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Combustion Synthesis of Ce^{3+} Activated Blue-Emitting $KBaPO_4$ Phosphors

Damodhar. B. Zade[1*], Sachin H. Dhawankar[1], Nitesh D. Punyapreddiwar[1]
[1*]Department of Physics, Shri Jivanrao Sitaram Patil Munghate Arts, Commerce and Science College, Dhanora - 442606, Dist. Gadchiroli, Maharashtra, India

ABSTRACT

Blue emitting $KBaPO_4$: Ce^{3+}phosphors sample is prepared using combustion synthesis method. Spectroscopic properties of Ce^{3+} and integrate the Ce^{3+} ion with host inorganic material show interest for most of the applications in photoluminescence studies. Prepared sample of $KBaPO_4$: Ce^{3+}carried out for emission and excitation spectra for photoluminescence measurement. XRD, morphology, absorption band and concentration of Ce^{3+} ion with emission intensity are reported in present work. Structural and morphological studies confirm phase and purity of prepared sample with crystalline in nature. PL spectra of Ce^{3+} due to the 4f–5d transition of Ce^{3+} ions peaking at 330 nm. Chromatic properties index with the help of the emission spectra with color coordinate of sample observed in blue region. The photoluminescence emission spectra of $KBaPO_4$: Ce^{3+}phosphor exhibit blue emission band centered at 440 nm.

Keywords: - XRD, Photoluminescence, morphology, chromatic, stability temperature, emission and excitation spectra.

I. INTRODUCTION

Every day lighting requirements attract interest for Solid state lighting in ultraviolet light emitting diodes and their potential applications. Light-emitting diode based white light sources are low power consumption, high efficiency, longer lifetime, and mercury-free excitation [12, 13]. Numerous domains have various applications in novel and vacuum-ultraviolet phosphors [3]. Physical properties of Stoichiometric rare earth with aluminates based phosphors have great attraction in recent [4, 14].

White light emitting diodes are high efficiency, long lifetime, energy saving, and positive environmental effect for lighting sources and illumination [6-7]. White light emitting diodes have two important factor Quantum efficiency and color rendering index of phosphor [8]. Most of the inorganic luminescence materials have working applications in many devices which shows high stability, brightness, and flexible in industrial process for lighting and display devices [8]. Phosphors like $BaAl_2O_4$:Eu^{2+}:Dy^{3+}[9] and $BaAl_2O_4$:Tb^{3+}[10] are prepared and studies for photoluminescence and high chemical stability. Blue luminescence [11] and green luminescence materials [8-6] based activated calcium aluminates are prepared by solid state method. The emission peak of sample NaLa(WO4)2:Ce3+ and LiLa(WO4)2:Ce3+ 378 and 425 nm (λexc = 350 nm) with Excitation wavelengths of Ce3+ and Dy3+ activated alkali lanthanide tungstates are in UV region which are report

applicable for solid state lighting [1]. $KBaPO_4$ powder doped with Sm^{3+},Eu^{3+},Dy^{3+} and synthesized for solid-state lighting show excitation and emission effectively[2] . A green phosphor light sample of KBaPO4:Tb3+ reported and synthesized by the higher temperature solid state technique which report emission peaks at 437, 490, 545, 586 and 622 nm which correspond to the 5D3→7F4 and 5D4→7FJ=6.5,4,3 transition of Tb3+ [15]. The present work report Ce^{3+} trivalent cerium ion used as different material in many appliances with luminescence and stability temperature in high energy research and medical imaging application. Blue emitting $KBaPO_4$: Ce^{3+} phosphors wet chemical method at 100^0c. $KBaPO_4$: Ce^{3+} sample are studies for photoluminescence measurement with analysis of emission and excitation spectra. Prepared sample show crystalline in nature. Absorption band are taken in range of 280 to 380 nm due to 4f – 5d transition. Luminescence property of prepared blue emitting phosphor sample concentration increases by adding trivalent cerium ion as a activator. Excitation and emission band spectra are observed at 330nm and 440 nm. Chromatic properties induced with the help of the emission spectra. Single host phosphor is blue emitting promising and mixed with other color emission to obtain white light emission diodes.

