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Synthesis and Characterization of Sm_2O_3 Nanoparticles using combustion method

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Abstract - *In the past decades, rare earth oxide nanoparticles have been used in wide range of diverse photoluminescent applications. In the present investigations, we report a simple and inexpensive technique of synthesizing Sm_2O_3 nanocrystalline powders using combustion method. Powder X-ray diffraction (XRD) was used to study the structural characterization of the synthesized sample and the results confirmed that samarium sesquioxide nanoparticles having a nanocrystalline structure with a cubic phase were formed. The surface morphology and the size of the particles were examined using scanning electron microscopy (SEM) and transmission electron microscopy (TEM). TEM results confirmed that spherical nanoparticles were formed. The optical properties of the sample were studied using ultraviolet-visible (UV-Vis) data analysis and photoluminescence (PL) studies. These properties revealed that they can be promising materials for luminescent applications.*

***Key Words*: Sm_2O_3 nanoparticles, combustion method, Photoluminescence.**

1.INTRODUCTION

Nano materials have captured global interest due to their exceptional physical and chemical properties arising from the morphology, dimensionality and size of the materials. These exhibit exceptional and functional electronic, optical, and magnetic properties which has numerous applications in various fields [1-2]. There has been an immense interest in the field of materials science in developing new luminescent materials. Nanoscale phosphors may have advantages over traditional micron-sized phosphors. Rare earth oxides have been broadly investigated due to their unique and interesting properties such as enhanced luminescence efficiency; lower lasing threshold, high-performance luminescent devices, catalysts, etc. It is reported that these changes in electrical and optical characteristics of very tiny particles are caused due to quantum effects owing to their high surface to volume ratio, which in turn increases the band gap, and improves surface and interfacial effects [3, 4]. Inorganic luminescent materials are of great interest because of their various potential applications. Now-a-days interest in this field is focused on the synthesis of phosphors by using better techniques and investigating novel applications in electronics, photonics, displays, detectors, optical amplification and fluorescent sensing devices. The rare earth oxides have been synthesized by various methods including microwave-assisted, solvothermal, sol gel, hydrothermal, solution combustion, co-precipitation etc. [5-10].

Among rare earth oxides, Samarium oxide (Sm_2O_3) is one of the important rare earth oxide materials and has been largely studied [11]. Samarium oxide nanoparticles are highly thermally stable and it is suitable for glass, optic, ceramic, catalytic applications, solar cells, nanoelectronics, semiconductor gases and biochemical sensors [12-14]. In this paper we have synthesized Sm_2O_3 using the combustion method. Of the methods used in material synthesis, combustion processes have some significant advantages, such as low-cost, reduced processing time, high efficiency, simple and convenient. Nanopowders with high purity can be easily synthesized in a very short time.

2. EXPERIMENTAL

Samarium (III) nitrate hexahydrate and urea (2.5 gm) were taken in a beaker. Urea was used as a fuel for combustion synthesis. Distilled water was added to it and was kept under magnetic stirring until a homogeneous solution was formed. It was then allowed to dry on a hot plate. The resulting powder was transferred into a crucible and then placed in the furnace at 1000°C for 3 hours.

3. RESULTS AND DISCUSSIONS

3.1 Powder X-ray Diffraction Analysis

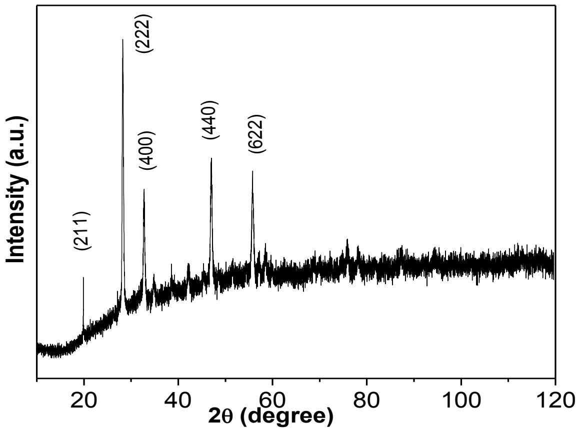

Fig -1: Indexed XRD of Sm_2O_3 nanoparticles.

