Synthesis and Characterization of triply doped Magneto-Luminescent Iron-oxide/SiO_2 and $NaGdF_4:RE^{3+}$

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Reported nanorice of Iron-oxide/SiO_2/$NaGdF_4:RE^{3+}$ (RE = 5%Ce, 5%Tb, x%Dy; x = 1, 5 and 10) has been synthesized using a single reaction microwave synthesis procedure, incorporating Iron oxide@SiO_2 as seeds. The hexagonal phase as β-$NaGdF_4$ was confirmed by powder X-ray diffraction and high-resolution transmission electron microscopy. The nanocrystals (~ 30 nm) display ferromagnetic properties at 300 K and 2 K. ZFC/FC measurements show clear magnetic contribution of rare-earth elements. of During the down-conversion emission, energy transfer process like $Ce^{3+}\rightarrow Gd^{3+}\rightarrow Tb^{3+}\rightarrow Dy^{3+}$ occurred, in which Gd^{3+} ions play an important intermediate role along with Tb^{3+}.The excitation spectra of all the samples consist of a broad band at around 250 nm and two sharp lines at about 275 nm and 310 nm, which can be attributed to the Ce^{3+}(4f–5d) transition and Gd^{3+} ($^8S_{7/2}$) $\rightarrow{}^6I_J$ transition and Gd^{3+} ($^8S_{7/2}\rightarrow{}^6P_J$) transition, respectively. The presence and intensity of Ce^{3+} and Gd^{3+} excitation peaks in the excitation spectra indicate the existence of energy transfer from Ce^{3+} and Gd^{3+} to the luminescent ions. Excitation into the Ce^{3+} band at 260 nm yields weak and sharp emission of Gd^{3+} at 310 nm, weak emission of Ce^{3+}(300–400 nm) and strong emission color lines of RE^{3+} (400–700 nm). The emission peaks (400–700 nm) are composed of the characteristic transitions of Tb^{3+} ($^5D_4\rightarrow{}^7F_J$, J = 6–3), and Dy^{3+} ($^4F_{9/2}$–$^6H_{15/2}$, $^6H_{13/2}$), respectively. Tunable multicolor down-conversion emissions are achieved from Iron-oxide/SiO_2/$NaGdF_4:RE^{3+}$ nanocrystals under an ultraviolet excitation. The CIE chromacity shows the green-yellow region, depending on concentration of Dy. The overall characteristics show strong magnetic behavior and considerable luminescence emission of the nanoscrystals leading to potential applications in biomedical field such as drug targeting and magnetic resonance imaging (MRI).

Keywords: Magnetite, $NaGdF_4$, Photoluminescence, hysteresis, Rare-earth magnetism, Energy transfer.

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References

[1] Hao-Xin Mai, Ya-Wen Zhang, et. al, J. Am. Chem. Soc. 128 (2006), 6426-6436.
[2] Feng Wang, Renren Deng, Xiaogang Liu, Nat. Protocol, 9, (2014), 1634-1644.
[3] Lilli Schneider, Thorben Rinkel, Benjamin Voß, et. al., Nanoscale, 8 (2016), 2832-2843.
[4] Ao Xia, Yuan Gao, Jing Zhou, et. al., Biomaterials, 32 (2011), 7200-7208.