II. EXPERIMENTAL

$KBaPO_4$:Ce^{3+}phosphors sample were preparedby wet chemical method at temperature of 100^0 C by using oven. For sample preparation KNO3(99.99% purity Merck),$Ba(NO_3)_2$ (99.99% purity Merck), KPO_4 (99.99% purity Merck) and and Cerium Nitrate ($Ce(NO_3)_3$, REI 99.9 %) mixed with double distillation water. The prepared sample is studies for different concentration of Ce^{3+} (1-10 mol %). All compound and element are mixed in stoichiometric ratio in a beaker with double distillation water and stirrer in magnetic stirrer for 3-4 hours. Once the homogeneous mixture found its kept in oven at 100 ^{0}C for 24 hours to obtain pasty solution. Formed solution is then shifted to silica crucible and kept in a muffle furnace to formed fine powder. The temperature of muffle furnace is maintained at 100^0C. The prepared sample powder is then carried out for the analysis of emission and excitation spectra for photoluminescence measurement and XRD. Photoluminescence (PL) emission for excitation was measured in Shimadzu RF5301PC spectroflurophotometer.

III. RESULTS AND DISCUSSION

Fig.1 shows the XRD patterns of as prepared sample of $KBaPO_4$:Ce^{3+} lampphosphors. The XRD pattern of sample is crystalline in nature. XRD-pattern of $KBaPO_4$:Ce^{3+} lamp phosphors is found good agreement with JCPDS no. 84-1462. The XRD-patter shows phosphor have good crystalline nature. The combustion synthesized powders have a good crystalline nature.

Morphology study of the sample $KBaPO_4$:Ce^{3+} phosphorsis in figure 2. Combustion synthesized $KBaPO_4$:Ce^{3+}phosphor under few microns to sub few micron. It indicate that prepared sample are sharp shape surface morphology and have grains of crystalline nature. The grain size of crystallite is in the range of sub micrometer as shown in SEM images.

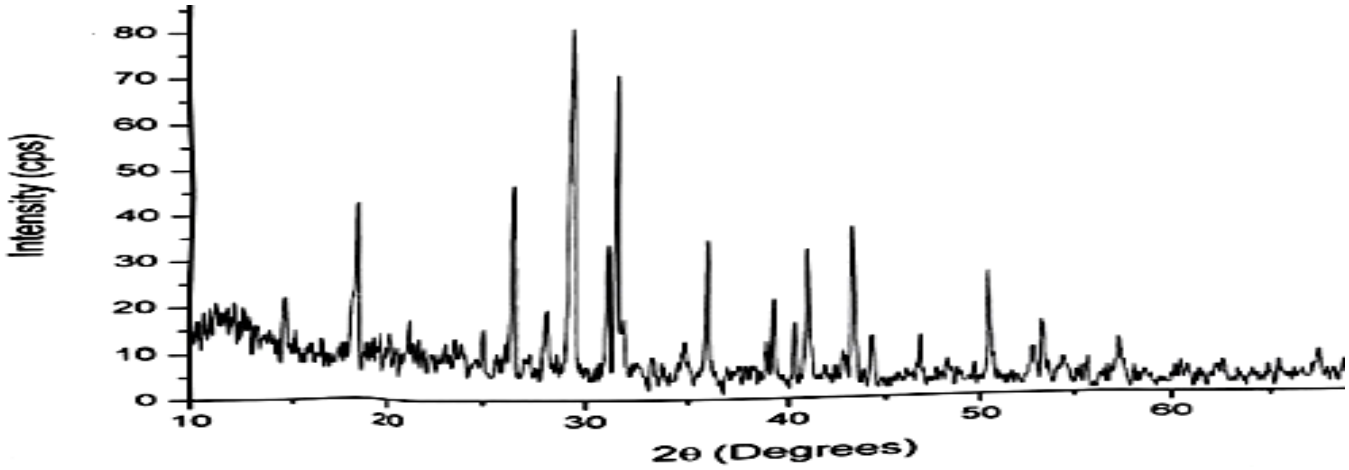

Fig.1 XRD-pattern of $KBaPO_4:Ce^{3+}$ lamp phosphors.

