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Study of the optical properties of lanthanide-based nanoparticles with energy up and down conversion properties obtained by co-precipitation.

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Nanoparticles of various compositions have been the subject of intense scientific research due to their unique properties and promising applications. Studies have focused on exploring these nanoparticles' optical, magnetic, and catalytic properties, as well as their potential in biological and renewable energy applications. In particular, crystals doped with rare earth elements have received special attention due to their energy upconversion (UC) and downconversion (DC) properties. UC is a nonlinear optical process in which at least two low-energy photons (near-infrared region) are converted into one high-energy photon (visible region). On the other hand, DC is a process in which a high-energy photon (ultraviolet region) is split into low-energy photons (visible region). In this study, nanocrystals of NaGdF₄:Eu and NaYF₄:Gd,Eu, as well as NaGdF₄:Yb,Er and NaGdF₄:Yb,Tm, were prepared using co-precipitation with ethylene glycol and lanthanide salts as precursors. NaGdF₄:Eu³⁺ and NaYF₄:Gd,Eu are examples of DC luminescence materials exhibiting intense multicolored visible emissions under a single 395 nm light excitation in the UV region. The emission spectrum recorded in the 575 to 700 nm spectral region corresponds to $7F_0 \rightarrow (5L_J + 5G_J)$ absorption transitions of Eu³⁺ ions. On the other hand, NaGdF₄:Yb,Er and NaGdF₄:Yb,Tm are examples of UC luminescence materials. In these materials, energy transfer from yttrium to erbium and thulium occurs when excited at 980 nm, corresponding to Yb³⁺ absorption (transition $2F_{7/2} \rightarrow 2F_{5/2}$). In NaGdF₄:Yb,Er, emissions are observed in the green (540 nm) and red (650 nm) regions of the electromagnetic spectrum due to the $4S_{3/2} \rightarrow 4I_{15/2}$ and $4F_{9/2} \rightarrow 4I_{15/2}$ transitions, respectively. In NaGdF₄:Yb,Tm, emissions were detected in the blue (450 and 475 nm) and infrared (800 nm) regions of the electromagnetic spectrum due to the $1D_2 \rightarrow 3F_4$, $1G_4 \rightarrow 3H_6$, and $3H_4 \rightarrow 3H_6$ transitions. These materials were characterized using X-ray diffraction (XRD), UV-Vis spectroscopy, photoluminescence, dynamic light scattering (DLS), and zeta potential.