How to Cite:
Samuel, T., & Kamal, C. h. S. (2022). Investigation of Luminescence properties of Bi3+, Dy3+ doped LaAlO3 nanophosphors for radiation dosimetry applications. *International Journal of Health Sciences*, *6*(S1), 11638–11642. https://doi.org/10.53730/ijhs.v6nS1.7851

Investigation of Luminescence properties of Bi^{3+}, Dy^{3+} doped $LaAlO_3$ nanophosphors for radiation dosimetry applications

T. Samuel
Physics Division, Department of Basic Science & Humanities, GMR Institute of Technology, Rajam-532127, A.P., India
Corresponding author e-mail: samueltalari82@gmail.com

Ch. Satya Kamal
Crystal Growth and Nanoscience Research Centre, Department of Physics, Government College (A), Rajamahendravaram-533105, A.P., India

***Abstract*---**Bi, Dy co-doped $LaAlO_3$ nanophosphors were synthesized by adopting the Polyol technique to study enhanced photoluminescence. PXRD and Photoluminescence characterizations were done to probe the structure and luminescence studies of the synthesized nanophosphors. It was found that Dy^{3+} ions has exhibited excellent characteristic emission at 576nm with an increase in photoluminescence during the $^4F_{9/2}$–$^6H_{13/2}$ transition when compared with single doping and co-doping with Bi^{3+}. The results indicated that the developed ($LaAlO_3$: Bi^{3+}, Dy^{3+}) phosphors under UV radiation could be suitable to be used for radiation dosimetry in cancer applications.

***Keywords*---**Polyol method, Bismuth co-doping, Photoluminescence, Radiation dosimetry.

Introduction

Lanthanum Aluminate ($LaAlO_3$) based perovskite nanophosphors are well-known for their usage radiation dosimetry in treatment of cancer. [1-4]. $LaAlO_3$ has a typical rhombohedral structure with a wide band gap (~5.6 eV) [5-8]. Doping of the $LaAlO_3$ with optically active trivalent rare earth ions (Eu^{3+}, Tb^{3+}, Dy^{3+} etc.,) or d-metals (Bi^{3+}) made it to exhibit increased luminescence properties to be useful for various medical applications[3,9,10].Teodoro Rivera-Montalvo et al [11] has reported the luminescence properties of $LaAlO_3$: Dy^{3+} with appreciable increase in emission of Dy^{3+} ions for radiation dosimetry applications. According to B.Jacquier [12] Bi^{3+} acts as a good activator of luminescence and it is proved that Bi^{3+} could be used as sensitizer ion to enhance the luminescence efficiency of rare earth ions in $GdAlO_3$ phosphors [13-14]. C.S.Shalgaonkar also reported the

luminescence properties of Bi and Dy co-doped CaS phosphors. Based on the the above reports, it is believed that co-doping with Bi^{3+} ions the luminescence properties of rare earth ions could be greatly enhanced. In this work, we have done the synthesis and characterization of $LaAlO_3$: Bi^{3+} nanophosphors co-doped with rare-earth Dy^{3+} ions and made an effort to look into the enhanced photoluminescence properties and investigated the possibility of synthesized phosphors to useful for radiation dosimetry applications under UV radiation.

Experimental details

$LaAlO_3$:Bi^{3+} and Dy^{3+} nanopowders were prepared by low temperature chemical route Polyol method. The precursors are taken as per the standard stoichiometry. The obtained nanopowders are characterized for XRD, Photoluminescence properties.

Results and Discussions
Powder X-ray Diffraction (PXRD) Analysis

The diffraction patterns of undoped $LaAlO_3$, $LaAlO_3$: Bi^{3+}, $LaAlO_3$: Bi^{3+}, Dy^{3+} nanophosphors annealed at 700^{O}C are shown in Fig.2. A single rhombohedral phase of $LaAlO_3$ with perovskite structure is observed, which is in good agreement with the standard data of $LaAlO_3$ (JCPDF 00-031-0022 for $LaAlO_3$. The PXRD showed characteristic peaks of the rhombohedral $LaAlO_3$ with (012), (110), (202), (024), (122), (214) or (208) planes. The planes (012) and (110) were recognized as characteristic reflections of rhombohedral $LaAlO_3$ [15].

