

## Preparation and Photoluminescence Properties of $\text{Eu}^{2+}$ Doped Lithium Alumino-Borate Phosphor, $\text{LiAlB}_2\text{O}_5 : \text{Eu}^{2+}$

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### ABSTRACT

Blue luminescence with near UV excitation has observed in  $\text{LiAlB}_2\text{O}_5:\text{Eu}^{2+}$  (LABO) phosphors.  $\text{Eu}^{2+}$  doped LABO has synthesized by the solution combustion method of corresponding metal nitrates (oxidizer) and urea (fuel) at furnace temperature as low as  $550^\circ\text{C}$ . The phase purity and morphology of LABO samples has characterized by powder X-ray diffraction (XRD) and scanning electron microscopy (SEM), respectively. Photoluminescence properties of the phosphor has investigated by measuring the excitation and emission spectra using spectrofluorometer at room temperature. The excitation spectrum of the blue fluorescence ( $\lambda_{\text{em}}=469\text{ nm}$ ) shows two bands with their peaks at about 207 and 288 nm, respectively, which are due to the crystal field splitting of the  $\text{Eu}^{2+}$  d orbital. Under the excitation of 207 and 288 nm, the emission spectrum shows a strong band with a peak at about 469 nm, which corresponds to 4f–5d transition of  $\text{Eu}^{2+}$  ions, and there is a shoulder emission which are very weak in the lower energy side peaking at 594 nm and 616 nm. The Commission International de l'Eclairage (CIE) coordinates (0.126, 0.053) evidence that the phosphors emit in the blue light region.

**Keywords:** Borate, Blue Phosphor, Combustion synthesis, Photoluminescence.

### I. INTRODUCTION

The Alumino-Borates have attracted much research interest in the past few years because of their potential applications as NLO materials [ - ]. Divalent europium is an important activator for luminescent materials, which have been extensively studied for years [ - ]. The luminescence of  $\text{Eu}^{2+}$  activated phosphors usually results from the ground 4f<sup>7</sup> levels to the excited 4f<sup>6</sup>5d configuration. Since the 4f–5d transition is electric-dipole allowed, the absorption and emission of  $\text{Eu}^{2+}$  are very efficient in many hosts. Furthermore, because of the large spatial extension of the 5d wave function, the optical spectra are usually broadened and depend on the surroundings of the  $\text{Eu}^{2+}$  ions. Thus, the

choice of host is a critical parameter for determining the optical properties of the  $\text{Eu}^{2+}$  ions [ - ]. Very recently, we have independently synthesized a series of alkaline earth halosilicate phosphors with excellent photoluminescence properties [ - ]. As the multiplex compound, alkali earth halosilicate crystal has lower synthesis temperature, higher physical and chemical stability, which makes it a suitable host lattice for luminescence materials.

In present work we discussed the solution combustion synthesis technique for fabrication of  $\text{Eu}^{2+}$  doped  $\text{LiAlB}_2\text{O}_5$  phosphor and studied their photoluminescence properties at room temperature.

## II. METHODS AND MATERIAL

Inorganic borate phosphors were prepared by a novel method described earlier [ - ], which is a variation of the combustion synthesis. The stoichiometric amounts of high purity starting materials, Li (NO<sub>3</sub>)<sub>2</sub> (A.R.), Eu<sub>2</sub>O<sub>3</sub> (high purity 99.9%), H<sub>3</sub>BO<sub>3</sub> (A.R.), CO(NH<sub>2</sub>)<sub>2</sub> (A.R.), Al(NO<sub>3</sub>)<sub>3</sub>·9H<sub>2</sub>O (A.R.) have been used for phosphor preparation. The starting materials with little amount of DD water were mixed thoroughly in agate mortar to obtain homogeneous solution. The excess water was removed by heating the samples at temperature 70 °C for about 10 min and the solution then transferred directly to the pre-heated furnace, maintained at temperature 550 °C, for combustion. Following the combustion, the resulting foamy samples were crushed to obtain fine particles and then annealed for 4 hr at temperature 850 °C under slightly reducing atmosphere. The prepared materials were characterized by powder XRD. Powder X-ray diffraction measurements were taken on Rigaku Miniflex II X-ray Diffractometer and compared with the ICDD files. Surface morphology of the calcined powder sample was observed by scanning electron microscopy (SEM). PL & PLE measurements at room temperature were performed on Hitachi F-7000 spectrofluorometer with spectral resolution of 2.5 nm.