Figure 1 shows the powder X-ray diffraction pattern of the synthesized Sm_2O_3 nanoparticles. Using the software Powder X the diffractogram is imported. After smoothening the data, separating the background and subtracting from the total profile, Cu-Kα_2 profile has been stripped out of the recorded profile. The peaks of the sample were identified and indexing was done. The prominent peaks are indexed and are shown in the given figure of the powder X-ray diffraction pattern. On comparing these peaks with JCPDS data (No. 65-3183), it was confirmed that these belong to cubic system with $Ia\bar{3}$ space group and lattice parameters a=b=c=10.91Å. The crystallite size was calculated using the Scherrer equation, $\tau = \frac{0.9\lambda}{\beta cos\theta}$ where τ is the average grain size of the crystallites, λ is the incident wave length, β is the line broadening at half the maximum intensity (FWHM), θ is the diffraction angle [15]. The average crystallite size was found to be around 5nm.

3.2 SEM Analysis

The morphology of the prepared nanopowder was examined using a scanning electron microscope (SEM) and the image is shown in Figure 2. The surface morphology observed in the SEM micrograph of Sm_2O_3 nanoparticles showed small amount of agglomeration.

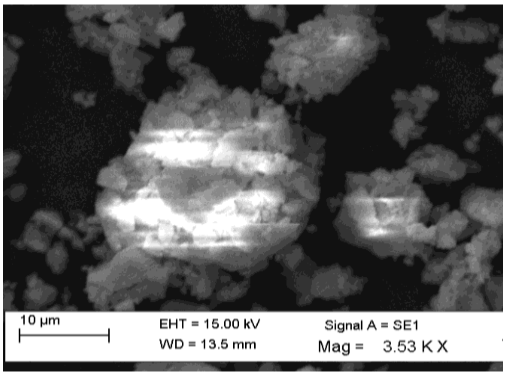

Fig -2: SEM image of Sm_2O_3 nanoparticles

3.3 TEM Analysis

TEM result confirmed that the synthesized Sm_2O_3 particles were spherical and in nano range. The TEM image obtained is shown in the Figure 3 (a) and the corresponding selected area electron diffraction (SAED) pattern in Figure 3 (b).The particle size was found to be around 15nm. Spotty annular rings are seen in the SAED pattern which further indicates the crystalline nature and reduced size of the particles.

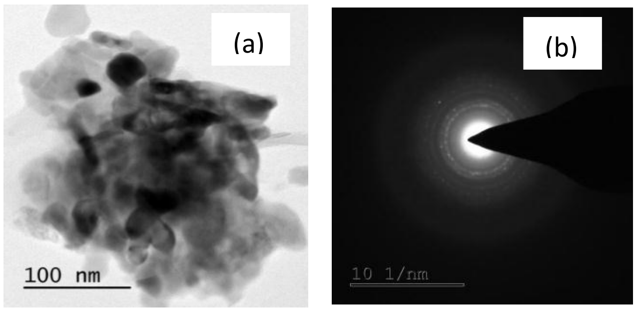

Fig -3: (a) TEM image of Sm_2O_3 nanoparticles (b) SAED pattern of Sm_2O_3 nanoparticles.

3.4 UV- Vis Analysis

Figure 4 represents UV-Vis absorption spectrum of Sm_2O_3 nanoparticles. Of the several absorption peaks, the strongest peak located at 405 nm is assigned to $^6H_{5/2} \rightarrow {}^6P_{3/2}$ transition. This excitation peak wavelength exactly matches with the near – ultraviolet (n-UV) light emitting diode (LED) chip's emission wavelength indicating that this nanophosphor can be effectively excited by n-UV (350-420 nm) LED chips. The other absorption peaks obtained are at 345nm, 364nm, 441nm and 473nm which correspond to $^6H_{5/2} \rightarrow {}^4K_{15/2}$, $^6H_{5/2} \rightarrow {}^4D_{3/2}$, $^6H_{5/2} \rightarrow {}^4G_{9/2}$ and $^6H_{5/2} \rightarrow {}^4I_{11/2}$ transitions respectively. These peaks are attributed to f–f spin-allowed transitions from the ground state to different crystal field spitting levels [16].

