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SYNTHESIS AND LUMINESCENCE STUDIES OF $Ca(PO_3)_2$:Eu^{3+}MATERIAL FOR SSL APPLICATIONS

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ABSTRACT

The phosphors in the system Ca_{1-x} $(PO_3)_2$: xEu^{3+} was synthesized by solid-state reactions and their photoluminescence properties were investigated. The synthesized host powder of Ca $(PO_3)_2$ was confirmed on Rigaku miniflex X-ray diffractometer (XRD) with scan speed of 2 deg/min with Cu Kα radiation. The photoluminescence spectra were recorded with the help of Hitachi FL-7000 photo spectrometer. The morphology of this phosphor was checked in the form of Scanning Electron Microscope (SEM) characteristics were carried out for this prepared phosphor. These phosphors have well absorption in the near UV region at 395 nm due to $7F_0$--$5L_6$ transition of Eu^{3+}, which is suitable for excitation of ultraviolet light emitting diodes (UV-LEDs). The orange-reddish emission of Eu^{3+} at 614 nm due to $5D_0$—$7F_2$ transition of Eu^{3+}, in these phosphors can be used as a red component in the tri-color system. The emission spectra exhibit orange-reddish performance (CIE chromaticity coordinates: X = 0.6775, Y = 0.3223), which is due to the $5D_0 \rightarrow 7F_2$transitions of Eu^{3+} ions.The results interpretation clears that Ca $(PO_3)_2$: Eu^{3+} phosphors could be used in white light UV-LEDs.

Keywords: *White Light UV-LEDs, Calcium phosphate, Rare Earth*

I. INTRODUCTION

Material science is a vast field for all round studies of materials in various fields. Some materials are quite unique in nature due to their special property of absorbing incident energy and converting it into visible radiations. Hence they are called as phosphors. Due to some lattice defects or impurity in materials, trapping levels are created and the electronic process involved in this process is responsible to luminescence phenomena. To know in detail the electronic energy level in the crystal of the materials, the study of their absorption and emission spectra is very important. Hence more new and new phosphors with different possible applications become the area of interest for the researchers. One use to link the applications of these materials for the sake of mankind. Why don't we try to synthesize some phosphor those are utilized for the benefit of society? Production of low cost light in the form of LEDs is one of them. We should have the resources to provide low cost energy sources for the betterment of the society.

White light ultraviolet light emitting diodes are the steps in the directions to reduce energy consumptions. Recently so many intentions was given in this direction [1-6]. Some of the biocompatible materials was synthesized by khan et al [7, 8] trying various low cost and simple methods [9-13] which have multipurpose applications including white LED [14] as well as for security purposes with different rare earths [15,16]. We prepared Eu (III) doped $Ca(PO_3)_2$ keeping in mind its use in solid state lighting (SSL) applications.

II. EXPERIMENTAL

Powder samples of Ca $(PO_3)_2$: Eu^{3+} was synthesized by solid state reactions. Starting materials were $CaCO_3$ (A.R.), $(NH_4)_2HPO_4$ (A.R.) and Eu_2O_3 (99.99 %). After being ground thoroughly in stoichiometric ratios by using an agate mortar, the mixed powders were transferred into china basin and then heated in a tube furnace at 925 °C for 2 hr in Air. The phase purity was determined by using a powder X-ray diffractometer (Rigaku miniflex) with scan speed of 2 deg / min with Cu Kα radiation. The photoluminescence (PL) excitation and emission spectra of the samples were

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characterized by using a Hitachi F-7000 fluorescence spectrophotometer, and the integrated areas of the emission peaks were used to represent the PL intensities.

III. RESULTS AND DISCUSSION

Fig. 1 shows the XRD pattern for Ca $(PO_3)_2$ prepared by using solid state synthesis.The XRD Pattern for Ca $(PO_3)_2$ agrees well with the standard data from ICDDfile (01-077-1953)

