchers substituted a rod-shaped virus for the DNA. While having a diameter close to that of actin, the virus has a charge density comparable to DNA. The resulting virus-membrane complexes have pore sizes about 10 times larger than the DNA-membrane complexes, and can be used to hold and organize large functional molecules.

"Even though these supramolecular systems were originally designed for gene therapy, we've shown that they can be used as templates for organizing other molecules," Wong said. "An example would be the biomineralization of inorganic nanocrystals, in a way analogous to bone formation."

To produce bone, nature uses organic molecules to organize inorganic components that become mineralized through additional chemical reactions. Scientists want to create synthetic molecules that work as nanostructured scaffolds of biomolecules and perform tasks ranging from non-viral gene therapy to biomolecular templating and nanofabrication.

"Ultimately, we would like to have designer molecules that do exactly what we want," Wong said. "Right now we are still elucidating the rules for making these scaffolds and their interactions with inorganic components. It will take some time to move from fundamental science to supramolecular engineering."

Source: University of Illinois at Urbana-Champaign