NIRT Highlight (Biosystems at the Nanoscale)

Application of Semiconductor Quantum Dots to Biology

The focus of this project is the application of nanoscale materials to environmental bioassays and to cell studies. Semiconductor quantum dots, materials that exhibit so-called quantum confinement effects when they are smaller than the Bohr radius, are being investigated as novel labels for biological molecules. We have successfully synthesized two forms of quantum dots – PbSe and Fe_2O_3. The PbSe particles were created with a novel reverse micelle synthesis that gives good control over the particle size. The iron particles were created with a laser ablation method, yielding particles that are about 2 to 6 nm. The optical properties of these materials are being explored with a view to making use of long wavelength emissions to avoid the problem of auto fluorescence from biological material when it is excited with short wavelength radiation.

The most exciting recent development concerns the discovery of a new way to make use of an old material, one of the lanthanide family. Lanthanide ions are known to exhibit a strong phosphorescent emission. Europium ions emit in the red part of the visible spectrum. The emission has a long lifetime, of the order of milliseconds. This allows time resolved detection to be carried out, thereby avoiding all of the background emission from other material that has a short lifetime. However, the lanthanides like Europium have been handled as chelates, a process that introduces complications and costs to the bioassays. Chelation was necessary to avoid strong quenching of the emission.

We discovered that it is possible to use nanoscale Eu_2O_3 particles that have been treated with microwave chemistry to cap their surface with a layer of SiO and functional groups such as NH_2, that permits conjugation to biological molecules. The emission of the Eu_2O_3 particles is strong and exhibits the typical spectrum of the Eu ions. The particles were created with laser ablation. This new treatment of the oxide particles is much simpler and cheaper than the chelating chemistry that has been used for the lanthanides up to now. We have applied this new label to an immunoassay for atrazine, a widely dispersed herbicide that has recently received considerable press coverage because of its ability to adversely affect the sexual behavior of frogs. With our new nanoscale Europium labels, the assay was an order of magnitude more sensitive to the presence of atrazine in an environmental water sample. Optimization of the assay could yield even more impressive improvements. We are also working with colleagues who are interested in applying this material for use in DNA translocation studies. Microwave treated nanoparticles of the lanthanide oxides show great promise as biological labels.

Reference:
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