Gold Nanoparticles

Lingjuan Shen Literature Seminar December 2, 2008

Gold nanoparticles (AuNPs) have gained increasing interest due to their special features, such as unusual optical and electronic properties, high stability and biological compatibility, controlable morphology and size dispersion, and easy surface functionalization.[1-4]

In typical synthesis, AuNPs are produced by reduction of gold salts such as $AuCl_3$ in an appropriate solvent. Usually a stabilizing agent is also added to prevent the particles from aggregating. Because thiol groups bind to gold surfaces with high affinity, most frequently thiol-modified ligands are used as stabilizing agents which bind to the surface of the AuNPs by formation of Au-sulfur bonds.[5] Synthesis of AuNPs with various sizes and shapes can be achieved through judicious choice of experimental conditions and additives.[6-8] Several mechanisms have been proposed to explain the dependence of the morphology and geometry of AuNPs on the growth conditions. However, none of these mechanisms is widely accepted.[9]

After synthesis, the stabilizing agents surrounding the AuNPs can be replaced by other molecules by ligand exchange reactions.[10] In addition, ligands can also be linked to the shell of stabilizing agents. One of the most common applications is the linkage of amino groups in biological molecules with carboxyl groups at the free ends of the stabilizing agents.[11] Functionalization of AuNPs makes it possible to adjust the surface properties and attach different kinds of molecules to the particles.

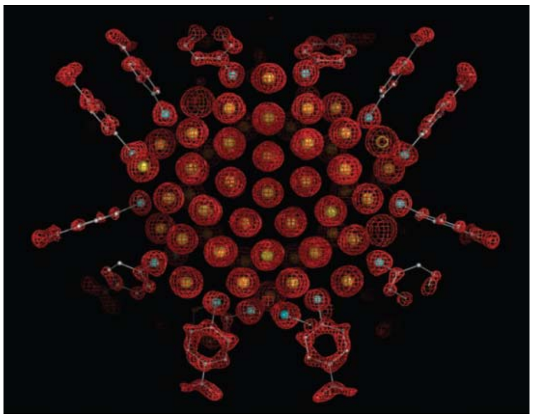

Fig 1. Electron density map (red mesh) and atomic structure (gold atoms depicted as yellow spheres, and p-MBA shown as framework and with small spheres) of $Au_{102}(p\text{-}MBA)_{44}$.

Jadzinsky *et al*. reported a crystal structure of a thiol monolayer-protected AuNP, which contains 102 gold atoms and 44 p-mercaptobenzoic acid (p-MBA) units.[12] This is the first detailed structural study of nanometer-sized AuNPs. The nanoparticles are chiral, although they crystallize in the centrosymmetric space group C2/c. The gold atoms in the core are packed in a Marks decahedron, whereas the thiol monolayer outside is stabilized by both gold-sulfur bonding and interactions between p-MBA molecules.

AuNPs have shown great potential applications in the fields of chemistry, physics, materials, biology, medicine, and related interdisciplinary fields.[13-15] Zhou *et al*. reported a method to detect copper(II) by azide- and alkyne-functionalized AuNPs based on the fact that the extinction efficient of gold nanoparticles is several orders of magnitude larger than those of traditional organic chromophores.[16] The 50 μM minimum concentration sets the record for detection of Cu^{2+} by the naked eye. Another exciting finding is that AuNPs have shown potential in therapies for HIV.[17] By attaching multiple copies of a low acting HIV drug onto AuNPs, Bowman and his coworkers have stopped HIV from infecting human white blood cells. The results demonstrate that we may find a simple strategy to convert therapeutically poorly active monovalent small organic molecules into highly active drugs by just conjugating them to AuNPs.

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