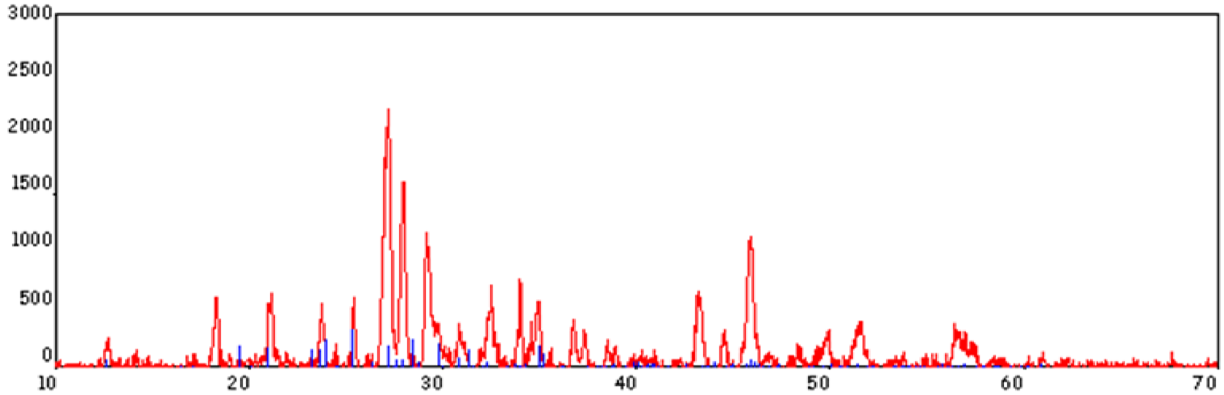

Fig. 1 XRD pattern of Ca $(PO_3)_2$Host material

SEM image is represented in Fig. 2 for combustion synthesized Ca $(PO_3)_2$: Eu^{3+}material. The material shows irregular shape particles with heap like structure. It shows the sizes of particles in micro region. The irregularity may be caused due to the irregular mass flow during synthesis process.

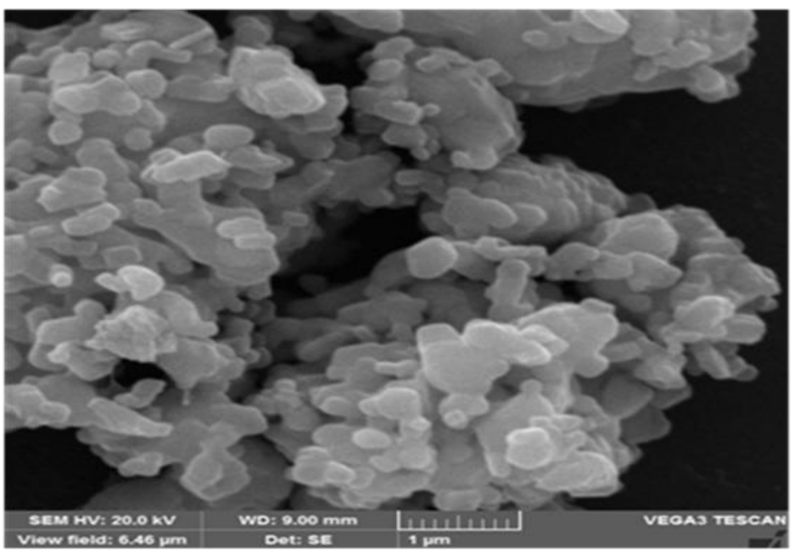

Fig. 2 SEM image of Ca $(PO_3)_2$phosphor prepared by solid state synthesis

Fig. 3 represents the Fourier transformed infrared spectroscopy (FTIR) spectra for Ca $(PO_3)_2$: Eu^{3+}material. The FTIR revealed prominent absorption with peaks for Ca $(PO_3)_2$: Eu^{3+} at 1211, 971, 614 and 537 cm^{-1}. The IR absorption at wave numbers smaller than 500 cm^{-1} mainly originates from the lattice dynamic modes. It is found that there are many closely spaced peaks above 1100 cm^{-1}, which are believed to come from the different bond lengths of P-O. Antisymmetric (ν3) and symmetric (ν1) P-O stretching vibrations of PO_4 group at 1050, 1100 and 962 cm^{-1},

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O-P-O bending (v4) vibrations of PO_4 group at 565 and 603 cm^{-1} , vibrational mode at 630 cm^{-1} of OH hydroxyapatite group and band at 1650 cm^{-1} from the vibration modes of adsorbed water can be found in spectra [17-19] Besides the band around 530 cm^{-1} of calcium deficient hydroxyapatite [20], small changes in shape of bands at 570 and 600 cm^{-1} can be found in spectrum.

