Abstract No: PO-11

Synthesis and characterization of lanthanide-based nanoparticles for potential biomedical applications

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Lanthanide-based nanoparticles show unique luminescent properties including monochromatic light emission, longer luminescent lifetimes, stable and well-defined emission bands, large Stokes shifts, and limited photo-bleaching. Our current research efforts are focused on developing lanthanide-based nanomaterials for biomedical applications including high throughput drug screening and cellular imaging. We have developed organic solvent-based high temperature decomposition methods and aqueous-based microwave-assisted synthetic methods to make nanoparticles with high colloidal stability and monodispersity. Europium metal ion doping was successfully achieved using sodium yttrium fluoride, lanthanum fluoride, calcium fluoride, and zinc oxide crystal matrices. The nanoparticles were characterized using transmission electron microscopy, powder X-ray diffraction, Energy dispersive X-ray, absorption spectroscopy, and luminescent methods. Sodium yttrium fluoride and calcium fluoride matrices produced nanoparticles with a diameter of 20 nm and 40 nm, respectively. The zinc oxide matrix resulted nanoparticles with a diameter of 30 nm. Powder X-ray diffraction studies confirmed that yttrium fluoride, calcium fluoride, and zinc oxide matrices produced nanoparticles with cubic closed packed, cubic, and hexagonal wurtzite crystal packing, respectively. Lanthanide metal ion doping did not significantly alter the basic crystal structure of the nanoparticles. Increasing reactant metal concentrations from 0.02 to 0.065 M decreased the calcium fluoride nanoparticle size from 1000 nm to 66 nm. Luminescent quantum yield was sensitive to the crystal matrix and the europium metal doping levels. The highest luminescent quantum yield of 17 % was observed for 10 % europium-doped sodium yttrium fluoride nanoparticles. All nanoparticle systems exhibited narrow emission bands at 615 nm with a full-width at half maximum around 15 nm upon 340 nm lamp excitation. Preliminary in vitro epifluorescence imaging studies confirmed the uptake of europium-doped zinc oxide nanoparticles by human embryonic kidney (HEK) 293 cells.

Keywords: Nanoparticles, Luminescence, Lanthanides, Imaging, Nano-synthesis.

Acknowledgment
This work was supported by the Faculty Research and Creativity Award and Summer Graduate Research Grants at Western Carolina University.