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Upconversion luminescence of NaGdF₄ : Yb³⁺, Ho³⁺ phosphors for potential biomedical applications

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Lanthanide ions (Ln³⁺) doped upconversion (UC) materials show great potential applications in optical and optoelectronic devices owing to their novel optical properties. Yb³⁺, Ho³⁺ co-doped NaGdF₄ materials were synthesized by a simple co-precipitation method. Powder X-ray diffraction and X-ray photoelectron spectroscopy analysis demonstrated successful formation and incorporation of ions in NaGdF₄: Yb³⁺, Ho³⁺ materials. The UC luminescence properties of NaGdF₄ materials co-doped with different Yb³⁺, Ho³⁺ concentrations were investigated, and the related UC mechanisms of Yb³⁺, Ho³⁺ co-doped NaGdF₄ depending on pump power were studied in detail. The intense green UC emission bands at 540, 549 nm, red emission at 645 nm and 752 nm signals in the emission spectra could be assigned to the 5S₂, 5F₄→5I₈, 5F₅→5I₈ and 5F₄→5I₇ transitions of Ho³⁺ via 980 nm near infrared excitation along with energy transfer from the Yb³⁺, respectively. It was confirmed that the green UC emission was generated via a two-photon process from a quadratic dependence of the emission intensity on the pumping power. The chromaticity coordinate (0.276, 0.708) of the optimized NaGdF₄: 15 mol% Yb³⁺, 2 mol% Ho³⁺ upconversion material was located in the green region and hardly changed due to the negligible red emission. The present Yb³⁺, Ho³⁺ co-doped NaGdF₄ phosphor is an interesting UC material with a stable crystal structure, good cytocompatibility and bioactivity possesses great potential for biomedical applications.

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