Photoluminescence and Magnetic Investigation of ternary ion activated enhanced Multicolor LaF_3 Nanophasphores

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The luminescence-tuneable multicolored LaF_3:xCe^{3+},xGd^{3+},yEu3+ (x = 5; y = 1, 5, 10 and 15 mol%) nanoparticles have been synthesized via a new low cost polyol method. Powder X-ray diffraction and high resolution transmission electron microscopy confirms the hexagonal phase of LaF_3:xCe^{3+},xGd^{3+},yEu^{3+} nanophosphors with average sizes (oval shape) from 5-7 nm. Energy-dispersive X-ray spectroscopy analyses show the uniform distribution of Ce^{3+}, Gd^{3+} and Eu^{3+} dopants in the LaF_3 host matrix. The photoluminescence spectra and electron paramagnetic resonance measurement guarantee the presence of Eu^{2+}, corroborated through DC susceptibility measurements of the samples displaying the paramagnetic behavior at 300 K, whereas a weak ferromagnetic ordering at 2 K. The non-radiative energy transfer processes from the $4f^1 \rightarrow 4f^5d^1$ state (Ce^{3+}) (ultraviolet excitation, λ_{ex} = 260 nm) to the intraconfigurational 4f excited levels of rare earth ions and simultaneous emissions in visible region from the $4f^65d^1$ (Eu^{2+}) and $^5D_0$ (Eu^{3+}) emitting level, leading to overlapped broad and narrow emission bands, have been proclaimed. The energy transfer mechanism proposes involvement of Gd^{3+} ion sub-lattice as bridge and finally trapping by $Eu^{2+/3+}$, upon excitation of Ce^{3+} ion. The calculation of experimental intensity parameters ($\Omega_{2,4}$) have been discussed and highest emission quantum efficiency (η = 85%) of Eu^{3+} ion for y = 10 mol% sample is reported. The advantageous existence of Eu^{2+}/Eu^{3+} ratio along with variously-doped nanomaterials described in this work, exhibit tunable emission color in the blue-white-red regions, highlighting their potential application in solid state lighting devices, scintillation, and multiplex detection.

Keywords: Photoluminescence; magnetic investigation; EPR; LaF_3:Ce,Gd,Eu; downconversion; Judd-ofelt.

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