World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:12, No:01, 2018

Design and Development of Bioactive a-Hydroxy Carboxylate Group Modified $MnFe_2O_4$ Nanoparticle: Comparative Fluorescence Study, Magnetism and DNA Nuclease Activity

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Abstract : Three new α-hydroxy carboxylate group functionalized $MnFe_2O_4$ nanoparticles (NPs) have been developed to explore the microscopic origin of ligand modified fluorescence and magnetic properties of nearly monodispersed $MnFe_2O_4$ NPs. The surface functionalization has been carried out with three small organic ligands (tartrate, malate, and citrate) having different number of α-hydroxy carboxylate functional group along with steric effect. Detailed study unveils that α-hydroxy carboxylate moiety of the ligands plays key role to generate intrinsic fluorescence in functionalized $MnFe_2O_4$ NPs through the activation of ligand to metal charge transfer transitions, associated with ligand-Mn^{2+}/Fe^{3+} interactions along with d-d transition corresponding to d-orbital energy level splitting of Fe^{3+} ions on NP surface. Further, $MnFe_2O_4$ NPs show a maximum 140.88% increase in coercivity and 97.95% decrease in magnetization compared to its bare one upon functionalization. The ligands that induce smallest crystal field splitting of d-orbital energy level of transition metal ions are found to result in strongest ferromagnetic activation of the NPs. Finally, our developed tartrate functionalized $MnFe_2O_4$ (T-$MnFe_2O_4$) NPs have been utilized for studying DNA binding interaction and nuclease activity for stimulating their beneficial activities toward diverse biomedical applications. The spectroscopic measurements indicate that T-$MnFe_2O_4$ NPs bind calf thymus DNA by intercalative mode. The ability of T-$MnFe_2O_4$ NPs to induce DNA cleavage was studied by gel electrophoresis technique where the complex is found to promote the cleavage of pBR322 plasmid DNA from the super coiled form I to linear coiled form II and nicked coiled form III with good efficiency. This may be taken into account for designing new biomolecular detection agents and anti-cancer drug which can open up a new door toward diverse non-invasive biomedical applications.

Keywords : $MnFe_2O_4$ nanoparticle, α-hydroxy carboxylic acid, comparative fluorescence, magnetism study, DNA interaction, nuclease activity
Conference Title : ICBN 2018 : International Conference on Biomaterials and Nanomaterials
Conference Location : Zurich, Switzerland
Conference Dates : January 15-16, 2018