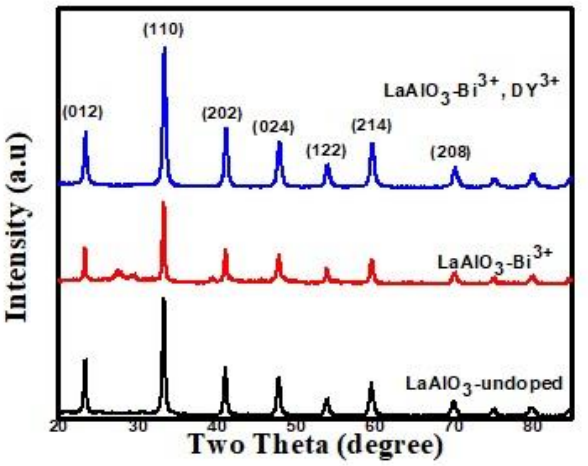

Fig.2 PXRD Patterns of 700^{o}C heated undoped, Bi^{3+} doped and Dy^{3+} co-doped $LaAlO_3$ nanophosphors

Photoluminescence (PL) from $LaAlO_3$: Bi (1 at %), Dy (1, 1.5, 2 at %) nanophosphors

The Figs. 3(a) & 3(b) demonstrate the PL emission and excitation spectra of $LaAlO_3$: (1 at. %) Bi^{3+}, (1, 1.5, 2 at %) Dy^{3+} nanophosphors. Under 278 nm excitation, blue-green and yellow emission lines due to Dy^{3+} were found from $LaAlO_3$: (1 at.%) Bi^{3+} , (1, 1.5, 2 at. %) Dy^{3+} samples. By keeping Bi^{3+} constant at 1 at. % and varying the Dy^{3+} content, the intensity of Bi^{3+} emission decreases gradually, while the intensity of Dy^{3+} emission increases, and reaches a maximum at Dy^{3+} (1.5 at. %), and then remarkably decreases on further increase in concentration. This is called as concentration quenching. After exciting at 278 nm, the $LaAlO_3$: (1 at. %) Bi^{3+}, (1, 1.5, 2 at. %) Dy^{3+} nanophosphor exhibited a bright yellow-greenish color luminescence and the emission spectrum [Fig. 3(a)] consists of Dy^{3+} ions characteristic peaks at 483 nm corresponding to $^4F_{9/2} \rightarrow {}^6H_{15/2}$ transition and at 576 nm relating to $^4F_{9/2} \rightarrow {}^6H_{13/2}$ transitions and 645 nm corresponding to $^4F_{9/2} \rightarrow {}^6H_{11/2}$ of Dy^{3+} respectively. The strongest emission peak is situated at 576 nm relating to the transition $^4F_{9/2} \rightarrow {}^6H_{13/2}$ of Dy^{3+}. In addition to this, from excitation spectra (Fig. 3(b)), when monitored at 575 nm, which is the typical $^4F_{9/2} - {}^6H_{13/2}$ emission line of Dy^{3+} ion along with broad band cantered around 278 nm of highest intensity in the near UV region due to Bi^{3+} co-doping. Few low intensity peaks are observed at 353 and 387 nm relating to $^6H_{15/2} \rightarrow {}^6P_{5/2}$ and $^6H_{15/2} \rightarrow {}^4G_{11/2}$ transitions of Dy^{3+}. This means Dy^{3+} is sensitized by the excited Bi^{3+} which demonstrates the existence of an efficient energy transfer (ET) from the Bi^{3+} to Dy^{3+} ions.

