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Investigation on optical band gap, photoluminescence properties and concentration quenching mechanism of $\text{Pb}_{1-x}\text{Tb}^{3+}_x\text{WO}_4$ green-emitting phosphors

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Abstract

A series of monophasic Tb^{3+} (2, 5, 7, 10 and 15 at%) doped PbWO_4 phosphors were successfully prepared via hydrothermal method. X-ray diffraction patterns revealed that the prepared samples possess a high crystallinity with tetragonal scheelite-type structure. FT-IR and Raman analysis exhibited a W–O stretching peak of WO_4^{2-} group, which is also related to the scheelite structure. UV-visible diffuse reflectance spectra indicated a reduction in the optical band gap with the replacement of Pb^{2+} by Tb^{3+} ions. The presence of strong and intense emission peaks characteristic of Tb^{3+} with the dominant peak at 545 nm (green, $^5\text{D}_4 \rightarrow ^7\text{F}_5$ transition) under UV irradiation at 320 nm demonstrated an efficient energy transfer from the host to Tb^{3+} ions. Using Van Uitert's model, the concentration quenching mechanism between Tb^{3+} ions in $\text{PbWO}_4:\text{Tb}^{3+}$ phosphor was attributed to a dipole–dipole interaction and the critical distance was determined to be ~ 12 Å. The decay lifetimes and CIE chromaticity co-ordinates of $\text{PbWO}_4:\text{Tb}^{3+}$ phosphors were also investigated in detail. These prepared materials might serve as a potential phosphor for LED applications.

Keywords: $\text{PbWO}_4:\text{Tb}^{3+}$; photoluminescence; charge transfer; concentration quenching

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