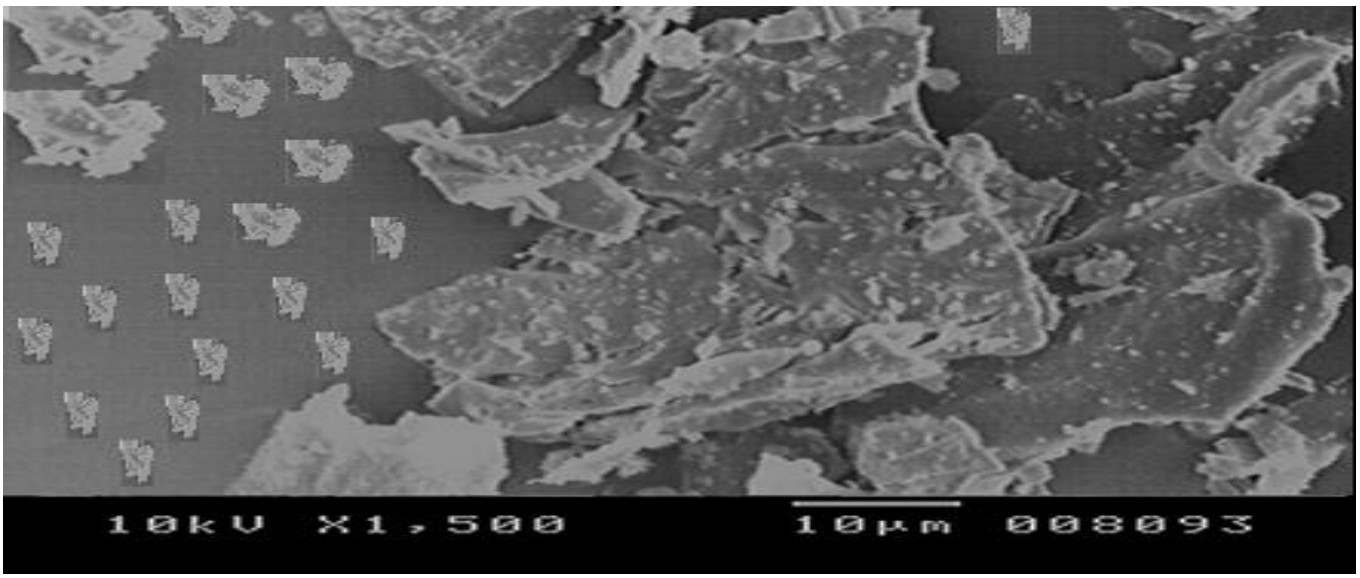

Fig.2 Morphology of the $KBaPO_4:Ce^{3+}$ phosphors.

Figure 3 and 4 shows photoluminescence excitation and emission spectra of prepared sample KBaPO4:$Ce3^{+}$ with wide absorption band in the range of 280 to 380 nm due 4f–5d transition of Ce^{3+} ions peak at 330 nm and exhibit blue emission band centered at 440 nm. The configuration of Ce^{3+} ion in ground state is divide into two levels $^2F_{5/2}$ and $^2F_{7/2}$ whereas the $5d^1$ excited configuration is divide by the crystal playing field ranging from 2 to 5 components. Emission spectra of the prepared samples shows broad blue emission band in the range of 400-650 nm peak at 441 nm. The excitation takes place at maximum ground level splitting to the 5d levels and emission developed from the excited level i.e. lowest level toward the two splitting ground levels state.