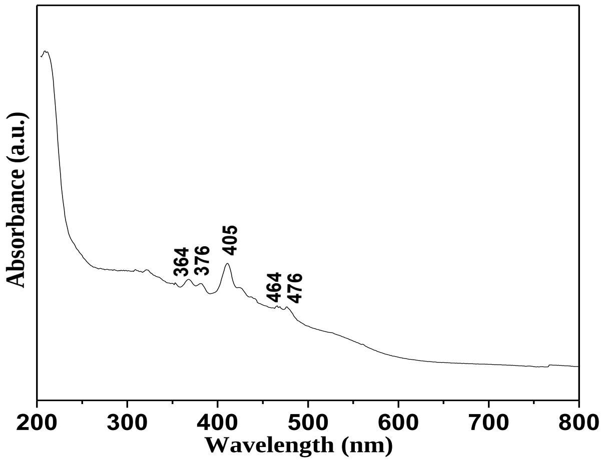

Fig -4: Absorption spectrum of Sm_2O_3 nanoparticles

3.5 Photoluminescence studies

The photoluminescence (PL) spectrum of the synthesized Sm_2O_3 nanoparticles excited under 400 nm wavelength is shown in Figure 5. On excitation, these particles show strong emission at 604 nm which correspond to $^4G_{5/2} \rightarrow {}^6H_{7/2}$ transition. Also, there are two emission at 562 nm and 647nm which correspond to $^4G_{5/2} \rightarrow {}^6H_{5/2}$, $^4G_{5/2} \rightarrow {}^6H_{9/2}$ [17 -19]. Hence it is seen that these nanophosphors emit reddish-orange under n-UV excitations. The luminescence properties show that they can be suitable for LED applications.

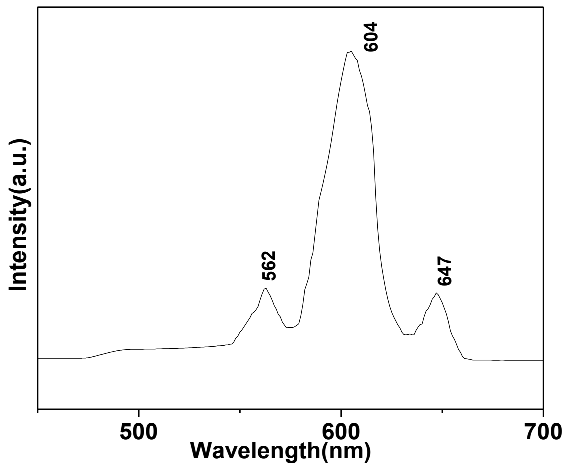

Fig -5: PL spectrum of Sm_2O_3 nanoparticles

4. CONCLUSIONS

Sm_2O_3 nanoparticles were synthesized using a simple and low cost combustion method. Sm_2O_3 nanoparticles were found to be highly crystalline and cubic in structure. Scherrer formula was used to calculate the size of the particles and the average crystallite size of the synthesized Sm_2O_3 nanoparticles was found to be around 5 nm. SEM was used for surface morphology studies. SEM micrograph of the prepared samples showed small amount of agglomeration. TEM results also confirmed that the particles are in nanosize and spherical in nature. The optical absorption and photoluminescence studies were found to be comparable with other reported values. The luminescence studies showed that it will be promising candidates for light emitting devices.

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REFERENCES

[1] M. C . Neto, G.H. Silva, A.P. Carmo, A.S. Pinheiro, N.O. Dantas, M.J.V. Bell and V. Anjos, "Optical properties of oxide glasses with semiconductor nanoparticles co-doped with rare earth ions," Chem. Phy. Lett., Vol. 588, 2013, pp.188.

[2] T. Tsuchiya, A.Watanabe, T. Nakajima and T. Kumagai, "Preparation of Y_2O_3: Eu thin films by excimer-laser-assisted metal organic deposition,"Appl. Phys. A, Vol. 101, 2010, pp. 681.

[3] T. Liu, Y. Zhang, H. Shao and X. Li, "Synthesis and Characteristics of Sm2O3 and Nd_2O_3 Nanoparticles," Langmuir, Vol.19, 2003, pp. 7569.

[4] B. Umesh, B. Eraiah, H. Nagabhushana, S.C. Sharma, D.V. Sunitha, B.M. Nagabhushana, C. Shivakumara, J. L. Rao and R.P.S Chakradhar, "Thermoluminescence and EPR studies of nanocrystalline Nd_2O_3:Ni^{2+} phosphor," Spectrochim. Acta, Part A, Vol.93, 2012, pp. 228.

