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Preparation and characterization of new photoluminescent nano-powder based on Eu^{3+}:$La_2Ti_2O_7$ and dispersed into silica matrix for latent fingerprint detection

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ABSTRACT

Pure lanthanum titanate doped with europium metal ions ($La_2Ti_2O_7$:Eu^{3+}) and dispersed in silica matrix phosphor powder was prepared by sol–gel process followed by thermal treatment. The prepared nanophosphors were characterized by powder X-ray Diffraction (XRD), Fourier Transform Infrared (FT-IR), Transmission Electron Microscope (TEM), Energy Dispersive Spectroscopy (EDX), and Photo-luminescence Spectroscopy (PL). The effects of silica, thermal treatment, Eu^{3+} ion, and surfactant (CTAB) concentrations on the crystal, morphology, and photoluminescence properties were investigated. The present work found that dispersion of $La_2Ti_2O_7$:Eu^{3+} into silica matrix significantly altered the morphology of $La_2Ti_2O_7$:Eu^{3+} from high crystalline micro-plate like shape into amorphous aggregated Nano-spherical shape. The high separated spherical shape with intense red PL emission and long lifetime was obtained from 10 mol% Eu^{3+}:$La_2Ti_2O_7$:Eu^{3+}, dispersed into silica matrix, and prepared in the presence of CTAB. The high PL Nano-phosphor has been successfully used in developing latent fingerprint from various forensic relevant materials.

1. Introduction

Lanthanide doped with inorganic co-doped into silica matrix has shown a great potential in various fields; such as light emitting devices, sensors, lasers, latent fingerprint detection, color display … etc. [1–3]. Among different lanthanide ions, europium (Eu^{3+}) ions have been recognized as the most efficient down-converting materials that convert ultraviolet light to visible emissions [4–9].

Amorphous oxide materials doped with inorganic lanthanide luminescent material are candidates for optical photonic applications including solid-state lasers, optical waveguides, fiber amplifiers, and phosphors [10]. The outstanding mechanical, thermal, and optical properties of silica amorphous materials hold them attractive matrices for luminescent Ln^{3+} ions [10]. Silica offers large loading capacity for various doping chemicals due to its high surface to volume ratio [1]. Doping SiO_2 with a very low percentage of lanthanide luminescent material in its Nano-size cavities, exhibits strong, intense, and stable fluorescence properties [11].

Latent fingerprint is an important tool for identifying people, yet 'Powdering' remains the primary physical fingerprint detection method [12]. The fingerprint powder is classified into three types; the regular, the metallic, and the luminescent. Regular fingerprint powder consists of a resinous polymer for adhesion and a colorant for contrast; for example, ferric oxide and rosin. Metallic powders containing meshed metals as lead, gold, and silver have been used [13]. On some difficult surfaces, traditional finger print powders are unable to develop latent detection and are mainly based on hazard metallic compounds that threaten the user's health [13]. The best solution to overcome such limitations is using a powder based on luminescent Nano-materials. Over the recent years, luminescent-lanthanide based Nano-powder was explored; a promising solution to obstacles facing fingerprint detection. Using lanthanide-based Nano-materials as labeling agents in fingerprint detection, therefore, has obviously aroused the scientific community's

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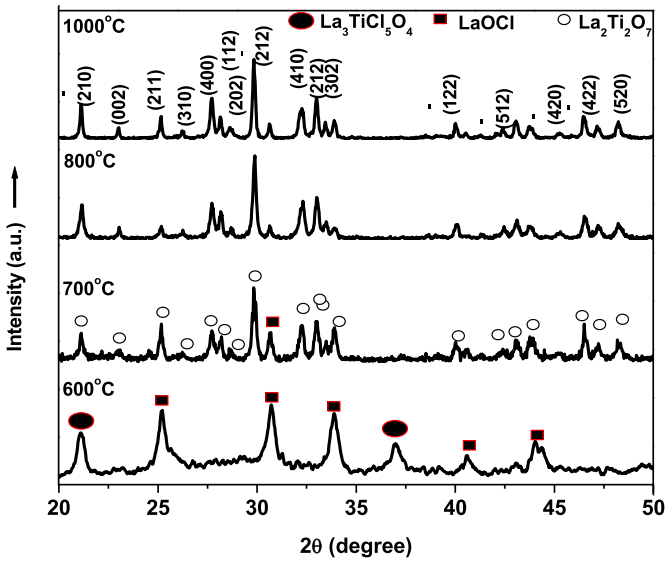

Fig. 1. XRD patterns of 10 mol% Eu^{3+}: $La_2Ti_2O_7$ annealed at different temperatures for 2 h.

