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PHOTOLUMINESCENCE OF A GREEN EMITTING PHOSPHOR $LiCaBO_3:Tb^{3+}$

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Abstract- The powder samples of $LiCaBO_3:Tb^{3+}$ have been prepared by a novel method which is slight variation of solution Combustion Synthesis Method. The synthesis is based on the exothermic reaction between the fuel (Urea) and Oxidizer (Ammonium nitrate). The powder XRD pattern of the powder sample was analyzed and found in good agreement literature. The photoluminescence properties of $LiCaBO_3:Tb^{3+}$ have been investigated. In $LiCaBO_3:Tb^{3+}$, intense green emission of Tb^{3+} at 545 nm have been observed under UV excitation of 254 nm.
Keywords- Borate, Green Phosphor, Combustion synthesis, Photoluminescence

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Introduction

Inorganic Borate host compounds have long been a focus of research for their variety of structure types, transparency to a wide range of wavelengths, and high optical quality (1). These compounds possess excellent optical properties. It is a well known that the boron atom can be coordinated by Oxygen atom to form variety of atomic groups, which are considered to be a dominant factor for optical properties of borates (2). The ultra-violet transparency range of borate host compounds is determined mainly by the energy gap of the anionic groups if the cations are alkali or alkaline earth metals (3).

Alkaline earth borates are the important luminescent materials. Several alkaline earth borate compounds (4-7) exhibits efficient luminescence. Because of their excellent chemistry and thermal stabilization, facile synthesis and cheap raw material, extensively applied in phosphor for lamps (8 - 9). The alkaline earth borate $LiCaBO_3$ is an excellent host of the various luminescent ions. L. Wu et. al. (10) determined the crystal structure from single-crystal diffraction data. The structure was further verified by Rietveld refinement on the powder diffraction data. The unit cell of $LiCaBO_3$ is Orthorhombic and the possible space group is Pbca with the lattice parameters a = 13:227Å, b = 6:1675 Å, and c = 6:0620 Å. The borate $LiCaBO_3$ exhibits efficient photoluminescence when doped with the rare earth ions Eu^{3+}, Tb^{3+}, Ce^{3+}, Sm^{3+}, Dy^{3+} etc. (11 - 13). The borate phosphor $LiCaBO_3$ doped with Tb^{3+} shows intense green emission at 543 nm under UV and near UV excitation. In the present work, the preparation of the inorganic borate host phosphor $LiCaBO_3$ doped with Tb^{3+} by solution combustion synthesis method have been reported and the photoluminescence properties have been investigated.

Experimental

The fine powder samples of the phosphor $LiCaBO_3$: Tb^{3+} was prepared by a novel synthesis technique which is slight variation of solution combustion method (14, 16). The stoichiometric amounts of the ingredients calculated on the basis of molar ratio (Table 1) were thoroughly mixed in an Agate Mortar, adding little amount of double distilled water and obtained an aqueous homogeneous solution. The aqueous solution was then transferred in to a china basin. The China basin was introduced in to preheated muffle furnace maintained at 550°C. The solution boils, foams and ignites to burn with flame and obtained a voluminous, foamy powder. The entire combustion process was over in about 5 minutes. Following the combustion, the resulting fine powders were annealed in a slightly reducing atmosphere provided by burning charcoal at temperature 750°C for about 40 min. and

suddenly cooled to room temperature.
The XRD analysis was performed on the Philips X- ray Difractometer (NBSS & LUP Nagpur) and the PL measurements were performed on Hitachi Fluorescence Spectrophotometer model - F-7000 at Department of Physics S G B Amravati University.

Table 1- Molar ratio and stoichiometric weights of the ingredients.

