Study of Photo- luminescence in Doped Metaphosphate NaCe(PO₃)₄

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Abstract

Inorganic Phosphor NaCe(PO₃)₄:Tb⁺ was synthesized by solid state diffusion method. The prepared sample was characterized by X-Ray diffraction and photoluminescence. The photoluminescence study shows doped Tb⁺ leads to a significant increase in the emission intensity in the range of 500-600 nm. This is due to the efficient energy transfer from Ce³⁺ to Tb⁺ under an excitation of 274 nm. Such phosphors can be used for UV lamps application in solid state lasers and in optical amplifiers.

In this paper photoluminescence in NaCe(PO₃)₄ and NaCe(PO₃)₄:Tb⁺ has been reported. Energy transfer phenomena have lead to the development of new and efficient photoluminescence materials.

Keywords: Cerium metaphosphate; Excitation and emission spectra; solid state synthesis; Energy Transfer.

1.0 INTRODUCTION

Rare Earth doped inorganic phosphors are used extensively in solid state lighting because they have long life, physical and chemical stability and environment friendly nature. The lanthanide ions like Tb³⁺ and Dy³⁺ in ortho and metaphosphates give a high quantum yield of visible Luminescence. Trivalent lanthanide ions are used extensively for optically pumped solid-state lasers because they possess suitable absorption bands and numerous fluorescence lines of high quantum efficiency in the visible and near-infrared.[1] Sensitization of characteristic fluorescence is a well known phenomenon on which a large number of experimental studies have been published.[2] Ce³⁺ has a strong absorption in many hosts and emission matching with 4f⁷ levels of other rare earth impurities, and thus it can be used as a sensitizer for Tm³⁺, Sm³⁺, Dy³⁺,

For NaCe(PO₃)₄:Tb³⁺ the constituents Ce(PO₃)₃ and NaPO₃ and sulphate Terbium were were taken in a stoichiometric ratio and crushed in a crucible for 1 h. Then this material was heated at 750°C for 20 hr, resulting in the compound NaCe(PO₃)₄:Tb in powder form. The samples were then slowly cooled at room temperature.
750°C
Ce(PO₃)₃ + NaPO₃ + Tb₂(SO₄)₃ → NaCe(PO₃)₄:Tb
20 hr

X-ray diffraction patterns were recorded on Philips PANalytical X’pert Pro diffractometer. Photoluminescence (PL) spectra in the spectral range 220-700 nm were recorded at room temperature on Hitachi F-4000 spectrofluorimeter with spectral slit widths of 1.5 nm.

### 1.1 RESULT AND DISCUSSIONS

Fig.1 shows the XRD of prepared NaCe(PO₃)₄. X-ray diffraction of prepared NaCe(PO₃)₄ is found to match with ICDD file 33-1233 of NaCe(PO₃)₄.

![XRD of NaCe(PO₃)₄](image)

The emission spectra of NaCe(PO₃)₄ shows intense PL emission with peaks at 327.6 nm and 346 nm which are due to transition from the lowest level of 5d configuration to the two ²F₅/₂, ²F₇/₂ multiples of the 4f¹ configuration in Ce³⁺ ions and half intensity peaks at 316 nm and 361 nm at λemn. =254nm(Fig.2). The PL excitation spectrum shows a broad band in the range 220 nm to 320 nm with peak at 298.6 nm, 254.4 nm and 227.6 nm and half intensity peaks at 310 nm and 282 nm at λemn. =346nm.

![PL spectra of NaCe(PO₃)₄](image)

Figure 2: PL spectra of NaCe(PO₃)₄.

Figure 3 shows Emission spectrum of NaCe(PO₃)₄ doped with 1% Tb and 5% Tb. For 5% Tb doping (curve b'), there is significant increase in the emission intensity in the range of 500-600nm showing transfer of energy from Ce³⁺ to Tb³⁺. For 1% doping of Tb³⁺ emission (curve b), it is excited at λext. =295nm and for Cerium, it is excited at λext. =254nm. For 5% doping of Tb³⁺, Ce³⁺ emission and Tb³⁺ emission takes place under an excitation of 274 nm. In emission spectra(curve b') peaks are observed at 379.6nm, 413.6nm, 434.8nm, 455.6nm, 487.2nm, 542.4nm and 585nm which correspond to ⁵D₄→⁷F₇, transitions of Tb³⁺. There is also weak emission in UV region (curve a,a') which is attributable to Ce³⁺ ions.

![PL spectra of NaCe(PO₃)₄:Tb(1mole%,5 mole %)](image)

Figure 3: PL spectra of NaCe(PO₃)₄:Tb(1mole%,5 mole %).

### 2.0 CONCLUSION

The metaphosphates NaCe(PO₃)₄ and NaCe(PO₃)₄:Tb have been successfully prepared. XRD of the synthesized compound matched excellently with the corresponding ICDD data files. At low concentrations blue emission is dominant. Near UV emission, at around 385 nm corresponding to ⁵D₄→⁷F₆ transition is also observable. For high concentrations, these emissions are quenched by cross relaxation and the green emission becomes dominant. Energy transfer phenomena have lead to the development of new and efficient photoluminescence materials. These phosphors may be applicable in scintillation applications and in the lamp industry.

### ACKNOWLEDGEMENT

Work received financial support from the Indian Council for Medical Research (ICMR), New Delhi. We are thankful to Dr. P.L. Muthal and Dr. S.M. Dhopte and his colleagues at National Environmental Engineering Research Institute, Nagpur for making PL measurements.

### References: