Toxicity Assessment of Bifunctional Fe₃O₄@SiO₂@GdOF:Ce³⁺,Tb³⁺ Nanomaterials in Zebrafish Embryos: Superparamagnetic Behavior and Green Emission

Zahid Ullah Khan¹, Gabriela Helena Da Silva², <u>Latif Ullah Khan²</u>, Diego Stefani Teodoro Martinez², Hermi Felinto Brito³, Magnus Gidlund¹

¹Universidade de São Paulo, ²Centro Nacional de Pesquisa em Energia e Materiais, ³Instituto de Química, Universidade de São Paulo

e-mail: zahidkhan@usp.br

The toxicity evaluation of the building block magneto-luminescent nanomaterials of Fe₃O₄@SiO₂@GdOF:xCe³⁺,yTb³⁺ (x = 5; y = 5, and 10 mol%) with efficient optical and magnetic properties were reported. These bifunctional nanomaterials were prepared by coating Fe_3O_4 core nanocrystals with thin layer of SiO₂, which were further coated with GdOF:RE³⁺ luminophores via chitosan assisted high temperature co-precipitation method. Face centered cubic and orthorhombic crystaline structures of Fe_3O_4 and bifunctional nanostructures were confirmed from X-rays diffraction. Toxicity of the Fe₃O₄@SiO₂@GdOF:xCe³⁺,yTb³⁺ nanomaterial was studied, employing 96 hours early life stage assay in *Danio* rerio embryos. The parameters assessed were acute toxicity, hatching rate, growth, yolk sac size, and sarcomere length after the exposure to Fe_3O_4 @SiO_2@GdOF:xCe³⁺,yTb³⁺ nanocomposite. This result indicates that the bifunctional nanoparticles present no acute toxicity to the embryos and larvae of zebrafish until 100 mg L^{-1} concentration. However, 16% edema and statistically significant increase in DNA damage compared to control from the alkaline comet assay were observed. In addition, the static magnetic measurements supported and manifested superparamagnetic behavior of the materials at 300 K and a verwey transition (T_v) was found near 120 K on the ZFC/FC curves of the Fe₃O₄. The emission spectra of the nanocomposites showed characteristic narrow emission lines assigned to the ${}^{5}D_{4} \otimes {}^{7}F_{I}$ transitions (J = 6-0) of the Tb³⁺ ion. Furthermore, the non-radiative energy transfer process among the Ce³⁺ ®Gd³⁺ ®Tb³⁺ ions were also studied and discussed.