Programmed Assembly of Nanoparticles on DNA Templates[1]

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Abstract

The ability to assemble nanoparticles into wires, arrays, networks, and circuits in a precise and controlled manner is key to the fabrication of a variety of nanodevices. Networks of nanometer–sized metal or semiconductor clusters may exhibit a variety of quantum phenomena, with applications in optical devices, nanometer-sized sensors, advanced computer architectures, ultra dense memories, and quantum-information science and technology. The challenge is that fabrication with nanoscale precision of nanoparticle arrays in a time and cost effective manner remains a formidable task. Interest in the concept of self-assembled nanostructures led to the idea of using DNA as a scaffold or template for the programmed assembly of nanoscale arrays. We will describe a new approach for binding nanoparticles to DNA. Functionalized nanoparticles are covalently bound to internal, chemically modified bases. Functionalized gold nanoparticles have been covalently bound to internal, modified sites on double-stranded DNA. Gold nanoparticles coated with mercaptosuccinic acid or thioctic acid were bound to amino-modified thymine bases on double-stranded DNA. Visible absorption spectra and atomic force microscopy (AFM) were used to analyze the products. Absorption spectra of gold particles in the presence of DNA show a significant hypochromic effect when the gold binds to the DNA and the absorption peak of the particles shifts to a longer wavelength after incubation with DNA. AFM images confirm the binding of the particles to DNA. Analysis of the AFM images shows that the average height of the DNA between gold particles is 0.74 nm, in good agreement with published values, while the height of the DNA bound to the particles is approximately 3 nm. Thiol groups were added to one end of the gold/nanoparticle product, which was then attached to a gold surface. This method has the potential to allow controlled placement of particles with sub-nanometer precision and to allow attachment of the product to fixed contacts for nanodevice fabrication.

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