$LiCaBO_3:Tb^{3+}$ 3%	$LiNO_3$	$Ca(NO_3)_2$	$Eu(NO_3)_3$	H_3BO_3	NH_2CONH_2	NH_4NO_3
Molar ratio	0.75	1	0.015	1	6	10.5
Weights (gms)	1.1930	2.3615	0.0909	0.6183	3.6036	8.4042

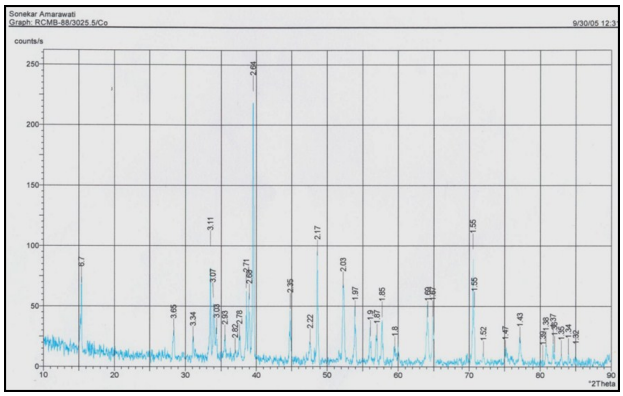

Fig. 1- Powder XRD pattern of $LiCaBO_3:Tb^{3+}$

Result and Discussion

The XRD pattern of the polycrystalline powder samples of $LiCaBO_3:Eu^{3+}$ have been analyzed for the structure confirmation. Fig.1 shows the powder XRD pattern of the sample. The XRD pattern of the phosphor $LiCaBO_3:Eu^{3+}$ was compared with the powder XRD of $LiCaBO_3:Eu^{3+}$ reported by Panlai Li et. al. (17) and found to be in good.
The emission spectrum of $LiCaBO_3$: Tb^{3+} phosphor is shown in Fig. 2. Under the UV 254 nm excitation, the emission spectrum exhibits four major emission bands at 486 nm, 545 nm, 590 and 622 nm, corresponding to the $^5D_4$ - $^7F_6$, $^5D_4$ - $^7F_5$, $^5D_4$ - $^7F_4$, and $^5D_4$ - $^7F_3$ typical transitions of Tb^{3+}, respectively. The strongest peak appears at 545 nm. Excitation spectrum for 610 nm emission of $LiCaBO_3$: Tb^{3+} is shown in Fig. 3. The excitation spectrum for 545 nm emissions mainly consists of an intense broad band around has several excitation bands. One band around 200-270 nm is assigned to the $4f^75d^1$. The excitation and emission spectra indicate that the phosphor $LiCaBO_3$: Tb^{3+} can be excited effectively by UV radiations. The phosphor LiCaBO3:Tb^{3+} exhibits intense green emission at 545 nm and hence could be a good green emitting candidate for tricolor lamps.

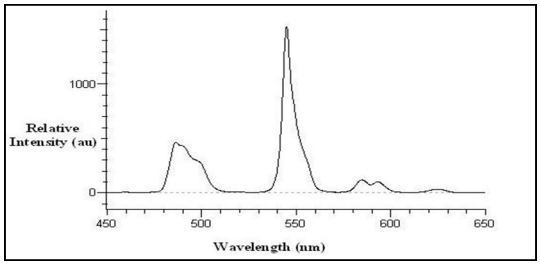

Fig. 2- Emission spectrum for 254 nm excitation of $LiCaBO_3$: Tb^{3+}.

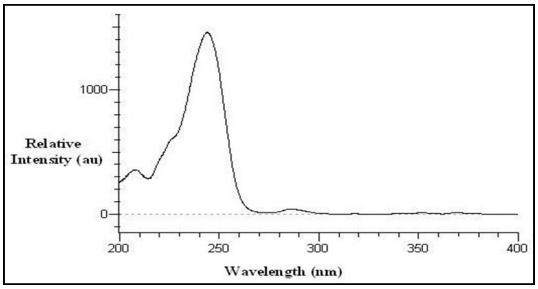

Fig. 3- Excitation spectrum for 610 nm emission of $LiCaBO_3$: Tb^{3+}

Conclusions

The inorganic Borate host phosphor $LiCaBO_3$: Tb^{3+} has been successfully prepared by a simple, low cost time saving Solution Combustion technique. The phosphor $LiCaBO_3$: Tb^{3+} exhibits intense red emission for UV excitation of 254 nm. The Pl emission spectrum of the phosphor is comparable with the commercial green phosphor $(Gd,Ce,Tb)MgB_5O_{10}$, so it could be a potential green component in tricolor Lamps.

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