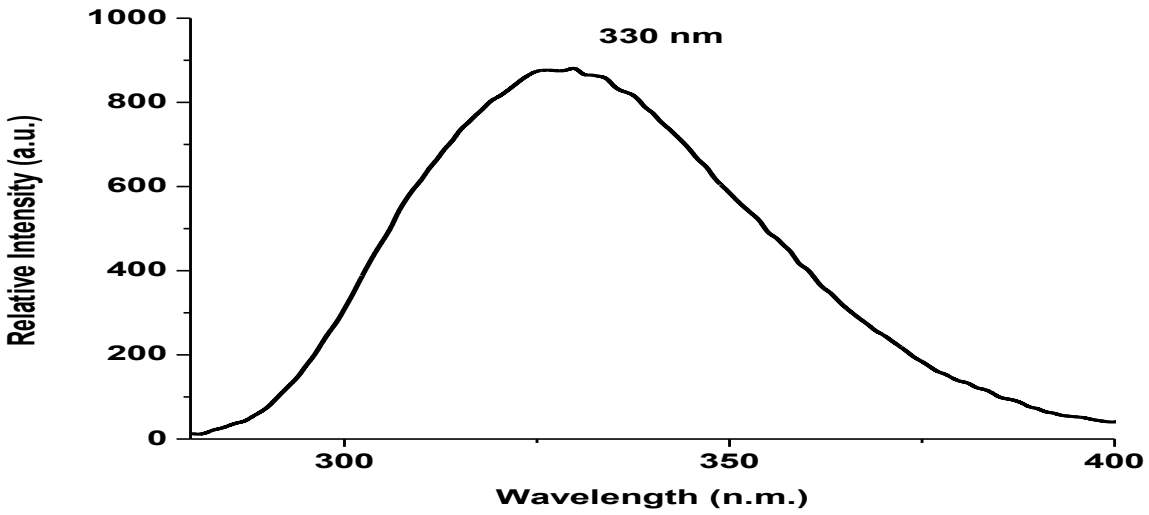

Fig.3 Excitation Spectra for $KBaPO_4:Ce^{3+}$ phosphors, λ_{em}= 440 nm.

