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# OPTICAL AND LUMINESCENCE STUDY OF CE3+ DOPED NAAL5O8 NOVEL PHOSPHOR

Physics

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## ABSTRACT

Cerium ions activated NaAl5O8 nano-phosphors were prepared by solution combustion synthesis. The prepared powder samples were characterized by Ultraviolet visible spectroscopy (UV–vis) and Photo-luminescence technique (PL). Under 320 nm excitation wavelength, the PL emission spectrum of Ce3+ activated NaAl5O8 nano-phosphor shows broad emission centered at 322 nm, which is ascribed due to the transitions of the 5d excited state to its ground-state configurations of the 2F7/2 of the Ce3+ ions. Therefore, these synthesized phosphors may be applicable in display devices and solid state lighting applications.

## KEYWORDS

Sodium Aluminate, Ce3+, NaAl5O8

### INTRODUCTION:

Luminescence field is now an emerging research field for researchers because of the applications of the luminescent materials in different fields. The luminescent materials are widely used in different applications such as display devices, CRO tubes, radiation dosimetry, solid state lighting, X-Ray imaging, Hg discharge lamps and LED's optical paints, optical amplifiers, lasers [1–4] and also it is used as luminescent stains for biomedical analysis, medical diagnosis, and cell imaging. Some luminescent materials are developed to use in the solar concentrator [5]. In many of these applications rare earth element ions are used as luminescent centres.

The rare earth elements possess unique properties than the other elements i.e. the partially filled 4f shells [6] The rare earth activated phosphors have attracted much attention for their high luminescence efficiency, color purity, long emission lifetimes values, and potential applications in different fields [7–10]. The luminescent property of rare earth activated phosphors strongly depends on host compositions, morphologies, sizes, crystalline nature etc. [11,12]. The Rare earth ions show unique optical property when these are doped into host materials. The ions of rare earth elements act as activators in solid solution of host compounds and show the luminescence property. The luminescence property of these ions results from the electronic transitions occurring within the partially filled 4f energy shell [13]. Recently different rare earth element activated many aluminates host are invented and studied by the researchers [13–16].

Characteristic emission of Ce3+ in the UV or blue and violet spectral region originates from parity allowed electric dipole transitions between the excited 5d and ground 4f states. The wide emission in cerium doped compound observed due to the expansion produced due to the addition of the cerium in the material. No one has carried out work related to the NaAl5O8 in any field as well as field of luminescence, so we have selected this material for our study. The aim of the present work was to prepare and study of the optical properties of Ce3+ activated NaAl5O8 phosphor. The samples were prepared using solution combustion synthesis then characterized using UV spectroscopy and PL technique.

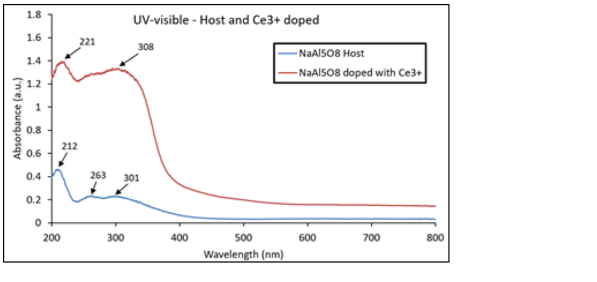
### Methodology:

Different chemical and physical methods are available to prepare the materials, among these methods the combustion synthesis is novel technique to prepare materials because of easy, less time consuming and less assembly requirements. Therefore, we have selected the combustion synthesis method for the preparation of the samples. The novel Ce3+ NaAl5O8 phosphors was prepared by using the solution combustion synthesis with 99.9 AR grade precursors. The precursors used for the synthesis were NaAl5O8 as host, Ce3+ as dopant and urea as fuel agent. All these precursors were weighted with stoichiometric ratio. The weighted Ce3+ was dissolved into 0.2475 gm nitric acid with warm heating. The prepared solution of Ce3+ and remaining precursors were dissolved into 20 mL deionized water. This solution was stirred for 30 min resulting into the homogeneous solution. The homogeneous solution was then transferred into furnace which was maintained at the 550 ◦C temperature. The solution was boiled and ignition took place due to the urea used as the fuel agent. During ignition different gases were evolved out and foamy material was obtained. Prepared material was grinded and nano-structured sample was obtained. These prepared samples are further characterized and studied by different characterization techniques.