[5] M. Zawadzki, "Microwave-assisted synthesis and characterization of ultrafine neodymium oxide particles," J. Alloys Compd., Vol. 451, 2008, pp. 297.

[6] M. Zawadzki and L. Kepinski, "Synthesis and characterization of neodymium oxide nanoparticles," J. Alloys and Compd., Vol. 380, 2004, pp. 255.

[7] L. Liu, H. Jiang, Y. Chen, X. Zhang, Z. Zhang and Y. Wang, "Power dependence of upconversion luminescence of Er^{3+} doped Yttria nanocrystals and their bulk counterpart," J. Lumin., Vol. 143, 2013, pp. 423.

[8] M. Iqra, A. F. Muhammad, J. Shaghraf, S. Maryam, K-R. Muhammad, "Synthesis of Gd_2O_3/Sm_2O_3 nanocomposite via sonication and hydrothermal methods and its optical properties," Superlattices Microstruct., Vol.77, 2015, pp. 256.

[9] M. Jayasimhadri, B.V. Ratnam, K. Jang, H.S. Lee, S-S. Yi, J-H Jeong, "Conversion of green emission into white light in Gd_2O_3 nanophosphors," Thin Solid Films, Vol.518, 2010 , pp.6210.

[10] M. Chandrasekhar, H. Nagabhushana , K.H. Sudheerkumar, N. Dhananjaya, S.C. Sharma, D. Kavyashree, C. Shivakumara and B.M. Nagabhushana, "Comparison of structural and luminescence properties of Dy_2O_3 nanopowders synthesized by co-precipitation and green combustion routes," Mater. Res. Bull. Vol.55, 2014, pp. 237.

[11] J. Gao, Y. Zhao, W. Yang, J. Tian, F. Guan, Y. Ma, J. Hou, J. Kang, Y. Wang, "Preparation of samarium oxide nanoparticles and its catalytic activity on the esterification," Mater. Chem. Phys., Vol.77, 2002, pp. 65.

[12] N. Jafari and S. A. Golzary, "Experimental design for the optimization of hydrothermal synthesis of samarium oxide (Sm_2O_3) nanoparticles under supercritical water condition," Int. J. Chem. Eng. Appl., Vol. 2, 2011, pp. 243.

[13] A. Rosengren and B. Johansson, "Valence instability of the samarium metal surface," Phys. Rev. B, Vol.26, 1982, pp. 3068.

[14] T.–D. Nguyen, D.Mrabet, T.-O. Do, "Controlled self-assembly of Sm_2O_3 nanoparticles into nanorods: simple and large scale synthesis using Bulk Sm_2O_3 powders," J. Phys. Chem. C, Vol.112, 2008, pp. 15226.

[15] Sulabha K. Kulkarni. "Analysis Techniques" in Nanotechnology: Principles and Practices, Springer, New Delhi, 2015, pp. 169.

[16] L. Minhong, R. Weiguang, Zhifan , Chunyan , J.Haiyan, L.Weina and S. Jinsheng, "A strategy for developing deep-UV phosphor: Sr_3AlO_4F: Tb^{3+}/Sm^{3+}," Mater Sci: Mater Electron, 2015, DOI 10.1007/s10854-015-3626-7.

[17] H. Lin, X.Y.Wang, L. Lin, D.L.Yang, T.K. Xu, J.Y. Yu and E.Y.B. Pun, "Spectral parameters and visible fluorescence of Sm^{3+} in alkali–barium–bismuth–tellurite glass with high refractive index," J. Lumin., Vol. 116, 2006, pp. 139.

[18] G. Pushpal, K. Simanta, K. Arik, K.V.Ramanujachary, L. Samuel and P. Amitava, "Synthesis and characterization of different shaped Sm_2O_3 nanocrystals," J. Phys. D: Appl. Phys., Vol.43, 2010, pp. 405401.

[19] G.R.Dillip, K.Munirathnam, B.Deva Prasad Raju, N.John Sushma and S.W.Joo, "An efficient orange-red-emitting $LiNa_3P_2O_7$:Sm^{3+} pyrophosphate: Structural and Optical Analysis for solid-state lighting," Luminescence, 2016, pp.1, doi : 10.1002/bio.3249.