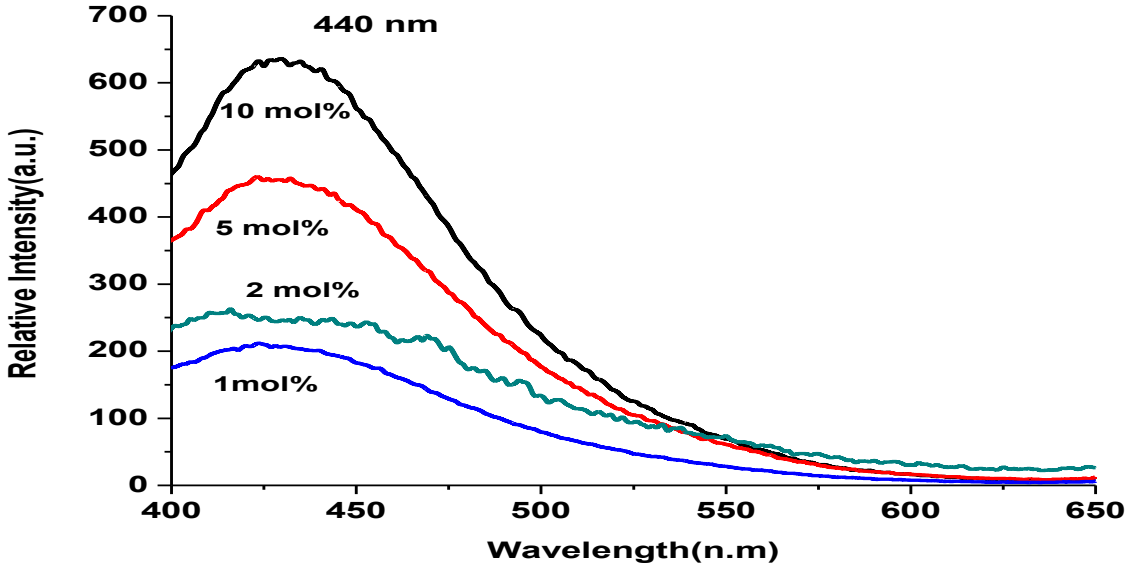

Fig. 4 Emission spectra for $KBaPO_4:Ce^{3+}$ phosphor λ_{ex}=330 nm

The emission spectra is clearly shows no another emission band was observed in emission spectrum indicating that trivalent cerium ion occupies one category of sites in the host material. So $KBaPO_4:Ce^{3+}$among blue emission is able to find potential applications as a blue emitting lamp phosphor. The sample compounds $KBaPO_4:Ce^{3+}$was synthesized by modified combustion synthesis method with activated by alkaline earth Ce^{3+} ion in concentration from 1 to 10 mol %. Prepared sample $KBaPO_4:Ce^{3+}$blue emittingphosphor gives in the emission spectra at 440 nm exhibit a blue shift moderately with commercial available phosphor.

Figure 5 shows relationship between Emission Intensity and Concentration of Ce^{3+} ion in $KBaPO_4:Ce^{3+}$ phosphor. A series of $KBaPO_4:Ce^{3+}$blue emitting phosphor with varying Ce^{3+} concentrations of 1 mol %. to 10 mol % was prepared. The effect of doped Ce^{3+} concentration on the emission intensity of $KBaPO_4:Ce^{3+}$ phosphor is anaysis. For study of relationships between concentration of Ce^{3+} ion and emission intensity in $KBaPO_4:Ce^{3+}$phosphor exactness is important. For every concentration as in sample graphical representation is shown. The concentration of Ce^{3+} does not transform and disturbed the emission spectrum only changes in the

intensity occur. At 2 mol. % concentrations of Ce^{3+} ion the peak for the luminescence spectra for the strong blue emission is obtained but the emission intensity is found weak. As concentration increases further the emission intensity increase with the concentration of Ce^{3+} ion. The maximum value of emission intensity is observer at concentration of 10 mol.% Ce^{3+} ion. The $KBaPO_4:Ce^{3+}$blue emitting phosphor prepared is effectively excited by 330 nm suitable for lighting lamp phosphor. The strong emission in the blue region at 440 nm with observing maximum emission intensity is shown in figure. From the graphical representation emission lines spectrum intensities are improved. for 10 m% of trivalent cerium concentrations the emission intensity is observed to be 635.4033 nm and the smallest amount of intensity for emission spectra is found to 208.9125 nm for 1 m% of Ce^{3+} concentration. All the observed values are tabulated in table 1. Addition of trivalent cerium ion in to $KBaPO_4:Ce^{3+}$host which improves the crystalline of prepared sample. As increases in the concentration of trivalent cerium ions which increases the size of particles shows increases in intensity of photoluminescence.

S.N.	Conc. of Ce^{3+}in $KBaPO_4:Ce^{3+}$ phosphor	Emission intensity (a.u.)
1	1 mol%	208.9125
2	2 mol%	251.2584
3	5 mol%	414.01
4	10 mol%	635.4033

Table1. Emission intensities w.r.to conc. of Ce^{3+} in $KBaPO_4:Ce^{3+}$ Blue emitting Phosphor

