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Synthesis and Photoluminescence Properties of Eu^{3+} activated $NaLi_2PO_4$ Phosphor for SSL Application

C. B. Palan[1]*, G.V. Chavan[2], S. K. Omanwar[3]
[1]Department of Physics, B. S. Patel Arts, Commerce and Science College, Pimpalgaon Kale, Tal. Jalgaon (Jamod) Dist Buldhana
[2]Department of ASH, MGI-COET, Shegaon, Buldana
[3]Department of Physics, Sant Gadge Baba, Amravati University, Amravati
*(Corresponding author email:*chetanpalan27@gmail.com)*

Abstract

The polycrystalline $NaLi_2PO_4$:Eu phosphor was successfully synthesized via solid state diffusion method. The structural of prepared phosphor was confirmed by using XRD (X-ray diffraction) technique. Additionally, the photoluminescence (PL) behaviors of $NaLi_2PO_4$:Eu phosphor was studied. The XRD pattern of prepared phosphor is well matched with JCPDS file with card no. (JCPDS # 80-2110). The PL excitation of prepared phosphor was monitored at 618 nm while emission was monitored at 393 nm. The CIE co-ordinates were calculated and obtained in orange- red region.

Keywords: *$NaLi_2PO_4$:Eu; Photoluminescence; JCPDS and CIE co-ordinates*

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1. INTRODUCTION

Since 1962, orthophosphates with the general formula $ABPO_4$ (where A and B are monovalent cation and divalent cation) compose a large family of mono-phosphates with different structure types depending on the relative size of the A and B ions [1]. The compounds $ABPO_4$ show excellent thermal and hydrolytic stability and are considered to be efficient luminescent hosts [2,3]. The Eu^{2+}activated $ABPO_4$ phosphors have been reported as blue-emitting phosphors excited by near UV- LEDs [4].

Phosphate compounds are usually referred as orthophosphates, have extensive utilization these days precisely in the field of lighting [5,6]. Being low-phonon energy materials [7,8] they could be important host materials for producing efficient luminescence. They possess excellent optical and ferroelectric properties along with many intriguing features such as good thermal, chemical and mechanical stability that make them unique for almost any display.

The $NaLi_2PO_4$ phosphor is belonging in $ABPO_4$ family. Shinde*et al.* reported luminescence properties of $NaLi_2PO_4$:Eu phosphor in 2011 and this phosphor was developed by using solid state reaction and time require was more than 24h [9]. Sahare *et al.* also reported photoluminescence properties of Eu doped $NaLi_2PO_4$ phosphor and compared its color purity with commercial red emitting Y_2O_3:Eu phosphor [10]. Sahare *et al.* reported TL and OSL properties of $NaLi_2PO_4$:Ce phosphor [11,12]. In 2016 Singh *et al.* reported radiation induced abnormal reduction of Eu^{3+} in $NaLi_2PO_4$ phosphor [13].

In the present paper, we have reported the preparation and characterization of $NaLi_2PO_4$:Eu^{3+} phosphor synthesized via solid state diffusion method. The structural phase purity of prepared sample was obtained low temperature as compared to reported ones. Also color purity of phosphors was checked by Commission Inter-national de l′Eclairage (CIE) co-ordinates witnessing the pre-pared phosphor as prime candidate for SSL and LED based applications.

2. SYNTHESIS METHOD

The Eu^{3+} activated $NaLi_2PO_4$ phosphor was successfully synthesized by using Solid State Diffusion method [14-19].

The phase purity of prepared phopshors were checked by means of X-ray powder diffraction (PXRD) using a Rigaku miniflex II diffractometer with Cu Kα (λ = 1.5405 Å) operated at 5 kV. The PL and PL excitation (PLE) spectra were measured on (Hitachi F-7000) fluorescence spectrophotometer with a 450W Xenon lamp.

3. RESULTS AND DISCUSSION

3.1. X-ray diffraction (XRD) pattern

The XRD pattern of prepared $NaLi_2PO_4$:Eu phosphor is shown in **Fig. 1.**

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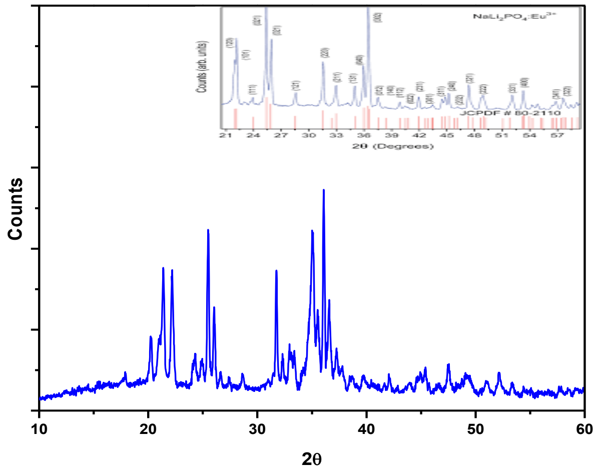

Fig.1. X-ray diffraction pattern of $NaLi_2PO_4$: Eu phosphor matched with JCPDF file

The peak positions in the diffraction pattern of the synthesized material is compared them with the standard data available in the literature (JCPDS # 80-2110) [20]. No separate peaks corresponding to any impurity phase are observed at concentration (0.005mole) showing that the impurity has a good solubility in the matrix.