No clearly distinguished peak at 630 cm^{-1} from the OH hydroxyapatite group is visible in spectrum. The absence of peaks in the range of 1550-2500 cm^{-1} supports the complete removal of residual nitrate and organic matter. The broad peak at about 3300-3500 cm^{-1} are corresponding to the stretching mode of O-H from the water crystallization in the complex but in spectra no such peaks are seen which conforms the absence of water contains in the prepared material

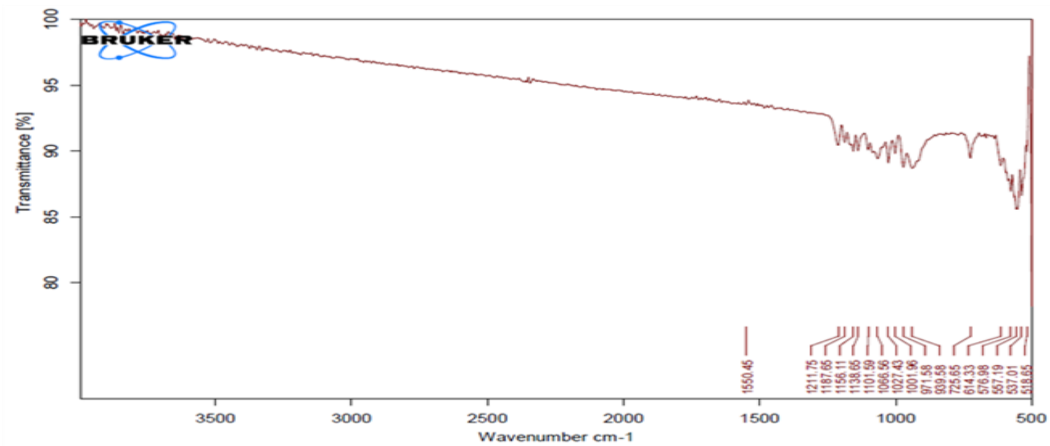

Fig. 3 FTIR image of Ca $(PO_3)_2$: Eu^{3+}phosphor prepared by solid state synthesis

The confirmed sample doped with europium is studied for the photoluminescence properties under near UV excitation source. Fig. 4a represents the excitation spectra while Fig. 4b represents emission spectra for the different concentration of Eu ions doped Ca $(PO_3)_2$ sample. From figures it is clearly seen that under the excitation of 395nm, the emission spectrum exhibits two sharp emission lines in each case, which belongs to the characteristic emission of trivalent Eu ion. The weaker emission line in the region near 595 nm is attributed to the Eu^{3+} typical transition $5D_0 \rightarrow 7F_1$. The main emission line peaking at 614 nm is assigned to the transition of $5D_0 \rightarrow 7F_2$ of Eu^{3+} [21].

This confirms that the Eu^{3+} takes the inversion symmetry site in the host. The excitation spectra for 614nm emission have several bands at 305, 324, 332, 359, 378, 390, 409 and 457nm which correspond to the characteristic f–f transitions of Eu^{3+}. The strongest one is at 395 nm, which is attributed to the $7F_0 \rightarrow 5L_6$transition of Eu^{3+}. Though there are lots of studies are remaining, the primary results of PL strongly support the ability of Ca $(PO_3)_2$: Eu^{3+} as a potential candidate for Solid State Lighting and other display applications [22, 23].

