NIR and visible Luminescence from Er^{3+}/Yb^{3+} co-doped rare earth Tantalate and Niobate

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Rare-earth luminescence is widely studied because of its many technological applications, as optical amplifiers, lasers, LEDs, biomarkers, phosphors, sensors, as structural probes and in solar cells[1]. Er^{3+}/Yb^{3+} co-doped materials which have low phonon energy can exhibit intense luminescence at visible spectral region and near infrared (NIR) emission when irradiated at 980 nm (NIR). In the present work, we report the synthesis, structural and spectroscopic characterization of Er^{3+}/Yb^{3+} co-doped rare earth tantalate and niobate using a novel synthetic method. Er^{3+}/Yb^{3+} co-doped yttrium tantalate and yttium niobate were prepared by the sol gel methodology using a controlled hydrolysis and condensation reactions of metal ethoxyde (tantalum or niobium) and $Y(NO_3)_3$ precursors in a basic and ethanolic solution. The solid was isolated by centrifugation and annealed at 600°C or 900°C for 2 hours. The X-ray diffraction analysis shows amorphous structure for the isolated particles without further annealing and crystallization of nanostructured orthorhombic Y_3TaO_7, with space group C2221 after annealing at 900°C. For the yttrium niobate, nanostructured orthorhombic Y_3NbO_7 was achieved after annealing at 600 ^oC and 900^oC. Depending on the synthesis parameters a fraction of $YNbO_4$ crystallizes. Vibrational structure was monitored by infrared spectroscopy FTIR and Raman and the presence of Ta-O, Nb-O and Y-O vibrational modes and absence of OH and organic residual groups were observed. Intense peaks of Stark components of $^4I_{13/2} \rightarrow {}^4I_{15/2}$ transition of Er^{3+} ions were observed at 1535 nm when excited at 980 nm radiation and an enhanced naked-eye visible green was observed. High intensity bands were observed at 530, 545 and 670 nm after excitation at 980 nm, which are attributed to $^2H_{11/2} \rightarrow {}^4I_{15/2}$, $^4S_{3/2} \rightarrow {}^4I_{15/2}$ and $^4F_{9/2} \rightarrow {}^4I_{15/2}$ transitions of the Er^{3+} ions respectively. Upconversion dynamics were determined by the photons number, which evidenced that ESA or ETU mechanisms are probably taking place. In the case of rare earth niobate, upconversion emission could be detected from the isolated samples at room temperature, making them excellent candidate as luminescent upconverters in biological systems, where low temperature is required for the synthesis. The energy transfer from Yb^{3+} to Er^{3+} ions was confirmed by presence of intense band at 978 nm associated to $^2F_{5/2} \rightarrow {}^2F_{7/2}$ transition of Yb^{3+} ions in the excitation spectrum with emission fixed at 1550 nm.

1. Eliseeva, S. V.; Bünsli, J. C. G. New Journal Chemistry. v. 35, p. 1165 – 1176, 2011.

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