Synthesis and characterization of europium-doped La_2O_3 nanoparticles

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Rare-earth sesquioxides (Y_2O_3, La_2O_3, Lu_2O_3, etc.) have been extensively studied as host matrices for lanthanide (Ln) ions in the field of luminescence. Furthermore, Ln doped sesquioxides in the form of thin films have been investigated for their potential applications in luminescent displays [1]. Lanthanum oxide is a semiconductor material with the largest band gap among rare earth sesquioxides with a value of 4.3eV. This compound has numerous applications in various fields of industry: as a component of catalyst supports, particularly in methanol production, and as a component of ceramics. Its synthesis in a form of fine dispersion represents now an exciting area of research [2].

When doping La_2O_3 with luminescent active Ln ions, such as Eu^{3+}, will allow combining the semiconductor properties of La_2O_3 with the red emission of Eu^{3+}. Such red phosphors have been previously investigated under the form of bulk and nanoparticle materials [3,4]. Due to quantum confinement effect and surface effect, nanosized materials with particle sizes of 100 nm or less may show electrical, optical and luminescent properties more efficient than the corresponding bulk materials. Up to now, nanoparticles of Eu-doped La_2O_3 have been synthesized by means of solution combustion synthesis [3], and nitrate decomposition procedures [4]. Such nanoparticles showed emissions centered in the red region of the electromagnetic spectrum, at around 626 nm.

Among organic-inorganic hybrid materials, polymer nanocomposites attract strong interest because of the combination of both the properties of the nanoparticles (optical, electronic or mechanical) and those of the polymer (solubility, film formation, and chemical activity) [5].

In the present work we developed the synthesis of Eu doped La_2O_3 nanoparticles by several synthesis methods such as: the modified Pechini method, which is an alternative to the conventional sol-gel method, the precipitation method and a hydrothermal process.

The nanoparticles obtained have been characterized by differential thermal analysis-thermogravimetric analysis (DTA-TG) in the temperature range from 300 K to 1100 K, infrared spectroscopy (FTIR), and by X-ray diffraction (XRD) to determine their crystalline structure and average grain sizes. Their morphology, homogeneity, distribution and particle size have been investigated by electronic microscopy such as scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The sizes of these nanoparticles range between 10 and 300 nm, depending on the synthesis method. Figure 1 shows some of the smaller particles obtained by the hydrothermal method, and the nanoparticles obtained by the modified Pechini method after calcination at 1073K. Finally, the photoluminescence (PL) and cathodoluminescence (CL) properties of the Eu doped La_2O_3 nanoparticles obtained have been analyzed. Photoluminescence is shown in Figure 2, after excitation of the nanocrystalline La_2O_3 doped with 5% Eu^{3+} at 250 nm. In this figure, the strongest emission peak is centered at 626 nm corresponding to the $^5D_0 \rightarrow {}^7F_2$ transition of Eu^{3+}, indicating that Eu^{3+} ions have been successfully incorporated in the structure of La_2O_3.

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Figures:

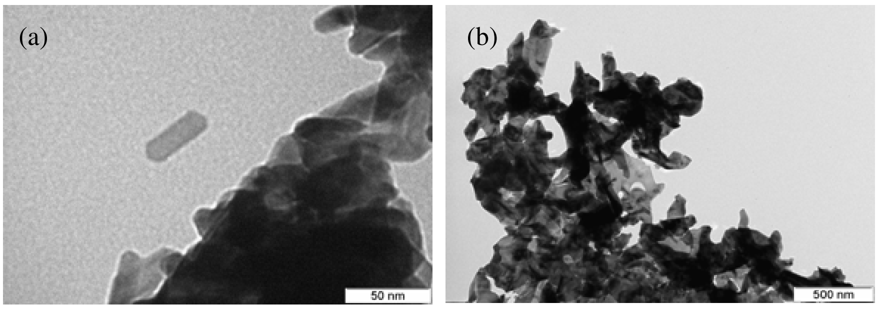

Figure 1. TEM image of nanoparticles obtained by (a) hydrothermal process and calcination at 873K; and (b) modified Pechini method and calcination at 1073 K.

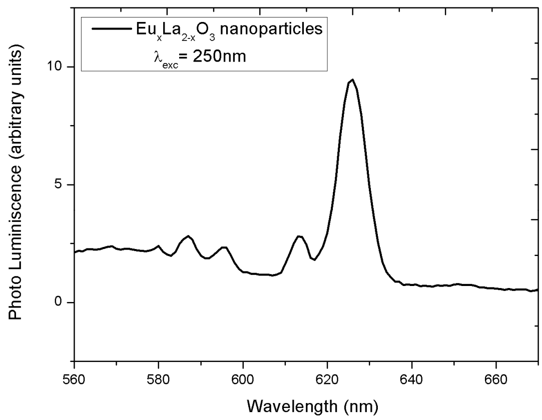

Figure 2. Emission spectra of nanocrystalline La_2O_3 doped with 5% Eu^{3+} ions under 250 nm excitation.