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Luminescence Study on the Impact of Alkaline Earth Metal Ions on Na3PO4:Ce3+ Phosphors for Colour Display Applications.

This study explores the impact of metal ions (Mg, Ca, Sr, and Ba) on the properties of Na₃PO₄. The resulting nanophosphors, NaMgPO₄, NaCaPO₄, NaSrPO₄, and NaBaPO₄, were synthesized using solid-state reaction techniques and doped with 1 mol% Ce³⁺. The synthesized nanophosphors were annealed at 900℃ for 4 hours, except for NaMgPO₄, which was annealed at 780℃ for the same duration. A combination of characterization techniques, including XRD, FE-SEM, UV-Vis, FTIR and PL spectroscopy, were employed to comprehensively characterize the phosphor materials. Additionally, Commission Internationale de l'Eclairage (CIE) plots were generated from the PL data to evaluate and compare the colour tuning properties of each phosphor material. XRD analysis revealed that NaMgPO₄ and NaSrPO₄ phosphors adopted monoclinic phase structures, whereas Na₃PO₄, NaCaPO₄, and NaBaPO₄ phosphors crystallized in orthorhombic phase structures. Notably, doping with 1 mol% Ce³⁺ did not alter the crystal structure phases of these phosphor materials. However, the particle sizes are confirmed to be in the range of 40 nm to 75 nm in all the prepared samples. SEM analysis revealed that all the prepared samples exhibited micrometer-scale dimensions, with varying sizes and shapes. Complementary energy-dispersive X-ray spectroscopy (EDS) spectra confirmed the presence of the expected chemical elements in the synthesized nanophosphors. The incorporation of Ce³⁺ ions into the NaSrPO₄ resulted in reduced absorption, confirming the presence of Ce³⁺ ions in the UV-visible region. The photoluminescence (PL) spectra of the Ce³⁺-doped samples were recorded with an excitation wavelength of 281 nm, and the emission spectra were monitored between 300-400 nm. A strong emission band centered at 385 nm was attributed to the 5d ⟶ 4f transition of the Ce³⁺ ions observed for all the doped nanophosphors. NaBaPO₄: Ce³⁺ exhibited the most intense photoluminescence. The CIE colour coordinates of the synthesized nanophosphors revealed a tunable light emission spanning from the blue to violet colour region with a range of colour purity of 58% to 97 %, respectively. This suggests that these nanophosphors have great potential for use in colour display systems as blue to violet light-emitting components.

Keywords: Nanophosphors, luminescence, solid-state reaction, effect of Mg, Ca, Sr, and Ba, Ce³⁺, and Colour tuning

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Primary author: SEFAGE, Amanda (University of Johannesburg)

Co-authors: SONDEZI, Buyisiwe (University of Johannesburg); Dr LETSWALO, Machaba Leanyatsa Abraham (University of Johannesburg)

Presenter: SEFAGE, Amanda (University of Johannesburg)

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