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Lanthanide ions doped Sodium niobate perovskites for photonics and photocatalysis

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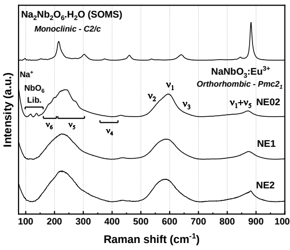
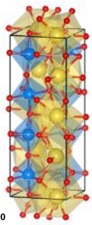
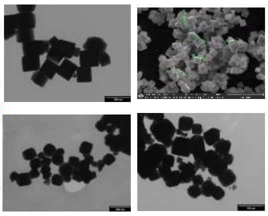
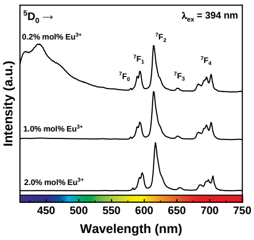
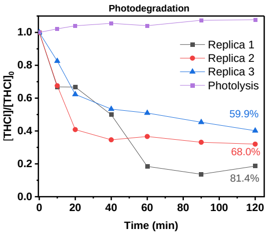
Perovskites oxides are a large group of functional materials with structure ABO_3, where the site A is occupied by large alkali or rare-earths (RE) cations, whereas site B is occupied by transition metals cations. As a result, these materials exhibit compositional and structural flexibility, especially through doping elements in the crystal lattice, modifying the psychochemical properties of the material [1]. Sodium niobate ($NaNbO_3$) emerges as a lead-free semiconductor photocatalyst with perovskite structure, featuring notable piezoelectric and ferroelectric properties, with remarkable features such as chemical stability, nontoxicity, high crystallinity and minimal environmental effect. Nevertheless, the recombination rate of photo-induced charge carriers and the wide band gap (E_g = 3.6 eV) restrict $NaNbO_3$ photocatalytic activity to UV light. Strategies, as doping, have been used to reduce the bandgap energy [2]. In this work, rare-earth doped $NaNbO_3$ nanoparticles, with mean size of 300 nm, were synthesized by the hydrothermal method, and characterized with XRD, FTIR, RAMAN, TEM and SEM techniques, demonstrating the stabilization of orthorhombic perovskite phase by the rare-earth dopant and morphology change from cube to sphere depending on the synthesis parameters. Spectroscopic characterization of $NaNbO_3$:Eu^{3+} was carried out under excitation at the charge transfer (CT) band (~319 nm) and at the electronic transition $^7F_0 \rightarrow {}^5L_6$ (394 nm), observing in the emission the $^5D_0 \rightarrow {}^7F_J$ (J = 0, 1, 2, 3 and 4) transitions and intense matrix emission (~430 nm) for some samples. Photoluminescence of Eu^{3+} indicates the substitution of Na^+ ions and occupation of more than one symmetry site. Band gap energy values, determined by diffuse reflectance and Tauc plot calculation, were lower than those reported for the undoped material (3.6 eV), such as 3.51 and 3.44 eV. Photodegradation experiments of the tetracycline hydrochloride antibiotic ($C_{22}H_{24}N_2O_8$.HCl) were conducted using both blue LED (450 nm) and UV lamp (365 nm) in a vessel containing the drug and the the $NaNbO_3$:Eu^{3+} under magnetic stirring. These experiments resulted in up to 82% degradation, highlighting the potential of rare-earth doped sodium niobate as a photocatalyst.











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