

Design and Development of Bioactive α -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- $\text{Mn}^{2+}/\text{Fe}^{3+}$ 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