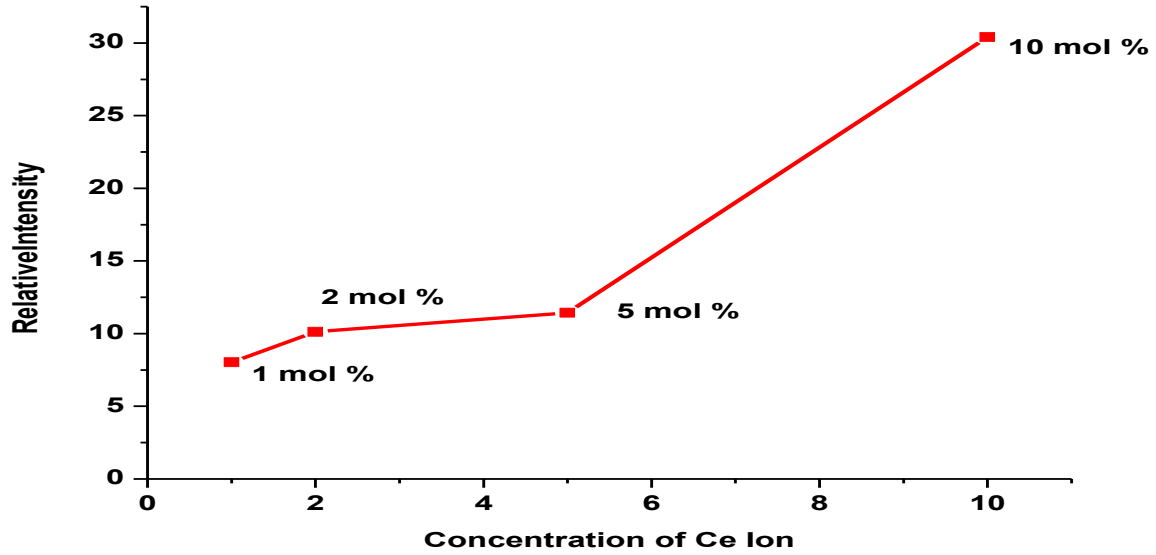

Fig. 5 Effect of conc. of dopant Ce^{3+} on emission intensity of $KBaPO_4:Ce^{3+}$ Phosphor

Figure 6 shows CIE chromatic diagram for $KBaPO_4:Ce^{3+}$ phosphor. The emission spectrum of Ce^{3+} was consider in blue regionfor further study and characterization the luminescent properties of $KBaPO_4:Ce^{3+}$blue emitting phosphors for achieve the complete emission of color. The coordinate prepared sample are been determine for chromaticity indexed with the help of the emission spectra of Ce^{3+}.

