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Photoluminescence in $NaCa_2Br_5:Eu^{2+}$ Novel Phosphor.

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ABSTRACT
A simple procedure to prepare Eu^{2+} activated bromide phosphor $NaCa_2Br_5$ is described. Sample was synthesized by simple low temperature wet chemical method. Photoluminescence (PL) results showed that the phosphor can be efficiently excited by UV-visible light from 200 to 430 nm and exhibited bright blue emission around 435 nm when excited by 365 nm near-ultraviolet light. The developed phosphor emits in blue and hence could provide one of the three primary colour components in phosphor converted LED producing white light.

Keywords: Solid State Lighting, wet chemical synthesis, blue phosphor, photoluminescence

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INTRODUCTION

Solid state lighting have a very bright future in various lighting applications because of their high energy efficiency and cost effectiveness compared to incandescent bulbs. It has the potential to make much more progress over the coming decade. A very effective way to produce white light from UV/blue LED is by coating on LED suitable phosphors excitable by LED light, so that white light is produced either by mixing of basic colours or complementary colours. Blue is at the short-wavelength (high-energy) end of the visible spectrum, it proved possible to "down convert" blue light into green, yellow and even red light using passive phosphorescent and fluorescent materials [1].

Eu^{2+} activated phosphors find use in many applications. $BaMgAl_{10}O_{17}$:Eu and $Sr_5(PO_4)_3Cl$:Eu are efficient tri-colour lamp phosphors [2, 3]. Efficient Eu^{2+} emission has been obtained in many compounds [4, 5–8] many of such phosphors have found applications. UV emitting phosphors are useful in eurythermal and photocopying lamps. Blue color emitting phosphors find applications as lamp phosphors and blue component of CTV phosphor. Several bromides containing alkali and alkaline earth ions are known. Amongst such bromides included $Ca_2B_5O_9Br$, Ba_4OBr_6, Sr_4OBr_6, $Sr_5(PO_4)_3Br$, KSr_2Br_5 [9]. $Ba_5GeO_4Br_6$:Eu^{2+} and $Ba_5SiO_4Br_6$:Eu^{2+} are being used as storage screens phosphors. Europium-doped strontium borate (SrB_4O_7:Eu^{2+}) has been used for Fluorescent Lighting (blacklight, cosmetic, UV-A). CsBr:Eu^{2+} phosphor is used as imaging plates for high resolution X-ray radiography. BaFBr:Eu^{2+} and CsBr:Eu^{2+} are storage phosphors [10].

Recently, some Eu^{2+} activated bromide phosphors are reported [11, 12]. However, there are not many studies on luminescence of Eu^{2+} in bromides. A relatively recent review [9] on luminescence of Eu^{2+} shows that very few bromides have been covered in luminescence studies. This prompted us to undertake investigations of luminescence of Eu^{2+} in some bromides.

METHODOLOGY

$NaCa_2Br_5$ phosphor is prepared by wet-chemical method. Stoichiometric amounts of $NaCO_3$, $CaCO_3$, Eu_2O_3 & HBr were taken as starting materials. The precursors used in this work are of AR grade. Sample is prepared by dissolving desired quantities of metal carbonates and Eu_2O_3 in preheated HBr. Excess acid was then boiled off and the solutions were evaporated to dryness. The resulting powders were dried and annealed for 1 h at 775 K in a reducing atmosphere provided by burning charcoal so as to reduce the activator to divalent state. An alumina crucible containing the compound was placed in another crucible. The annular space was filled with charcoal. A tight fitting lid covered the outer crucible. This treatment was found sufficient to yield bright phosphors exhibiting intense Eu^{2+} emission. No nitrogen/H2 circulation was needed. Compounds formed are hygroscopic and catch moisture if left in open. They are to be stored in tight-capped bottles. The annealed powders were quickly sandwiched between quartz plates and transferred to photoluminescence (PL) cell. Photoluminescence spectra in the range 220–700nm were recorded on Hitachi F-4000 spectro-fluorimeter with spectral slit width of 1.5 nm. Samples were also found to be stable against UV irradiation that was used for the PL measurements. No changes in spectral positions or intensities were observed during several, successive PL runs.

RESULTS AND DISCUSSION

$NaCa_2Br_5$ crystalizes in orthorhombic (space group Pnma) crystal system [13, 14]. Figure 2 (curve b) presents the PL excitation spectrum of Eu^{2+} activated $NaCa_2Br_5$ phosphor. The excitation band consists of unresolved bands due to the $4f^65d^1$ multiplets of Eu^{2+} excited states. It is characterized by two prominent peaks around 275 nm, 338 nm and a shoulder around 370 nm is also observed attributable by Eu^{2+}. Thus possessing appreciable response throughout the entire UV region, consequently the utility of the material in SSL application is confirmed.

