

## Synthesis and Fluorescence properties of LnPO<sub>4</sub>: RE<sup>3+</sup> (Ln = Y, La & Gd; RE = Eu, Tb & Ce) powder phosphors for Display Applications

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### Abstract

Inorganic luminescent materials have found many practical applications in modern lighting and display fields, such as fluorescent lamps, cathode ray tubes, field emission displays and plasma display panels. The present paper reports the synthesis, dopant ion concentration of Eu, Tb and Ce, single, dual host compositional effects on fluorescence properties of LnPO<sub>4</sub>: RE<sup>3+</sup> (Ln = Y, La, Gd; RE = Eu, Tb, Ce). Here, we have adopted a precipitation technique, which involves a direct and clean reaction between lanthanide oxides and phosphoric acid without any by-products other than water. Soon after the completion of the synthesis, the emission of these phosphors under UV light observed reddish-orange (LnPO<sub>4</sub>:Eu<sup>3+</sup>) and green (LnPO<sub>4</sub>: Tb<sup>3+</sup>). The phase purity of the synthesized powder phosphors were checked qualitatively by XRD and quantitatively by SEM-EDAX. From the fluorescent spectra of Eu<sup>3+</sup>-doped single and dual host lanthanide phosphates it is clear that the magnetic dipole transition <sup>5</sup>D<sub>0</sub> → <sup>7</sup>F<sub>1</sub> is dominating the electric dipole transition <sup>5</sup>D<sub>0</sub> → <sup>7</sup>F<sub>2</sub>. The intensity of emission transitions were found to be increased with Eu- concentration up to 5 mol. %. Moreover, the emission peaks got shifted over a few nanometers depending upon the host composition. From the fluorescence spectra of LnPO<sub>4</sub>: Tb<sup>3+</sup>, the hypersensitive transition <sup>5</sup>D<sub>4</sub> → <sup>7</sup>F<sub>5</sub> is responsible for green color emission. Spectral features denote the intensity of the emission peaks increase with an increase in terbium concentration up to 0.05 mol., beyond which the fluorescence quenching has been observed. Similarly, in the case of Ce<sup>3+</sup>: phosphors, two bands corresponding to the following electronic transitions are identified as: <sup>2</sup>D (5d) → <sup>2</sup>F<sub>5/2</sub> (4f) (342 -341 nm) and <sup>2</sup>D (5d) → <sup>2</sup>F<sub>7/2</sub> (4f) (460 - 458 nm).

The emission transition <sup>2</sup>D (5d) → <sup>2</sup>F<sub>5/2</sub>, appears more intense and broader in all Ce<sup>3+</sup>: phosphors, the emission intensity increases with Ce-content up to 5 mol. %, beyond which it tends to quench. Colour coordinates (X, Y) of all Eu<sup>3+</sup>, Tb<sup>3+</sup>-phosphors are computed and well fitted in the CIE - chromaticity diagram of reddish-orange, green regions, respectively. Since the Ce<sup>3+</sup>-phosphors are emitting in the UV region we could not able to compute the color coordinates. From the FT-IR absorption spectra of Gd<sub>0.95</sub>PO<sub>4</sub>: Eu<sup>3+</sup><sub>0.05</sub>, La<sub>0.95</sub>PO<sub>4</sub>: Tb<sup>3+</sup><sub>0.05</sub> and La<sub>0.95</sub>PO<sub>4</sub>: Ce<sup>3+</sup><sub>0.05</sub>, two bunches of absorption bands have been observed in the wave- number region 1200-900 and 700-400 cm<sup>-1</sup>, which are attributed to M-OPO<sub>3</sub> (M = Gd, La, Y, Eu, Tb and Ce) bonds. Thermogravimetry of Gd<sub>0.95</sub>PO<sub>4</sub>: Eu<sup>3+</sup><sub>0.05</sub>, La<sub>0.95</sub>PO<sub>4</sub>: Tb<sup>3+</sup><sub>0.05</sub> and La<sub>0.95</sub>PO<sub>4</sub>: Ce<sup>3+</sup><sub>0.05</sub> indicates the total thermal stability with respect to chemical as well as crystalline phase transformation changes in a covered temperature range. From the measured SEM images of Gd<sub>0.95</sub>PO<sub>4</sub>: Eu<sup>3+</sup><sub>0.05</sub>, La<sub>0.95</sub>PO<sub>4</sub>: Tb<sup>3+</sup><sub>0.05</sub> and La<sub>0.95</sub>PO<sub>4</sub>: Ce<sup>3+</sup><sub>0.05</sub>, it is noted that the particles are agglomerated and are having a spherical shape with a grain size in the range of 150 – 200 nm. Life time (τ) measurements of the phosphors YPO<sub>4</sub>:Eu<sup>3+</sup> and (Gd<sub>0.25</sub>, Y<sub>0.75</sub>)PO<sub>4</sub>: Eu<sup>3+</sup> have been done for the emission transitions of <sup>5</sup>D<sub>0</sub> → <sup>7</sup>F<sub>1, 2</sub> and found to be in the milli second (ms) range.

Thus, a systematic study could therefore result in the formulation of Gd<sub>0.95</sub>PO<sub>4</sub>: Eu<sup>3+</sup><sub>0.05</sub>, La<sub>0.95</sub>PO<sub>4</sub>:Tb<sup>3+</sup><sub>0.05</sub>, La<sub>0.95</sub>PO<sub>4</sub>:Ce<sup>3+</sup><sub>0.05</sub>, YPO<sub>4</sub>:Eu<sup>3+</sup><sub>0.05</sub> and (Gd<sub>0.25</sub>, Y<sub>0.75</sub>)PO<sub>4</sub>: Eu<sup>3+</sup><sub>0.05</sub> phosphors as the promising coating materials in order to observe bright reddish-orange and green from certain display systems.