Luminescence Properties of $Cd_2P_2O_7$: Tb Phosphor Prepared by Slow Vaporization Method

Megha Rathod[1], Z. S. Khan[2*], N. B. Ingale[3], S. K. Omanwar[1]

[1]Department of Physics, SGB Amravati University, Amravati 444602 India
[2]Government Vidarbha Institute of Science and Humanities, Amravati 444604 India
[3]Prof. Ram Meghe Institute of Technology and Research, Badnera, Amravati-444701, India

Abstract

The luminescence properties of a newly prepared $Cd_2P_6O_7$: Tb inorganic phosphors, prepared first time by economical, simple and time saving slow vaporization synthesis technique are discussed. The structure of this prepared phosphor is characterized by using X-Ray diffraction. FTIR characteristics of the phosphor is also carried out. The photoluminescence (PL) measurement is carried out. It shows our sample exhibit emission with peaks at 488 nm, 534 nm and 550 nm corresponding to the transitions of Tb ion. The excitation spectra monitored at 550 nm shows broad intense excitation band at 236 nm. The phosphor shows CIE 1931 color coordinates as blue (x= 0.05466, y= 0.25409) and yellow (x= 0.3016, y= 0.6923) which combines to give white light. The phosphor is well suited for White light emitting diodes (WLED) applications.

Keyword: Phosphate; Luminescence; WLED

1. Introduction

Pyrophosphates with divalent metal ions are as well as alkaline earth metals are of great interest to the researchers. Apart from these, some are characterized by cation of small radii, have closely related structures in all their polymorphs [1-4] while others show four polymorphs [5-10]. Cadmium pyrophosphate are also investigated for various applications [11-13]. We tried a new method for the synthesis of pyrophosphates called slow Vaporization method keeping in mind the luminescence properties of it. We have already study rare earth doped phosphates $Ca_2P_2O_7$ by solution combustion synthesis method [14-16]. Not only doped but also pure pyrophosphates are supposed to be very important because of their multipurpose belongings including luminescent, dielectric, semiconductor, catalytic, magnetic, fluorescent and ion-exchange properties. Recently, Doat et al [17] and Schipper et al [18] proposed the luminescent applications of europium-doped calcium pyrophosphates and hafnium pyrophosphate. Hence we proposed the luminescence properties of this phosphor for it's used in white LED applications

2. Experimental

Polycrystalline $Cd_2P_2O_7$: Tb phosphor is prepared by slow Vaporization method. The Method is described in figure 1. The prepared sample was confirmed by Rigaku Miniflex X-Ray Diffractometer with scan speed of 10.00 deg/ min and with Cu Kα radiation (λ = 1.5406 Å).

