

NANO HIGHLIGHT

Lanthanide oxide nanoparticles in biology

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PIs: Ian Kennedy, Bruce Hammock, Valerie Leppert, Subhash Risbud, Kit Lam
University of California Davis, Davis, CA 95616

Lanthanide oxide nanoparticles attract great interest as potential fluorescent labels for biological applications. They offer long fluorescence lifetimes (about 1 ms) and a lack of photo bleaching. These properties allow the label fluorescence to be separated from the short-lived bio fluorescence and make possible the development of new detection techniques in biochemistry. The morphology of the nanoparticles is of key importance for their application: they must be comparable in size and chemically compatible with bio molecules such as enzymes, proteins, antibodies, DNA etc. Nanoparticles also must have appropriate functional groups on their surface (or to be functionalized) in order to facilitate binding with bio molecules.

We have developed a gas-phase and spray pyrolysis method for synthesis of nanoparticles based on various lanthanide oxides. The main advantage of this method is its simplicity, high efficiency and the possibility to functionalize the particles during the synthesis. In addition, it allows doped materials to be easily obtained. Nanoparticles were obtained with different chemical composition: Eu_2O_3 , $\text{Eu}_2\text{O}_3/\text{SiO}_2$, $\text{Eu}:\text{Y}_2\text{O}_3$, $\text{Tb}:\text{Y}_2\text{O}_3$. Eu – based particles have red fluorescence while Tb – based particles emit green under UV excitation. Lifetimes greater than 1 ms were measured for all the samples. We have successfully demonstrated a gas phase process to functionalize the particles as they are formed. Before collecting the synthesized particles, they pass through a chamber with saturated vapor of 3-aminopropyltrimethoxysilane (APTMS) where NH_3 groups are attached to the surface of the particles. This way, the collected particles are ready to be conjugated with the desired biomolecules.

Under properly controlled conditions, the flame-synthesized nanoparticles are spherical and in the size range of 10-200 nm. We are developing a method for separation of "single-size" fractions of nanoparticles, as an obvious step after the synthesis. Firstly, the particles with diameter above 100 nm are separated by centrifugal settling in MeOH suspension. As a fine separation step, we have developed a micro electrical field flow fractionation (μ -EFFF) device in order to obtain fractions with narrower size distribution. The particle size distributions after each stage were evaluated by means of Transmission Electron Microscopy (TEM).

Quenching of nanoparticles. Our preliminary study shows that the fluorescence of Eu-based nanoparticles can be quenched by a commercially available dye, QSY21. Our ongoing research aims to clarify the mechanism responsible for this quenching. The quenching of nanoparticles fluorescence can be directly applied for DNA analysis via a molecular beacon approach where time gated detection will improve sensitivity of the assay, possibly allowing single molecule detection.