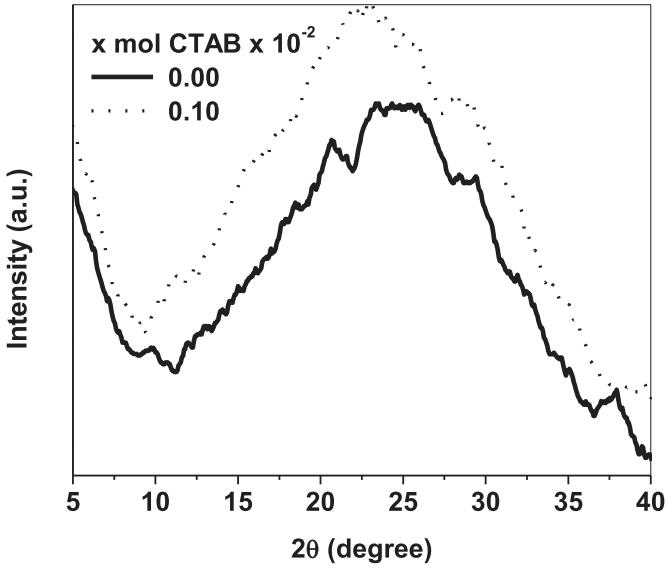

Fig. 2. XRD patterns of 10 mol% Eu^{3+}: $La_2Ti_2O_7$ dispersed into silica matrix in the absence and presence of CTAB. All samples annealed at 800 °C for 2 h.

interest. Most of the published research had focused on using lanthanide complexes containing organic sensitizing ligands such as 1, 10-phenanthroline for fingerprint detection [11,14]. Luminescence of lanthanide complexes based on organic ligand as a sensitizer is greatly affected by the surrounding species in the environment. This drawback can be eliminated by doping SiO_2 with pure inorganic-based lanthanide such as fluorite or pyrochlore matrices [2,15]. The use of pure inorganic lanthanide material doped with silica matrix for latent fingerprint detection is limited. First research results concerning the application of $Y_2Zr_2O_7/SiO_2$ and $Y_2Ti_2O_7/SiO_2$ doped with lanthanide ions in latent fingerprint detection were published by our research group [1,2].

Continuing our previous work [1,2], herein, we report the preparation conditions of new Eu^{3+}:$La_2Ti_2O_7/SiO_2$ Nano-phosphor powder for latent fingerprint application.

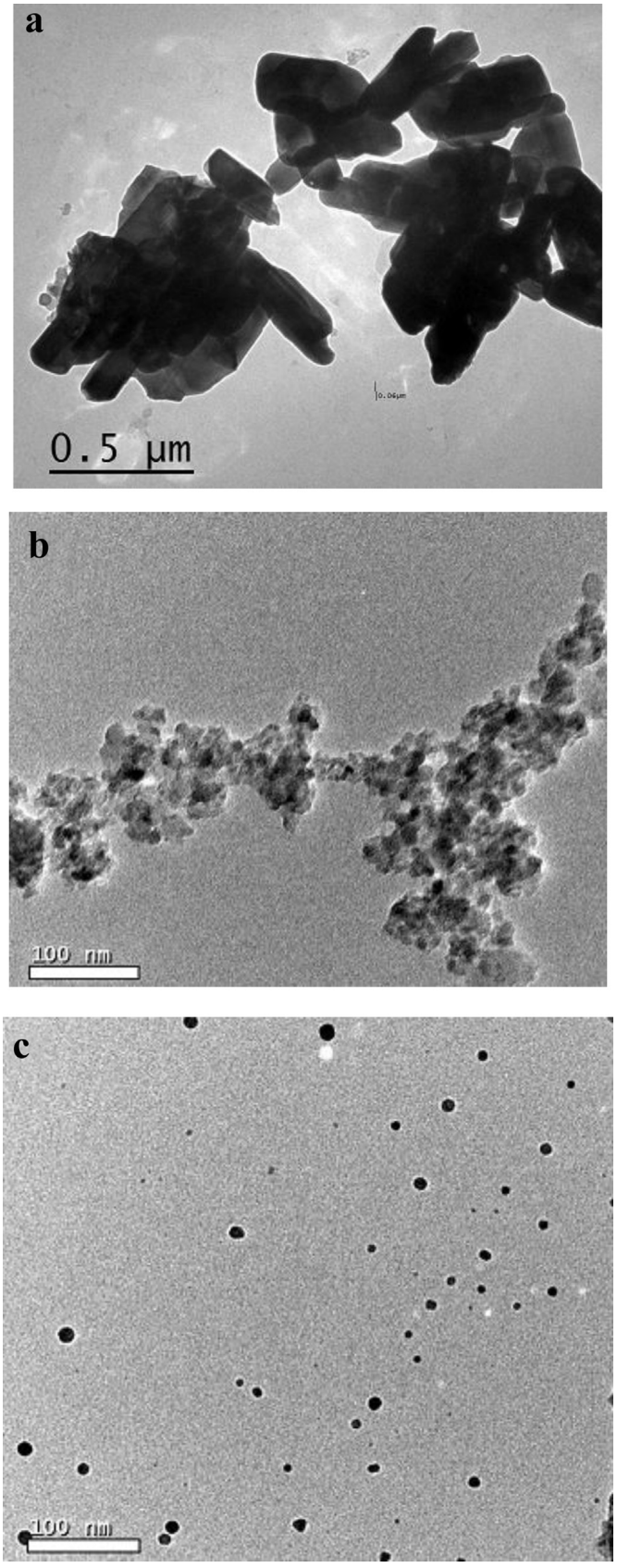

Fig. 3. TEM images of pure 10 mol% Eu^{3+}:$La_2Ti_2O_7$ (a) and 10 mol% Eu^{3+}:$La_2Ti_2O_7$ dispersed into silica matrix prepared in the absence (b) and presence of CTAB (c).