Figure 2 (curve a) presents photoluminescence emission spectrum of Eu^{2+} activated $NaCa_2Br_5$ phosphor for 1 nm slit width. An intense blue emission spectra is obtained for $NaCa_{1.98}Br_5$:$Eu^{2+}_{0.02}$ quenched from 775 K under 365 nm excitation. Emission spectra show strong broad band emission peaking at 439 nm corresponding to $4f^65d \rightarrow {}^8S$ allowed electric dipole transition. Since the phosphor was hygroscopic and XRD facility was not easily available, XRD characterization was not carried out. No reference is found for photoluminescence of $NaCa_2Br_5$:Eu^{2+} in the literature for comparison. Therefore, this could be the first report on the Eu^{2+} activated host. The Stoke's shift is small hence the luminescence is highly efficient. Maxima of emission spectra is in blue region; it indicates that this phosphor is a candidate of blue phosphor for application in Solid State Lighting

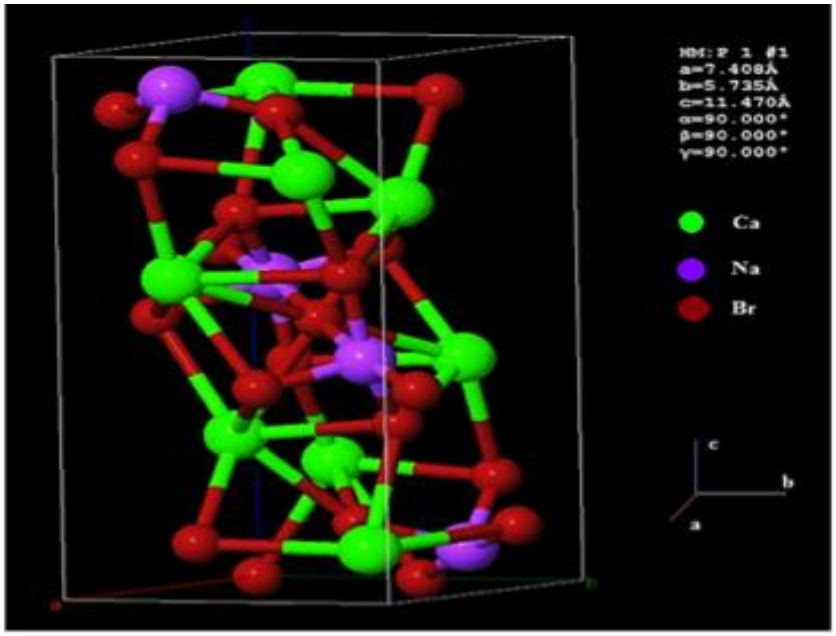

Fig. 1 Unit Cell of $NaCa_2Br_5$

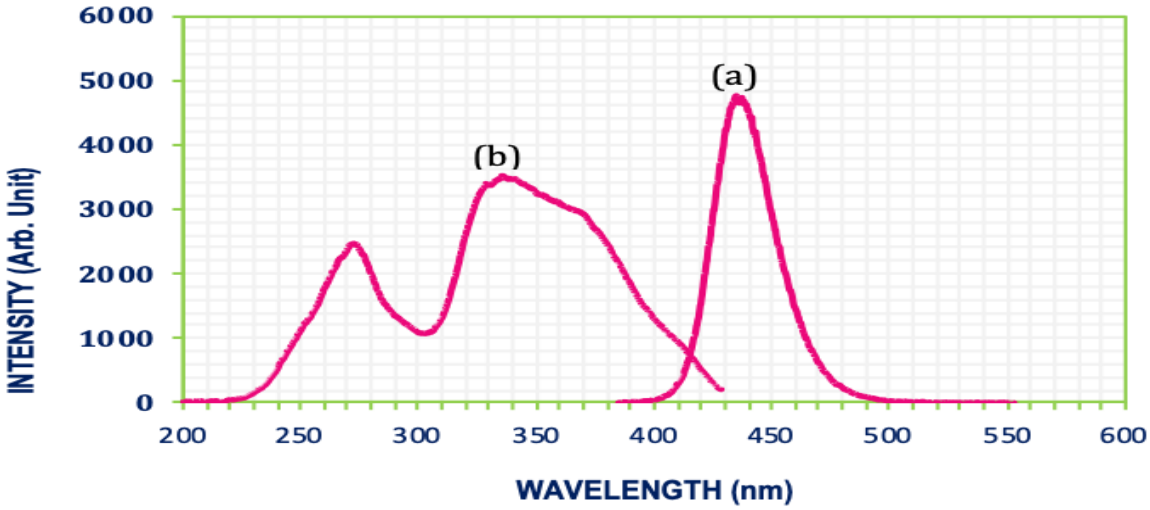

Fig. 2 Photoluminescence Spectrum of Eu^{2+} activated $NaCa_2Br_5$ phosphor
(a) Emission Spectra of $NaCa_2Br_5$: Eu^{2+} for 365 nm excitation.
(b) Excitation spectra of $NaCa_2Br_5$: Eu^{2+} for 435 nm emission.

CONCLUSION

A simple wet chemical method for the synthesis of Eu^{2+} activated $NaCa_2Br_5$ phosphors is described. Efficient luminescence is observed near 435 nm in blue violet region with excitation in the near UV range. It is suggested that this result will be significant for developing phosphors with near UV excitations needed in applications such as solid state lighting.

Conflicts of interest: The authors stated that no conflicts of interest.

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