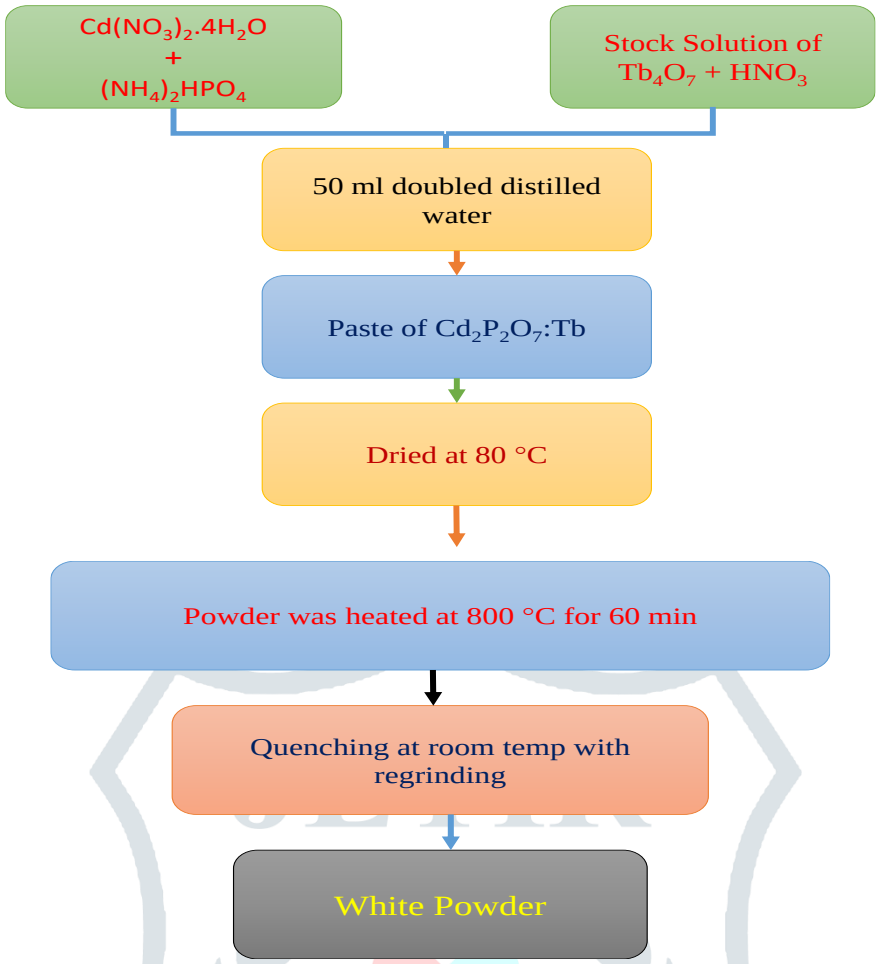

Figure 1. Experimental procedure for preparation of $Cd_2P_2O_7$: Tb

3. Results and Discussion

Fig shows the XRD structural pattern of $Cd_2P_2O_7$: Tb phosphor. It is done on Rigaku Miniflex X-ray diffractometer with the scan rate of 10 deg/min by Cu Kα radiations. The main peak matched with the standard data of the sample [13]

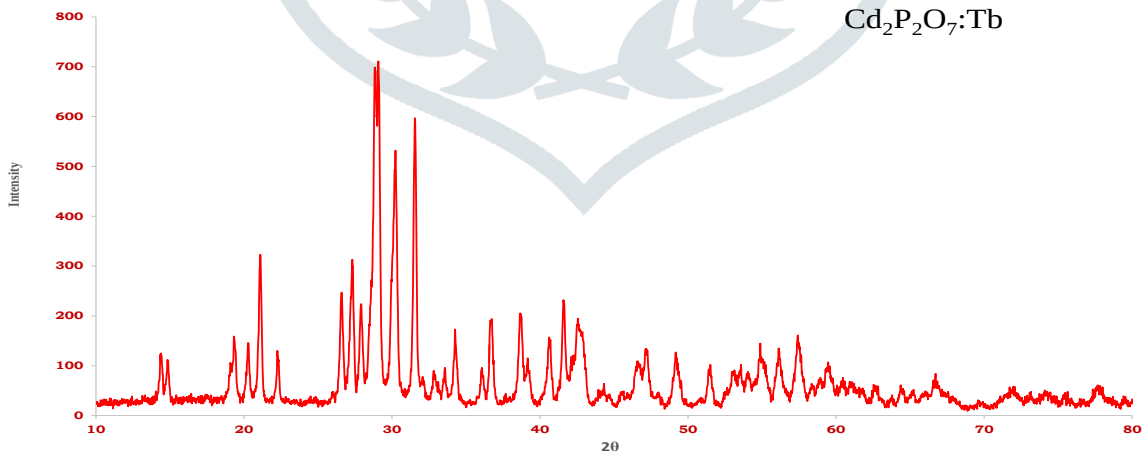

Figure 2. XRD image of $Cd_2P_2O_7$: Tb phosphor

The FTIR spectra of the $Cd_2P_2O_7$: Tb phosphor have been taken on SHIMADZU FTIR spectrometer as shown in figure 3. The FTIR revealed prominent absorption with peaks for $Cd_2P_2O_7$: Tb phosphor are at 3874, 2902, 1417, 1189, 1093, 1058, 881, 682, 662, 601, 576, 563, 533, 521 and 511 cm^{-1} as shown in figure. The peak at 1189 cm^{-1} is for Pentaborate group used for the preparation of $Cd_2P_2O_7$:Tb. The IR absorption

at wave numbers smaller than 500 cm^{-1} mainly originates from the lattice dynamic modes. The IR spectrum confirms the existence of both trigonally and tetrahedrally coordinated boron atoms, consistent with the results obtained from the crystallographic study [19]

