



Luminescence of SrAl₂O₄: Sm Phosphor

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Abstract

Polycrystalline sample of SrAl₂O₄:Sm³⁺ was prepared by employing modified combustion synthesis method. The prepared sample was characterized by using XRD and FTIR Techniques. The PL and PLE spectra indicated that the main emission peaks of SrAl₂O₄: Sm³⁺ are at 561, 598 and 643 nm for 402 nm Excitation. The excitation and emission spectra shows that this phosphor can be used as a red component in white LEDs.

Keywords: Aluminates, Combustion Synthesis, Phosphors, LEDs

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1. INTRODUCTION

Phosphors based on oxide matrices are attractive host materials for the development of advanced phosphors due to their ease of synthesis and stability. Rare earth activated inorganic phosphors are widely used in a variety of applications, such as lamp industry, color display, radiation dosimetry and X-ray imaging [1]. Out of these inorganic materials, aluminate phosphors have been extensively investigated because of their high chemical stability and bright emission characteristics in the visible light region. Rare earth doped alkaline aluminates have been reported to be excellent and versatile phosphor hosts [2,3]. Sr, Ca and Ba-based aluminate phosphors are safe, chemically stable, and bright with long lasting photoluminescence without any harmful radiation [4]. Among these phosphors, strontium aluminate phosphors doped with rare earth metal ions have emerged as materials with great potential and also there has been increasing interest in rare earth doped strontium aluminate (SRA) phosphors because of their long afterglow properties[5,6]. The emission of Sm³⁺ is tuned between orange to red region and the emission spectra the intra- 4f orbital transition from the ⁴G_{5/2}, level to the ⁶H_{5/2}, ⁶H_{7/2} and ⁶H_{9/2} levels of Sm³⁺ [7]. However, synthesis method plays an important role for the preparation of the phosphors in the field of the luminescence. There are many methods for the preparation of the phosphors but we chose modified combustion synthesis method for the preparation of the luminescent phosphors. The advantages of the combustion synthesis method are lower synthesis temperature, shorter synthesis time and controlled size of the particles. In addition, it is a more reliable method for preparing long afterglow phosphors [8, 9].

2. Experimental

We have prepared the strontium aluminate using the solution combustion synthesis method. We have taken strontium nitrate and aluminum nitrate as an oxidizers, urea as fuel and samarium oxide (Sm₂O₃) as activator. The materials were mixed according to the formula Sr_{1-x} Al₂O₄Sm_x. In the process of synthesis all the precursor materials are mixed in a china crucible and crush to get a paste. The paste was kept on heating menthol for removal of excess of water and heated till we get a complete clear solution from the paste. As prepared clear solution then transferred to the pre heated furnace maintained at 600°C to 650°C. After warming it for 5 Min the self redox reaction was completed and the fine white powder of SrAl₂O₄:Sm is obtained. As prepared sample is the heated for 1 hr at 700°C to remove the excess of urea and carbon impurities left during the reaction.

As synthesized host samples were then subjected to the XRD analysis on Rigaku miniflex X-ray diffractometer with scan speed of 2.000 deg./min and with Cu K α radiation. The FTIR spectra of the phase pure hosts have been taken on SHIMADZU FTIR spectrometer. Photoluminescence measurements at room temperature were performed on a Hitachi F-7000 spectrofluorimeter equipped with a 450W Xenon lamp, in the range 200–650 nm, with spectral slit width of 2.5 nm and PMT voltage at 600V. Spectra were corrected using Rhodamine B standard by following the procedure prescribed by Hitachi.

3. Results and Discussion

3.1.1 XRD Analysis

- 3.2 The formation of the crystalline phase of as-prepared products was confirmed by X-ray diffraction. Fig. 1 shows the X-ray patterns of SrAl₂O₄: Sm powder. The X-ray pattern of combustion synthesized sample

at furnace temperature 500 °C indicated a dominant phase of the standard SrAl₂O₄ (ICDD, 00-034-0379). It has been reported in the literature that phase-pure SrAl₂O₄ could be achieved using conventional solid state process, the required temperature for synthesizing SrAl₂O₄ being 1400–1600 °C [10, 11] whereas in this work, pure and single Strontium aluminates was prepared by solution combustion synthesis successfully. The XRD shows that the formed material is completely crystalline and is in single phase with monoclinic structure where a=b=5.209 and c=8.761.