### Result Analysis:

### UV-Visible Spectroscopy Analysis:

Fig. 1shows the UV spectra of the NaAl5O8 host, Ce3+ doped NaAl5O8. The UV–vis absorption spectrum of NaAl5O8 host Ce3+ doped NaAl5O8 recorded in the range of 200 nm–800 nm at room temperature. The notable change in the absorption spectra is well seen in terms of the intensity and absorption edge. The increase in the UV absorbance is observed due to more and more electrons are excited and gone into the excited state due to excitation of Ce3+ ions doped in NaAl5O8 than the pure NaAl5O8. The peak at 308 and 301 nm confirms the formation of sodium aluminate according to Liu et.al. [19].




**The fig.1:** UV-visible spectra of the NaAl5O8 and Ce3+ doped NaAl5O8 phosphor

### Photoluminescence (PL) Spectroscopic Analysis:

Fig. 2 and Fig.3 represents the PL emission spectra of NaAl5O8 host and Ce3+ activated NaAl5O8 are monitored under 300 nm excitation wavelength at room temperature. The concentration of Ce3+ in the host NaAl5O8 is 1m%. The peak is observed at 322 nm for the 1 mol% of Ce3+ doped NaAl5O8 and for host the peak is observed at 395 nm. According to PL emission spectra, it is observed that with increase in the concentration Ce3+ ion in NaAl5O8 host, the intensity of the emission is increased and the peak is observed for 1 mol% Ce3+ doped NaAl5O8.

The excitation energy 320 nm matches with the separation between lowest excited state of 5d orbit and ground state of the 4f orbit of the Ce3+ ion. The ground state of Ce3+ ion consist two levels 2F5/2 and 2F7/2 and the transition takes place from lowest 5d level to these two ground state levels. The separation between these two ground states depends upon the surrounding of the Ce3+ ion. If the crystal field strength is strong then the quantization of the two ground states 2F5/2 and 2F7/2 is takes place and these two levels make a one ground state level which shows emission at a single wavelength with broad peck [17,18]. The high emission intensity peck of the synthesized Ce3+ doped NaAl5O8 phosphor is observed at the 322 nm and therefore this phosphor may be applicable to UV excitation and blue light emission lamps.

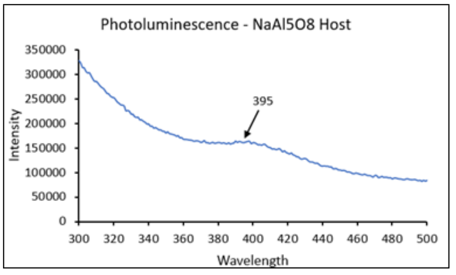



**Fig.2:** Pl emission spectra of NaAl5O8 host

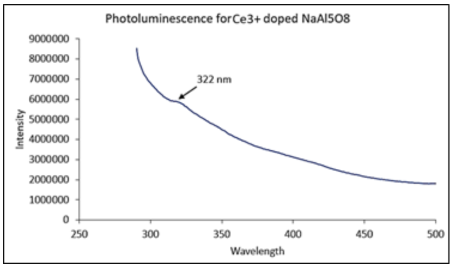



**Fig.3:** Pl emission spectra of Ce3+ doped NaAl5O8 phosphor

## CONCLUSION:

The Ce3+ activated NaAl5O8 nano phosphor prepared by using solution combustion synthesis. NaAl5O8 confirms by the peak obtained using UV-Visible spectra and also it shows the shifting in absorbance due to the Ce3+ doping in NaAl5O8 phosphor. PL measurement has shown the peak at 322 nm for 1 mol% concentration and hence it may be applicable to the light emitting devices.

## REFERENCES:


[1] D.S. Bobade, P.B. Undre, Synthesis and luminescence properties of Eu3+ doped Sr2SiO4 phosphor, Integr. Ferroelectr. 205 (2020) 72–80, https://doi.org/10.1080/10584587.2019.1675001.

[2] A. Edgar, Luminescent material, springer handbook. Electroni and Photonic Materials, 2nd edt., Springer, Cham, 2017, pp. 997–1012, https://doi.org/10.1007/978-3-319-48933-9. Part D.

[3] P. Mahbub, M. Macka, Radiometric characterisation of light sources used in analytical chemistry – a review, Anal. Chim. Acta 1123 (2020) 113–127, https://doi.org/10.1016/j.aca.2020.04.048.

[4] Z. Xia, A. Meijerink, Ce3+-Doped garnet phosphors: composition modification, luminescence properties and applications, Chem. Soc. Rev. 46 (2017) 275–299, https://doi.org/10.1039/c6cs00551a.

[5] C. Yang, R.R. Lunt, Limits of visibly transparent luminescent solar concentrators, Adv. Opt. Mater. 5 (2017) 1–10, https://doi.org/10.1002/adom.201600851.