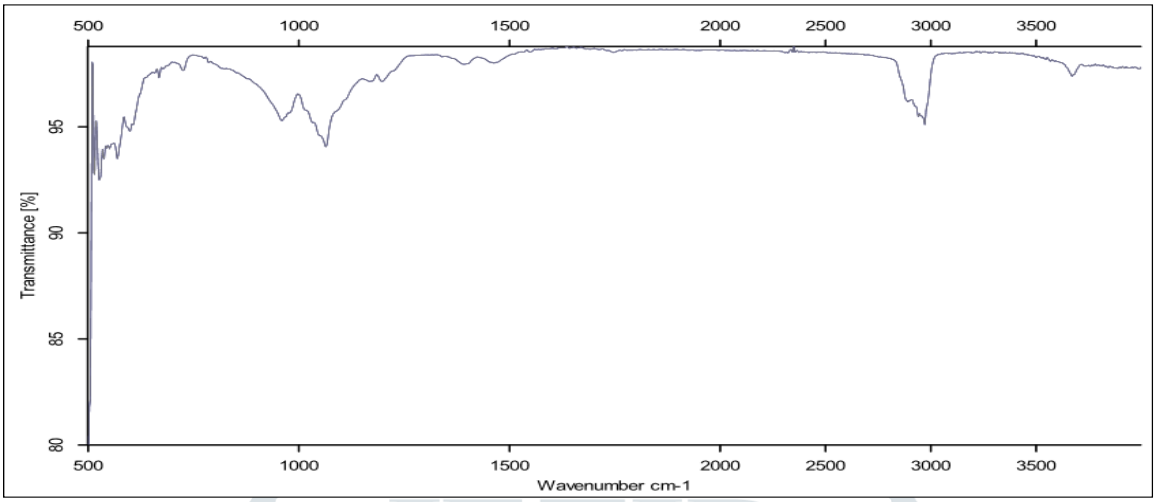

Figure 3. FTIR image of $Cd_2P_2O_7$: Tb phosphor

The photoluminescence spectra of our powder sample $Cd_2P_2O_7$: Tb was taken to confirm the existence of Tb in it. The phosphor $Cd_2P_2O_7$: Tb shows characteristic emission of Tb at 482 nm, 534 nm and 550 nm due to its characteristics transition on excitation with optimum 236 nm wavelength. The optimum concentration of Tb for $Cd_2P_2O_7$: Tb was found to be 0.005 moles. The PL spectra indicates the characteristic emission of Tb as shown in figure.

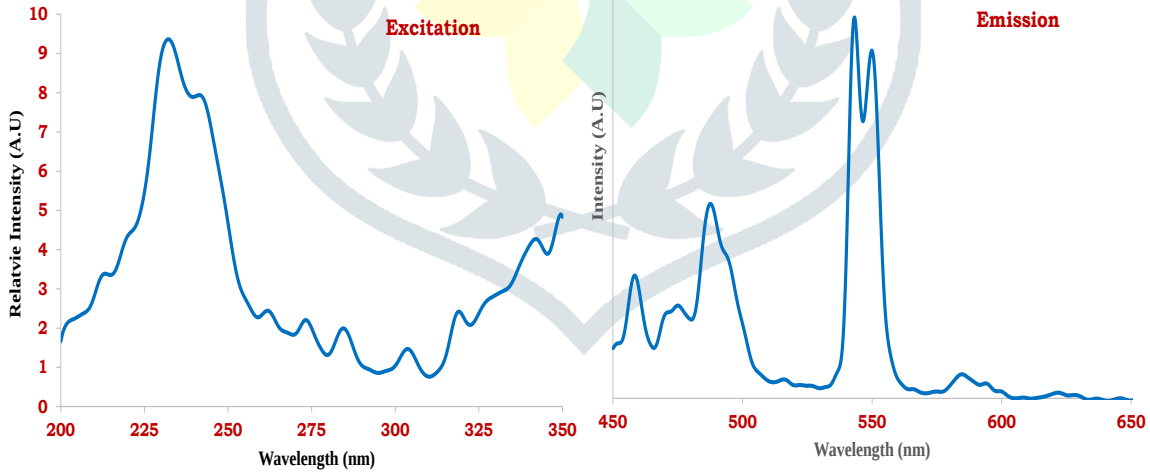

Figure 4. Excitation and Emission of $Cd_2P_2O_7$: Tb phosphor

The CIE coordinates of prepared phosphor was calculated and found for blue (x= 0.05466, y= 0.25409) and yellow (x= 0.3016, y= 0.6923) as shown in figure 5.