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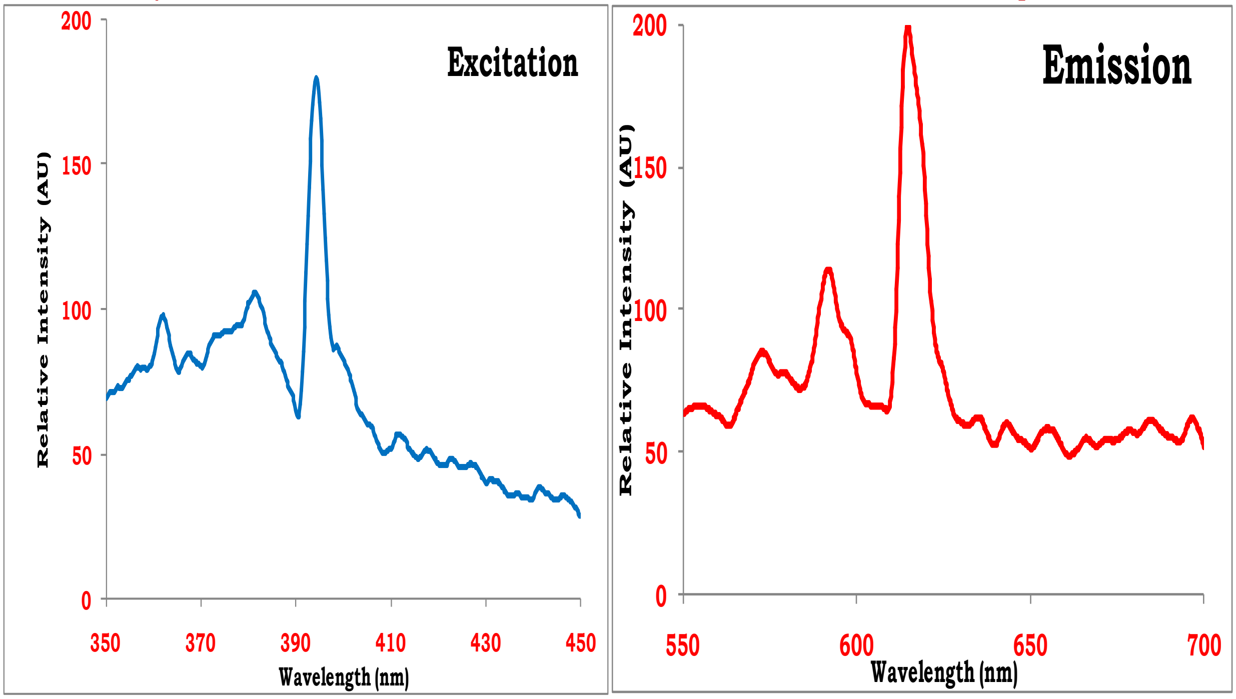

Fig. 4 Excitation and Emission spectra of Ca $(PO_3)_2$:Eu^{3+}

The emission spectra exhibit orange-reddish performance (CIE chromaticity coordinates: X = 0.6775, Y = 0.3223), which is due to the $5D_0 \rightarrow 7F_2$transitions of Eu^{3+} ions.The results interpretation clears that Ca $(PO_3)_2$: Eu^{3+} phosphors could be used in white light UV-LEDs.

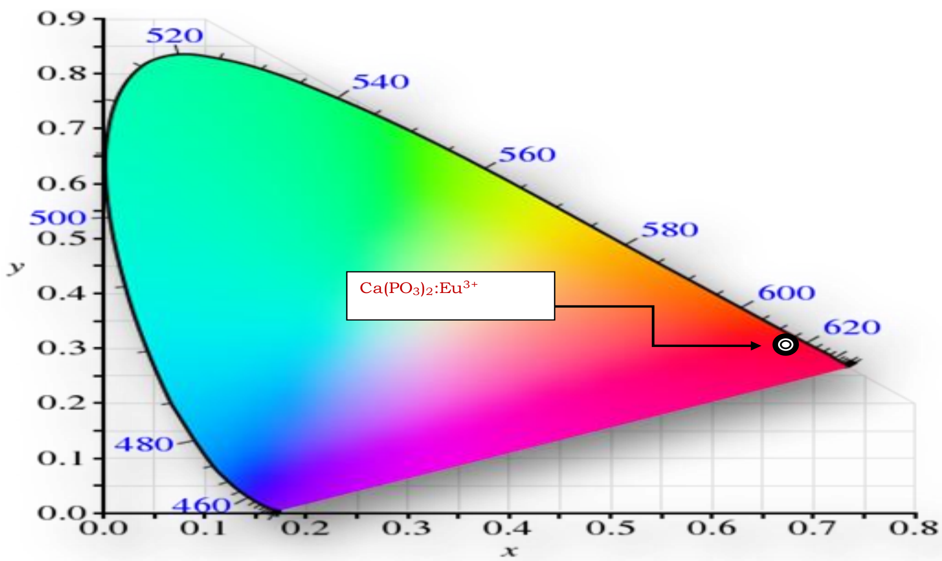

Fig. 5 CIE color space chromaticity diagram of Ca $(PO_3)_2$:Eu^{3+} phosphor

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IV. CONCLUSION

In current report, X-ray Diffraction result support the complete crystalline and single phase formation of Ca $(PO_3)_2$doped with Eu by solid state synthesis. The phosphor gives strong orange-red emission under N-UV excitation. The primary photoluminescence emission and excitation spectrum gives an evidence for the capability of material as promising candidate in SSL and other display applications including white light UV-LEDs.

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