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Effect of metal ions of different oxidation states Mx+ (x = 1 to 4) on the photoluminescence properties of Zn4B6O13:Eu3+ phosphor material.

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In this study, Eu³⁺ (fixed at 1 mol.%) activated Zn₄B₆O₁₃ phosphors incorporated with metal ions of different oxidation states M^{x+} (x = 1 - 4) were successfully prepared by combustion synthesis method using urea as a fuel. Partial substitution of metal ions with varying oxidation states enhanced the luminescence properties of Zn₄B₆O₁₃:Eu³⁺. The crystal structure properties of the prepared materials were studied by X-ray diffraction (XRD), which revealed the formation of a zinc metaborate cubic crystal structure for all the samples. Surface features and the elemental analysis of the phosphor materials were studied by SEM and EDS respectively. The optical properties analysed by the UV-Vis show that the metal ions that cause high reduction in the band gap of the material is that with M³⁺ oxidation state. The Fourier transform infrared spectroscopy (FTIR) method was used to study the molecular structure and chemical bonding of the prepared phosphors. Excitation and emission scans were recorded for different metal ions. Upon excitation at 395 nm, the emission spectrum exhibited five distinct peaks at 580 nm, 592 nm, 614 nm, 653 nm, and 706 nm, corresponding to the ⁵D₀ → ⁷F_J (J = 0 - 4) transitions, confirming the presence of the Eu³⁺ ion. The optimal emission of the Eu³⁺ dopant into the Zn₄B₆O₁₃ host was of M³⁺ substitution, which resulted in the phosphor achieving an excellent PL intensity and a color purity of 91.16%. Tunable luminescence from the reddish-orange area (0.620, 0.355) of Commission Internationale de l'éclairage (CIE) towards the red area (0.641, 0.351) was achieved by substituting different oxidation states M^{x+} (x = 1 - 4). Therefore, different oxidation states M^{x+} (x = 1 - 4) and Eu³⁺ doped Zn₄B₆O₁₃ phosphor may be suitable candidates for the development of display devices and white light emitting diodes.
Keywords: Phosphor, Luminescence, Metal ion, Color purity.

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