3.2 Photoluminescence properties

The combined excitation and emission spectra of $NaLi_2PO_4$:Eu phosphor is shown in **Fig. 2.** The excitation was monitored at 618 nm and emission was monitored at 393 nm. The excitation spectra consists of series of sharp lines at 310, 363, 377 and 394 nm correspond to the $^7F_0 \rightarrow {}^5H_3$, $^7F_0 \rightarrow {}^5D_4$, $^7F_0 \rightarrow {}^5L_7$ and $^7F_0 \rightarrow {}^5L_6$ transitions respectively. Out of all these peaks, the excitation at 394 nm is the strongest, as shown in **Fig. 2.** On the other hand emission spectra consist of two sharp peaks 595nm and 618nm with one weak peak at 653nm. The emission at 595 nm corresponds to the $^5F_0 \rightarrow {}^7D_1$ (magnetic dipole), the emission at 618 nm corresponds to the $^5F_0 \rightarrow {}^7D_2$ (electric dipole) and weak emission at 653nm corresponds to the $^5F_0 \rightarrow {}^7D_3$ transition of Eu^{3+} ions [21].

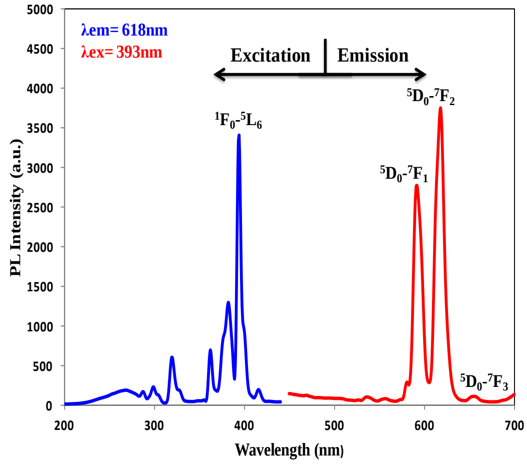

Fig.2. Combine excitation and emission spectra of $NaLi_{1.995}PO_4$:$_{0.005}$Eu phosphor

3.3 CIE Chromaticity Diagram

The CIE chromaticity coordinates were plotted using Radiant Imaging software. The calculated CIE parameters were plotted on a CIE 1931 x–y chromaticity diagram [22-24]. Figure 3 represents the CIE 1931 x–y chromaticity diagram of the $NaLi_2PO_4$:Eu^{3+} phosphor. The CIE chromaticity coordinates were found to be at (0.6747, 0.3250) at dominant wavelength point of 618 nm and this point corresponds to red color emission. The as prepared phosphors were found to be suitable candidates for red LEDs

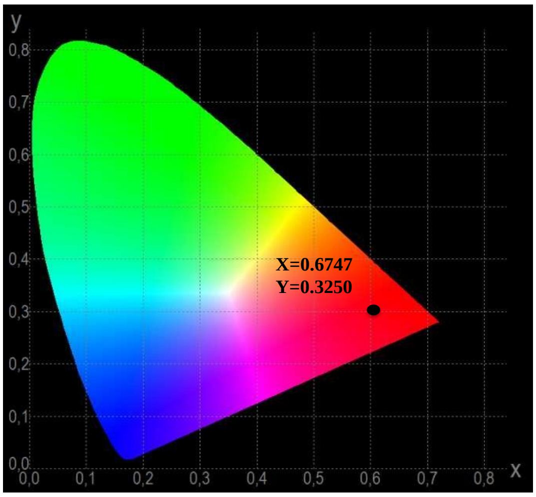

Fig. 3 CIE colour coordinates for $NaLi_2PO_4$:Eu^{3+} phosphor

4. CONCLUSIONS

The polycrystalline $NaLi_2PO_4$:Eu^{3+} phosphor was successfully synthesized by solid-state diffusion method. The XRD pattern of prepared $NaLi_2PO_4$:Eu^{3+} phosphor was in good agreement with the JCPDS file with card no. 80-2110. The excitation was monitored at 618 nm and emission

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was monitored at 393 nm. The excitation spectra consists of series of sharp lines at 310, 363, 377 and 394 nm correspond to the $^7F_0 \rightarrow ^5H_3$, $^7F_0 \rightarrow ^5D_4$, $^7F_0 \rightarrow ^5L_7$ and $^7F_0 \rightarrow ^5L_6$ transitions respectively. On the other hand emission spectra consist of two sharp peaks 595 nm and 618 nm with one weak peak at 653 nm. The emission at 595 nm corresponds to the $^5F_0 \rightarrow ^7D_1$, the emission at 618 nm corresponds to the $^5F_0 \rightarrow ^7D_2$and weak emission at 653nm corresponds to the $^5F_0 \rightarrow ^7D_3$ transition of Eu^{3+} ions. The CIE chromaticity coordinates of the as-prepared phosphors were determined to be (0.6747, 0.3250). The results indicate that $NaLi_2PO_4:Eu^{3+}$phosphor is a potential candidate for Solid State Lighting.

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