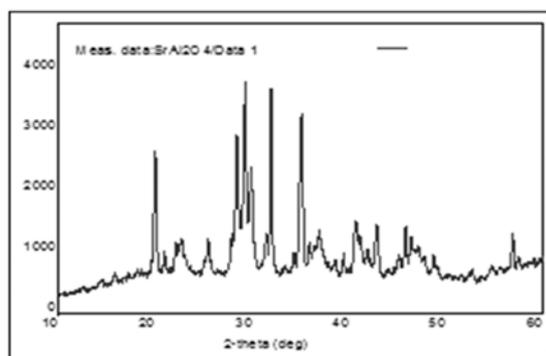


Fig.1. XRD pattern of SrAl₂O₄ (ICDD file 00-034-0379)

3.2 FTIR Analysis:

FTIR is an important tool for the conformation of the sample because no two unique molecules can produce the same infrared spectrum. In FTIR, IR radiation passes through the sample and some of the radiations are absorbed by the sample, while other are transmitted. Thus, the resulting spectrum represents the molecular absorption and transmission spectra. The FT-IR spectrum of SrAl₂O₄:Sm powder is shown in Fig. 2. This spectrum exhibits broad band near 3433 cm⁻¹ due to the OH- stretching vibrations of free and hydrogen-bonded hydroxyl groups. However a weak absorption band at 1632 cm⁻¹ appears from deformation vibration of water molecules, which is probably due to water absorption during the compaction of the powder specimens with KBr [12]. The appearance of a very weak band at 1382 cm⁻¹ is due to the symmetric stretching vibrations of the N-O group, which might have resulted from the nitrate of the starting material [13]. The metal-oxygen stretching frequencies in the range 400–1000 cm⁻¹ are associated with the vibrations of Al-O, Sr-O and Sr-O-Al bonds [14]. The sample showed a strong peak at 846 cm⁻¹, assigned to the formation of SrAl₂O₄ [15].

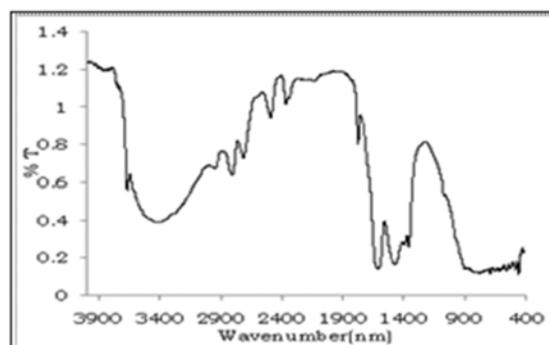


Fig 2: FTIR spectra of SrAl₂O₄

3.3 Photoluminescence

The peak intensity of Sm depends on its concentration in the host [16]. When Sm is doped in SrAl₂O₄, it gives three main Sm³⁺ emissions peak at 562, 596, and 643 nm which are located in the orange to red region. The emission spectra is contributed from the intra-4f orbital transition from the ⁴G_{5/2} level to the ⁶H_{5/2}, ⁶H_{7/2} and ⁶H_{9/2} levels of Sm³⁺. The strongest emission (⁴G_{5/2} to ⁴H_{7/2}) is located at 596 nm, and the others are 562 and 643 nm. Particularly, lines at 596 and 643 nm are the most important emissions. They are produced by the electron transition, which is attributed to the intra-4f orbital transition. Sm³⁺ acted as a trap level which captured the free holes in the SrAl₂O₄: Sm phosphor system. The trapped and detrapped recombination procedure brought about the brightness [17]. The PL and PLE spectra of SrAl₂O₄: Sm is as shown in figures 3 and 4.

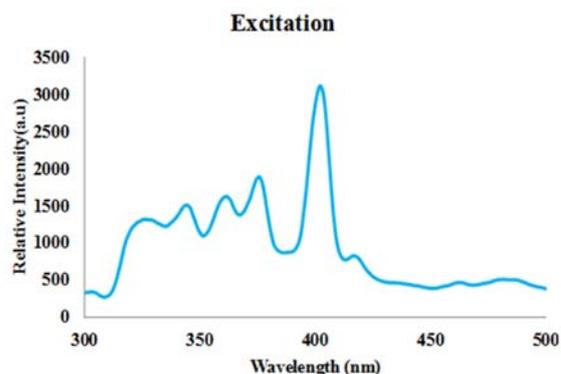


Fig.3: Excitation spectrum of SrAl₂O₄:Sm³⁺

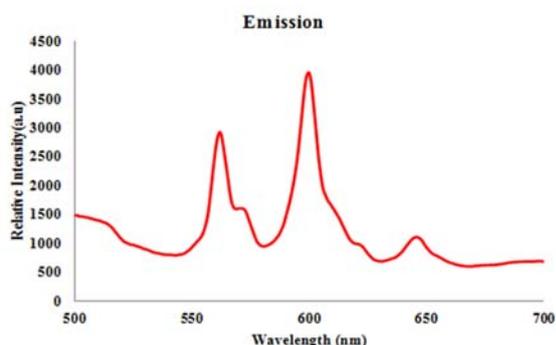


Fig.4: Emission spectrum of $SrAl_2O_4:Sm^{3+}$

4. CONCLUSIONS

Polycrystalline pure and single phase sample of $SrAl_2O_4$ was successfully prepared using solution combustion synthesis. The sample exhibits photoluminescence intensity of Sm^{3+} and shows good orange to red emission for 401nm Excitation. This suggests that this phosphor can be used as a red component in white LEDs and can be a promising red phosphor..

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