

Time dependence of solvothermal synthesis of NaYF₄:Ln³⁺ nanoparticles on their structural and luminescent properties

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Highlights

In this work, ~20nm NaYF₄ nanoparticles have been synthesized through a facile solvothermal method. The variation of the synthesis time has caused a shift in the phase of the obtained nanomaterials.

Abstract

The NaYF₄ matrix has been widely used recently for various applications involving downshifting, upconverting and XEOL luminescence, such as photodynamic therapy, correlative bioimaging, information encoding, etc [1]. In order to be used in many of its current applications, this material must be prepared in the form of nanoparticles, and the size, morphology and crystalline phase of the nanomaterials must be well controlled. In this work, we use a facile solvothermal synthesis method of the NaYF₄ matrix [2], in which the solvents are water, ethanol and oleic acid and the reactants are yttrium stearate and sodium fluoride. The reaction medium is then transferred to an autoclave and heated to a certain temperature and for a certain time. The control of both the temperature and the reaction time has a great influence on the obtained materials, as can be shown in Figure 1 (a), that shows the diffraction pattern for nanomaterials synthesized with different reaction times. It was observed that, for shorter times, the crystalline phase obtained is the α phase. If the reaction is held for longer times, the β phase starts to be observed, indicating that a phase transition occurs for longer reaction times. The TEM images recorded for the materials prepared at 150°C for 24h (Figure 1 (c)) show that their size is 23,24 nm. Therefore, the solvothermal synthesis method is suitable for the preparation of small and uniform nanocrystals of NaYF₄. Also, NaYF₄:10%Eu³⁺ nanomaterial has been prepared in a synthesis at 150°C for 24h, to take advantage of the hypersensitive transitions of Eu³⁺. The emission spectrum of this material indicates that the Eu³⁺ occupies a site with high symmetry, which can be determined by the comparable intensities of the ⁵D₀ → ⁷F₁ and the ⁵D₀ → ⁷F₂ transitions. This results agrees with the previous result that it is formed a mixture of the α (cubic) and β (hexagonal) phases in those synthetic conditions.

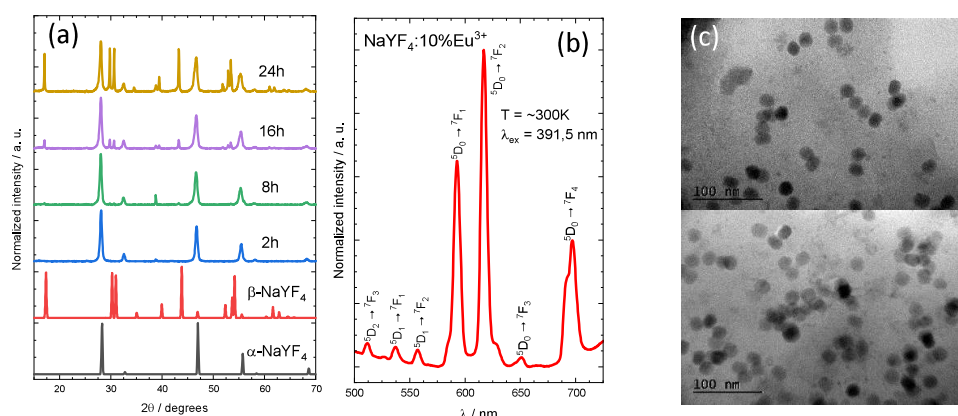


Figure 1 – (a) Diffraction patterns of samples prepared with different synthesis times. The patterns of the pure α (ICSD – 60257) and β (ICSD - 51917) phases are shown. (b) Emission spectrum of the NaYF₄:10%Eu³⁺ nanoparticles synthesized by the solvothermal method for 24h at 150°C. (c) TEM microscopies of the undoped NaYF₄ nanomaterials prepared by the solvothermal method at 150°C for 24h.

Acknowledgments

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