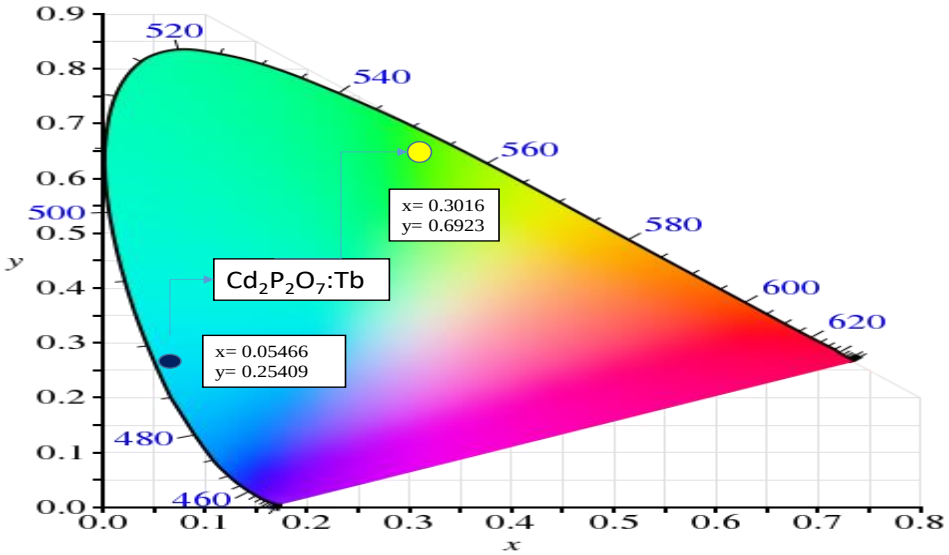

Figure 5. CIE image of $Cd_2P_2O_7$: Tb phosphor

4. Conclusion

In current report X-ray diffraction result support the crystalline formation of $Cd_2P_2O_7$: Tb by slow vaporization synthesis method while PL spectra support the role of activator Tb in it. The FTIR of the sample is studied. From the photoluminescence studies we can conclude that this phosphor $Cd_2P_2O_7$: Tb, was said to be a good candidature for white LED applications.

References

1. K. Lukaszewicz, R. Smajiewicz. Rocz, Chem. 35 (1961) 741
2. B. E. Robertson, C. Calvo, Acta Cryst. 22 (1967) 665
3. C. Calvo, Acta Cryst. 23 (1967) 289
4. K. Lukaszewicz, Bull. Acad. Po1. Sci. Ser. Sci. Chim, 15 (1967) 47
5. C. Calvo, Inorg. Chem. 7 (1968) 1345
6. N. C. Webb, Acta Cryst, 21 (1966) 942
7. L. Hagman, I. Jansson, C. Magneli, Acta Chem. Scand., 22 (1968) 1419
8. Z. S. Khan, N. B. Ingale, S. K. Omanwar, Mater. Lett., 158 (2015) 143-146
9. Z. S. Khan, N. B. Ingale, S. K. Omanwar, Materials Today: Proceedings 2 (2015) 4384-4389
10. Z. S. Khan, N. B. Ingale, S. K. Omanwar, AIP Conference Proceedings 1953 (2018) 070024
11. P. K. L. Au, C. Calvo., Can. J. Chem. 45 (1967) 2297
12. C. Calvo, P. K. L. Au, Crystal structure of $Cd_2P_2O_7$, C. J. Chem., 47 (1969) 3109
13. L. Song, J. Yang, P. He, S. Zhang, Cer. Int., http://dx.doi.org/10.1016/j.ceramint.2016.10.183.
14. Z. S. Khan, N. B. Ingale, S. K. Omanwar, Environ Sci. Pollut. Res, 23 (2016) 9295-9302
15. Z. S. Khan, N. B. Ingale, S. K. Omanwar, Opt-Int J Light Electron Opt., 127 (2016) 9679-9682
16. Z. S. Khan, N. B. Ingale, S. K. Omanwar, Opt-Int J Light Electron Opt., 127 (2016) 6062-6065
17. A. Doat, F.Pelle, A. Lebugle, J. Solid State Chem. 178 (2005) 2354-2358
18. W. J. Schipper, J. J. Piet, H. J. De Jager, G. Blasse, Mater. Res. Bull. 29 (1994) 23-27
19. C. C. Ribeiro, I. Gibson, M. A. Barbosa, Biomat., 27 (2006) 1749-1752].