## III. RESULTS AND DISCUSSION

### 3.1 X-ray Diffraction Pattern

The XRD pattern of the host lattice of LiAlB<sub>2</sub>O<sub>5</sub> is as shown in Fig. 1 and it was found to be in good agreement with the standard ICDD file No. 01-070-5423.

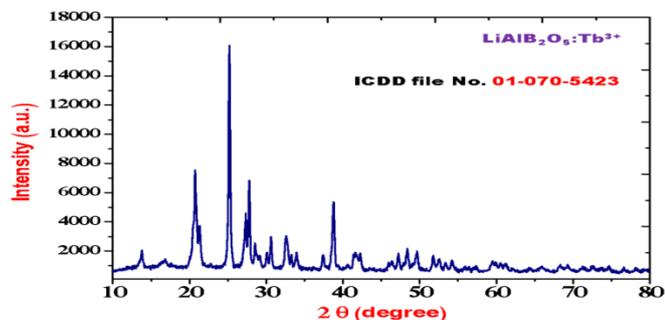


Fig. 1 XRD pattern of LiAlB<sub>2</sub>O<sub>5</sub> phosphor.

### 3.2 SEM images of phosphor powders

The FE-SEM photograph of LiAl<sub>0.97</sub>B<sub>2</sub>O<sub>5</sub>:0.03Eu<sup>2+</sup> powder prepared by solution combustion method is as shown in Fig. 2. The shape of the particles was observed to be foamy random nature with high agglomerate phenomenon.



Fig. 3 FE-SEM micrograph of LiAl<sub>0.97</sub>B<sub>2</sub>O<sub>5</sub>:0.03Eu<sup>2+</sup> phosphor.

### 3.3 Photo Luminescence of LiAlB<sub>2</sub>O<sub>5</sub>:Eu<sup>3+</sup>

Fig. 4 shows the excitation and emission spectra of the Li(1-x)AlB<sub>2</sub>O<sub>5</sub>:xEu<sup>2+</sup> (x=0.03) phosphor. The excitation spectrum of the blue fluorescence (λ<sub>em</sub>=469 nm) shows two bands with their peaks at about 207 and 288 nm, respectively, which are due to the crystal field splitting of the Eu<sup>2+</sup> d orbital. Under the excitation of 207 and 288 nm, the emission spectrum shows a strong band with a peak at about 469 nm, which corresponds to 4f-5d transition of Eu<sup>2+</sup> ions, and there is a shoulder emission which are very weak in the lower energy side peaking at 594 nm and 616 nm. These may be due to the 5d energy level of Eu<sup>2+</sup> and the lower level of 4f state overlap, so the electron of 4f state can be excited to 5d state. The broad luminescence of Eu<sup>2+</sup> is due to 4f<sup>6</sup>5d<sup>1</sup>→4f<sup>7</sup> transitions. However, the 5d state is easily affected by the crystal field; that is to say, different crystal field can split the 5d state in different way. This makes Eu<sup>2+</sup> emit different wavelength light in different crystal fields and the emission spectrum can vary from the ultraviolet to the red region [ ]. The two possible sites for Eu<sup>2+</sup> incorporating into LiAlB<sub>2</sub>O<sub>5</sub> lattice are the Al<sup>3+</sup> sites or Li<sup>+</sup> sites. The Li<sup>+</sup> (0.76 Å) ion has a much larger ionic radius, compared with that of Al<sup>3+</sup>