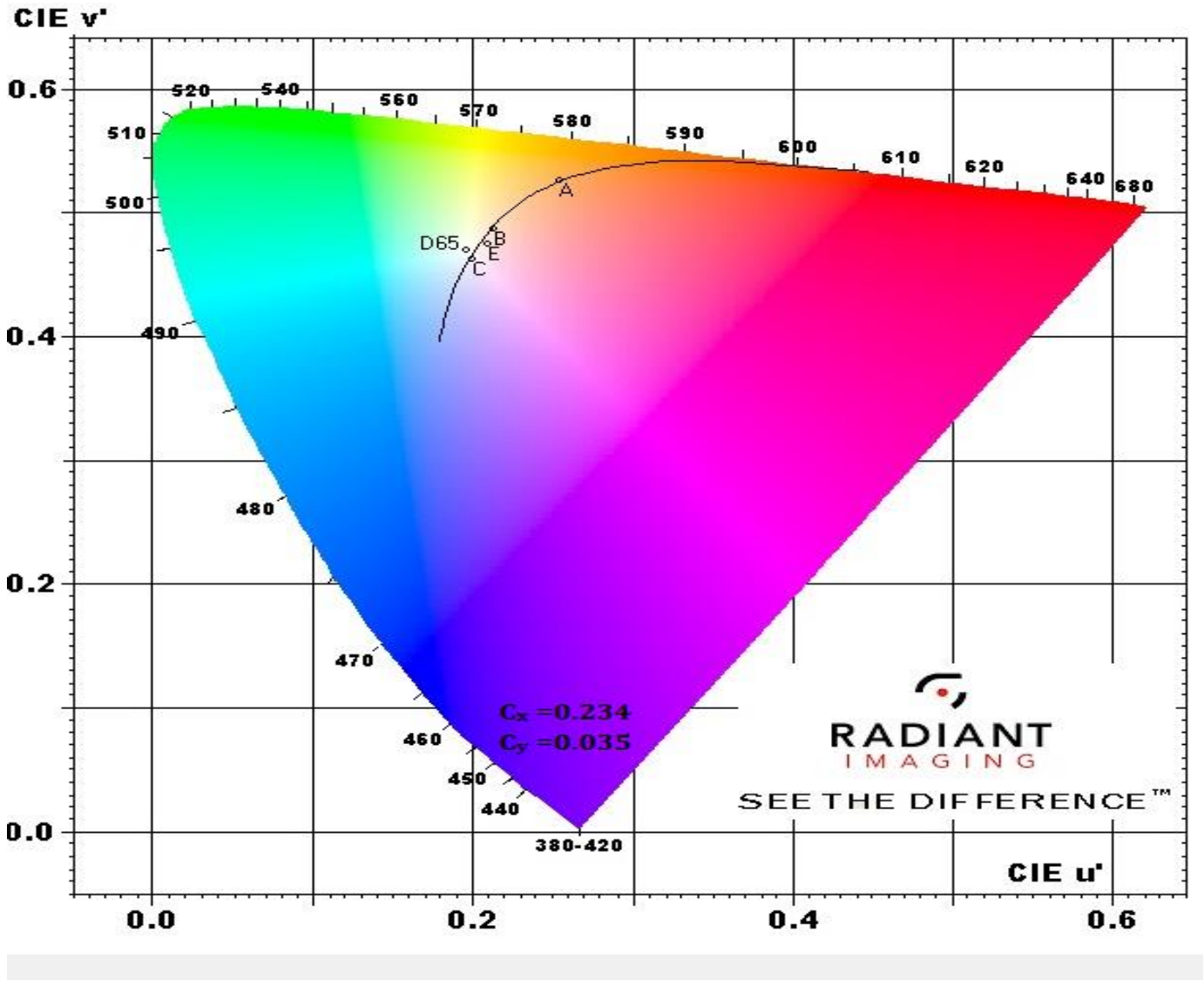

Figure 6 CIE chromatic diagram for $KBaPO_4:Ce^{3+}$ phosphor.

The color coordinates of the $KBaPO_4:Ce^{3+}$phosphor sample observed in blue region with coordinate at C_x =0.234, C_y =0.035. CIE diagram explains that the $KBaPO_4:Ce^{3+}$phosphors are very near to the CIE graph frame, which easy to shows the color clarity of prepared phosphor material. The system of chromaticity coordinates (x, y) calculated with the help of the color calculator program radiant imaging.

IV. CONCLUSION

The photoluminescence characteristics of Ce^{3+} activated blue-emitting $KBaPO_4:Ce^{3+}$phosphors report in the near UV–vis range shows the excitation bands at 330 nm and emission band at 441nm due to spectral overlap of two energy level. Doping concentration of $KBaPO_4:Ce^{3+}$phosphor has been report a minor change in relative intensity of the $5d\text{-}^2F_{5/2}$ to $5d\text{-}^2F_{7/2}$ with self absorption improved splitting of crystallite. XRD pattern of prepared $KBaPO_4:Ce^{3+}$phosphor reveals the good crystalline in nature. Scanning electron microscopic images shows morphology of the phosphor at microns to sub few microns. The complete characteristics of Ce^{+} doped $KBaPO_4:Ce^{3+}$reveals that, it is a promising blue emitting single-host phosphor for lamp industries and mixed with other color emission phosphors to obtain white light.

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