

Ordered Nanostructures Made Using Chaperonin Polypeptides

This method exploits the ability of chaperonins to assemble into complex structures.

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A recently invented method of fabricating periodic or otherwise ordered nanostructures involves the use of chaperonin polypeptides. The method is intended to serve as a potentially superior and less expensive alternative to conventional lithographic methods for use in the patterning steps of the fabrication of diverse objects characterized by features of the order of nanometers. Typical examples of such objects include arrays of quantum dots that would serve as the functional building blocks of future advanced electronic and photonic devices.

A chaperonin is a double-ring protein structure having a molecular weight of about 60 ± 5 kilodaltons. In nature, chaperonins are ubiquitous, essential, subcellular structures. Each natural chaperonin molecule comprises 14, 16, or 18 protein subunits, arranged as two stacked rings approximately 16 to 18 nm tall by approximately 15 to 17 nm wide, the exact dimensions depending on the biological species in which it originates. The natural role of chaperonins is unknown, but they are believed to aid in the correct folding of other proteins, by en-

closing unfolded proteins and preventing nonspecific aggregation during assembly.

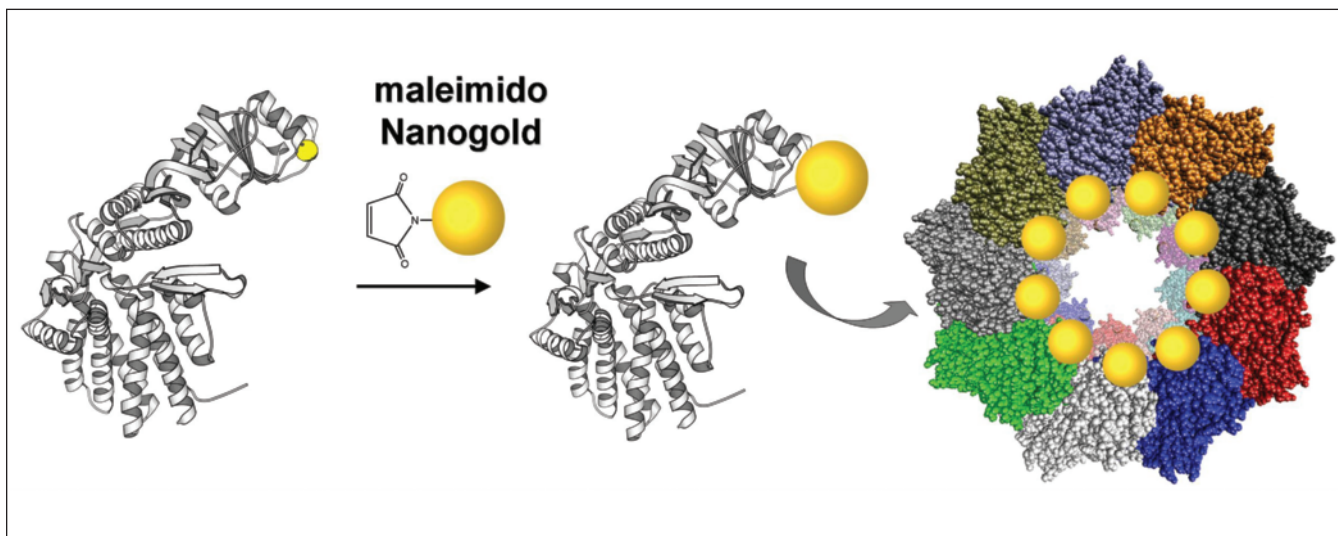
What makes chaperonins useful for the purpose of the present method is that under the proper conditions, chaperonin rings assemble themselves into higher-order structures. This method exploits such higher-order structures to define nanoscale devices. The higher-order structures are tailored partly by choice of chemical and physical conditions for assembly and partly by using chaperonins that have been mutated. The mutations are made by established biochemical techniques.

The assembly of chaperonin polypeptides into such structures as rings, tubes, filaments, and sheets (two-dimensional crystals) can be regulated chemically. Rings, tubes, and filaments of some chaperonin polypeptides can, for example, function as nanovessels if they are able to absorb, retain, protect, and release gases or chemical reagents, including reagents of medical or pharmaceutical interest. Chemical reagents can be bound in, or released from, such structures under suitable controlled conditions.

In an example of a contemplated application, a two-dimensional crystal of chaperonin polypeptides would be formed on a surface of an inorganic substrate and used to form a planar array of nanoparticles or quantum dots. Through genetic engineering of the organisms used to manufacture the chaperonins, specific sites on the chaperonin molecules and, thus, on the two-dimensional crystals can be chemically modified to react in a specific manner so as to favor the deposition of the material of the desired nanoparticles or quantum dots. A mutation that introduces a cysteine residue at the desired sites on a chaperonin of *Sulfolobus shibatae* was used to form planar arrays of gold nanoparticles (see figure).

This work was done Jonathan Trent, Robert McMillan, and Chad Paavola of Ames Research Center; Rakesh Mogul of University of California, Santa Cruz; and Hiromi Kagawa of SETI Institute. For further information, access <http://www.ipt.arc.nasa.gov/trent.html> and <http://amesnews.arc.nasa.gov/audio/bionanosound/bionano9.html>.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-14744.



This Planar Array of Gold Nanoparticles was formed on a carbon film by the method summarized in the text.