#### IV. CONCLUSION

(0.54 Å) ion. However, the ionic radius of  $\text{Li}^+$  (0.76 Å) is slightly smaller than that of  $\text{Eu}^{2+}$  (1.12 Å). So it would be expected that  $\text{Eu}^{2+}$  would replace  $\text{Al}^{3+}$  in the crystal lattice, and could hardly incorporate into the groups  $[(\text{Al}_2\text{O}_7)^{8-}]$ . The CIE chromaticity coordinates for  $\text{LiAl}_{0.97}\text{B}_2\text{O}_5:0.03\text{Eu}^{2+}$  were calculated from the PL spectra under 288 nm excitation and marked with a star in the CIE 1931 chromaticity diagram in Fig. 5. The chromaticity coordinates (x,y) of this phosphor are calculated to be (0.126,0.053), respectively, which indicates that the emission color of the as prepared phosphors is located in the bright blue region with some greenish touch.

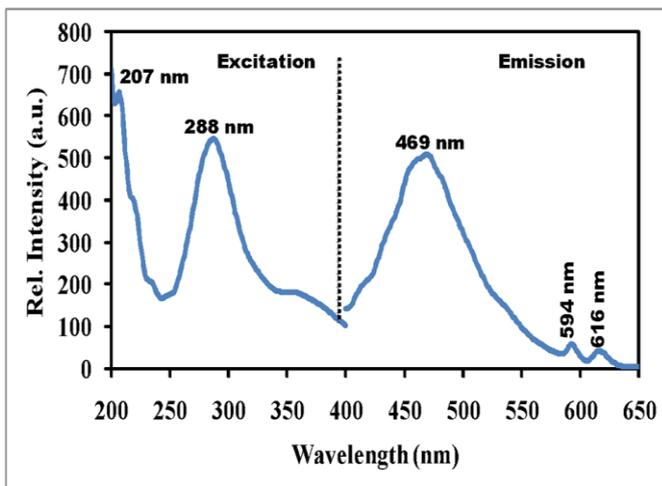


Fig. 4 Representative PL excitation and emission spectra of  $\text{LiAl}_{0.97}\text{B}_2\text{O}_5:0.03\text{Eu}^{2+}$  phosphor.

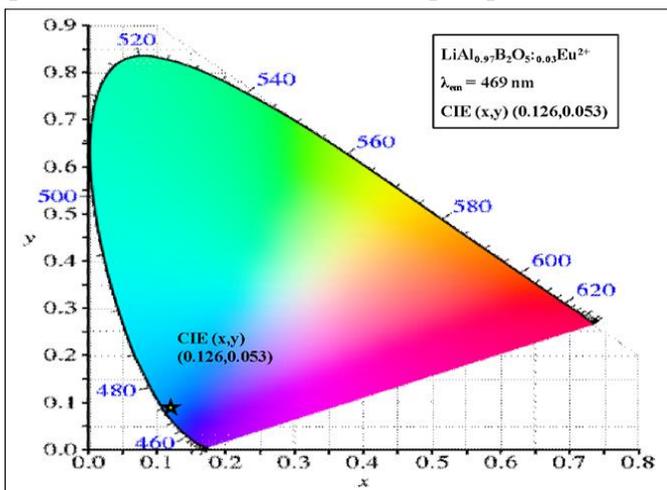


Fig. 5 Chromaticity coordinates of  $\text{LiAl}_{0.97}\text{B}_2\text{O}_5:0.03\text{Eu}^{2+}$  phosphor in the CIE 1931 chromaticity diagram.

The phosphor  $\text{LiAl}_{0.97}\text{B}_2\text{O}_5:0.03\text{Eu}^{2+}$  was synthesized by a simple, time saving and cost effective solution combustion technique. Under the excitation of 207 and 288 nm, the emission spectrum shows a strong band with a peak at about 469 nm, which corresponds to 4f-5d transition of  $\text{Eu}^{2+}$  ions, and there is a shoulder emission which are very weak in the lower energy side peaking at 594 nm and 616 nm. The phosphor possesses excellent blue emitting property that could be attractive to a wide range of potential applications.

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