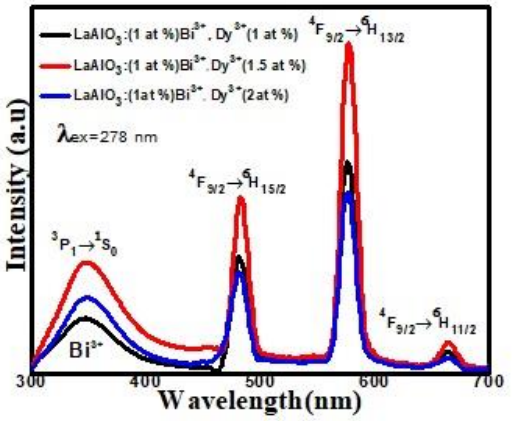

Fig. 3(a) Emission of spectra of $LaAlO_3$: Bi^{3+}, Dy^{3+} nanophosphors

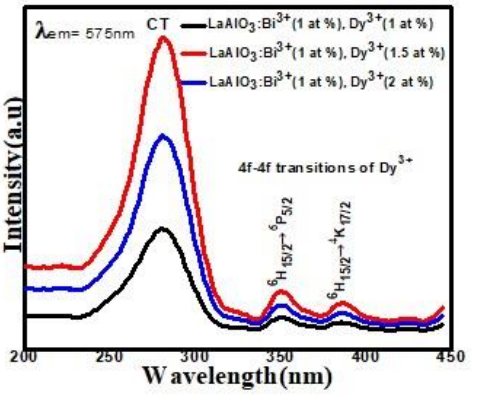

Fig. 3(b) Excitation of spectra of $LaAlO_3$: Bi^{3+}: Dy^{3+} nanophosphors

Conclusions

Bi and Dy co-doped $LaAlO_3$ nanophosphors were synthesized using the Polyol. Photoluminescence characterizations were done to investigate luminescence properties of Dy3+ ion doped with Bi^{3+}. It was found that Dy^{3+} ions had an outstanding characteristic emission at 576nm with an increase in photoluminescence during the $^4F_{9/2}$–$^6H_{13/2}$ transition when compared with single doping and co-doping with Bi^{3+}. The results confirmed the feasibility of these materials to be useful in radiation dosimetry applications when undergone with thermo luminescence studies.

References

[1] N. Alves, W.B. Ferraz, L.O. Faria, Radiation Measurements 71 (2014) 90-94.
[2] Pazik, R.; Tekoriute, R.; Hakanson, S.; Wiglusz, R.; Strek, W.; Seisenbaeva, G. A.; Gun'ko, Y. K.; Kessler, V. G. Chem.Eur. J, 15(2009) 6820.
[3] Liu, X.; Lin, J. Solid State Sci. 11 (2009) 2030.
[4] Sun, C.; Wang, J.; Hu, P.; Kim, M. J.; Xing, X. Dalton Trans. 39 (2010) 5183.
[5] Robert Pazik,, Gulaim A. Seisenbaeva, Rafal J. Wiglusz, Leszek Kepinski and Vadim G. Kessler, Inorg. Chem., 50 (2011) 2966–2974.
[6] P. Ma, Y. Song, B. Yuan, Y. Sheng, C. Xu, H. Zou, K. Zheng, Ceramics International 43 (2017) 60–70.
[7] J. Young Park , H. Chae Jung , G. Seeta Rama Raju, B. Kee Moon, J. Hyun Jeong, S.Mo Son, J. Hwan Kim, Materials Research Bulletin 45 (2010) 572–575.
[8] Zhong-Qing Tian, Hong-Tao Yu, Zhen-Lin Wang, Materials Chemistry and Physics 106 (2007) 126–129.
[9] Ryba-Romanowski,W.; Gozab, S.; Dominiak-Dzik, G.; Sok_olska, I.; Berkowski, M. J. Alloys Compd. 22 (1999) 284.
[10] Lakshminarasimhan, N.; Varadaju, U. V. Mater. Res. Bull. 41 (2006) 724.
[11] TeodoroRivera-Montalvo[a]RosalbaAlvarez-Romero[a]AlfredoMorales-Hernández[b]JuanZarate- Medina, Physical Review B 59 (1999) 4146–4153.

[12] B. Jacquier, G. Boulon, G. Sallavuard F. Gaume-Mahn, Journal Of Solid State Chemistry 4 (1972) 374-378
[13] P. Delugas, V. Fiorentini, A. Filippetti, Physical Review B 71 (2005)134302.
[14] X.R. Dong, X.Y. Cui, Z.L. Fu, S.H. Zhou, S.Y. Zhang, Z.W. Dai, , MaterialsResearch Bulletin 47 (2012) 212–216.
[15] M. M̨aczka, A. Bednarkiewicz, E.M. Mendoza, A.F. Fuentes, L. K̨epi´nski, Journal of Solid State Chemistry 194 (2012) 264–269.