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Seminar

Materials Science & Engineering

Presents:

Dr. Agnes Ostafin

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"Fluorescent NanoGold"

Fluorescent nanoparticles have enabled great advances in medical imaging and sensing because of their robust emission, small size, and targeting ability. However not all fluorescent nanoparticles (silica, CdS, ZnSe, polymers) are equivalent when it comes to medical use, especially in living organisms. Some of these can cause short or long term toxic effects in the body that make the procedure risky, at least for some individuals. Over the last twenty years there has been interest in developing safer and durable fluorescent nanoparticles. Gold has been looked to as a potential candidate since the use of gold in the body as a therapeutic has a long and successful history. However gold intrinsically has only a weak fluorescence. In the last decade gold materials with considerable more emission have been discovered. Among these are quantum-confined structures and ligand complexes. Harnessing these materials has proven challenging and there is a great deal of confusion about the origin of fluorescence and how it is affected by particle morphology and environment, two critical factors that must be understood for these materials to be useful. Achieving purity of synthesis, size control, stability under intense illumination are materials science challenges that have contributed to the current state of affairs. Currently it is not possible to make pure monodisperse materials, the side products are too small and too similar in nature to separate, and strong interparticle interactions promote flocculation. One approach which has been of modest success is to use stabilizing matrices during the synthesis, but their nature can influence the properties of the formed gold materials, and for it to be adequately protective requires a loss of interaction with the outside world interfering with laboratory testing to understand how these materials really behave and to assess their capability for use as chemical sensors.

We have developed a synthesis that gives monodispersed near infrared emissive fluorescent gold nanoparticles, two nm in diameter coated with very short bifunctional stabilizing ligand so that we can study the emissive, optical, and physical stability properties of the particle and the effect of environment. The scientific importance of this work is that systematic manipulation of the local environment can be used to understand the origins of the emission and develop theory for designing particles with desirable characteristics. Practically, these particles would eventually be used in some kind of non-ideal environment so this work can lay the foundation for real applications. Based on our studies we found that the emission we observed is actually from a ligand complex covalently attached to gold and modified by gold electronic characteristics. Short changes in the length of stabilizer make a notable difference in energy of the ground state and the intensity of emission, indicating that the interactions of the ligand involve multiple sites and the likely effect is that a shift in Au-Au electronic density at the particle surface. Similar effects observed as a function of pH change suggest pH changes in ligand interaction can be accompanied by pH-dependent Nernstian shifts in the electronic energy levels of the underlying gold. The main conclusions we have reached so far is that it is possible to make monodispersed fluorescent gold nanoparticles using our method, but that the emissions arise from a complex mixture of gold and ligand complex interactions. Matching the ligand complex energetics to that of the underlying gold seems to be critical in obtaining the brightest emissions. This leads to the hypothesis that if you could control the gold size (and therefore the energetic level profile) it would be necessary to have different types of ligand complexes on the surface. This poses some problems since there are a limited number of atoms that bind well to gold. In its current form the particles we have studies have practical use as a targetted fluorescent imaging agent. Other uses which are worthy of exploration include their use as sentinel reporters for interactions of a matrix with a noble metal catalysts.

Wednesday September 16, 2009
4:10-5:00 p.m.
1230 WEB