[6] P. Li, Z. Wu, F. Wu, C. Cao, C. Guo, Y. Wu, Y. Liu, Z. Sun, C.M. Cheng, D.S. Lin, F. Steglich, H. Yuan, T.C. Chiang, Y. Liu, Tunable electronic structure and surface states in rare-earth monobismuthides with partially filled f shell, Phys. Rev. B 98 (2018) 1–10, https://doi.org/10.1103/PhysRevB.98.085103.

[7] Y.R. Parauha, V. Chopra, S.J. Dhoble, Synthesis and luminescence properties of RE3+ (re = eu3+, Dy3+) activated CaSr2(PO4)2 phosphors for lighting and dosimetric applications, Mater. Res. Bull. 131 (2020) 110971, https://doi.org/10.1016/j.materresbull.2020.110971.

[8] Y.R. Parauha, R.S. Yadav, S.J. Dhoble, Enhanced photoluminescence via doping of phosphate, sulphate and vanadate ions in Eu3+ doped La2(MoO4)3 downconversion phosphors for white LEDs, Opt. Laser Technol. 124 (2020) 105974, https://DOI:10.1016/j.optlastec.2019.105974.

[9] A. Zhang, W. Xu, R. Chen, Z. Wang, Q. Yan, Y. Miao, H. Jia, B. Xu, W.Y. Wong, Program controlling the emission color of blend polymer phosphors containing Eu (III), Tb(III), Be(II) ions for WLEDs, Opt. Mater.89 (2019) 250–260, https://doi.org/10.1016/j.optmat.2019.01.030.

[10] B. Fan, W. Zhao, L. Han, Eu3+ co-doped Sr3Gd(PO4)3:Dy3+ phosphors: luminescence properties and color-tunable white-light emission for NUV-WLEDs, Appl. Phys. A Mater. Sci. Process. 126 (2020) 1–10, https://doi.org/10.1007/s00339-020-3444-5.

[11] P. Halappa, H.M. Rajashekar, C. Shivakumara, Synthesis and structural characterization of orange red light emitting Sm3+ activated BiOCl phosphor for WLEDs applications, J. Alloys. Compd. 785 (2019) 169–177, https://doi.org/10.1016/j.jallcom.2019.01.155.

[12] T. Grzyb, M. Runowski, A. Szczeszak, S. Lis, Structural, morphological and spectroscopic properties of Eu3+-doped rare earth fluorides synthesized by the hydrothermalmethod, J. Solid State Chem. 200 (2013) 76–83, https://doi.org/10.1016/j.jssc.2013.01.012.

[13] K.A. Gedekar, S.P. Wankhede, S.V. Moharil, R.M. Belekar, D–f luminescence of Ce3+ and Eu2+ ions in BaAl2O4, SrAl2O4 and CaAl2O4phosphors, J. Adv.Ceram. 6 (2017) 341–350, https://doi.org/10.1007/s40145-017-0246-0.

[14] K. Ganesh Kumar, P. Balaji Bhargav, K. Aravinth, R. Arumugam, P. Ramasamy, Dysprosium activated strontium aluminate phosphor: A potential candidate forWLED applications, J. Lumin. 223 (2020) 117126, https://doi.org/10.1016/j.jlumin.2020.117126.

[15] Y.F. Liu, S.G. Zhang, B. Liu, H.L. Shen, An alkaline fusion mechanism for aluminate rare earth phosphor: cation–oxoanion synergies theory, Rare Met. Mater. Eng. 38 (2019) 299–305, https://doi.org/10.1007/s12598-017-0898-5.

[16] X. Zhang, J. Zhang, X. Wu, L. Yu, Y. Liu, X. Xu, S. Lian, Discovery of blue-emitting Eu2+-activated sodium aluminate phosphor with high thermal stability via phase segregation, Chem. Eng. J. 388 (2020) 124289, https://doi.org/10.1016/j.cej.2020.124289.

[17] X. He, X. Liu, R. Li, B. Yang, K. Yu, M. Zeng, R. Yu, Effects of local structure of Ce3+ ions on luminescent properties of Y3Al5O12:Ce nanoparticles, Sci. Reports 6 (2016) 22238, https://doi.org/10.1038/srep22238.

[18] A. Selot, M. Aynyas, M. Tiwari, K. Dev, Synthesis, characterization and photo luminescence study of Ce3+ activated aluminates based phosphor, AIP Conf. Proc. 1728 (2016), https://doi.org/10.1063/1.4946314, 020263-1–020263-3.

[19] Liu, W., Huang, Y., Yin, Z., & Ding, Z. (2018). Investigation on the decomposition process of sodium aluminate solution by spectroscopic and theoretical calculation. Journal of Molecular Liquids, 261, 115–122. doi:10.1016/j.molliq.2018.04.014