

# Synthesis and Characterization of Lanthanum Doped Strontium Aluminate Nanophosphor using Sol-Gel Synthesis

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**ABSTRACT:** Lanthanum doped strontium aluminate nanophosphor ( $\text{SrAl}_4\text{O}_7:\text{La}$ ) was prepared by sol-gel method. The obtained materials were characterized by SEM, XRD, EDAX and PL. Monoclinic structure was confirmed by X-ray diffraction analysis, particle size was determined by Scherrer formula. The particles were of somewhat round shaped and interlinked with each other, leading to the formation of bigger particle. Also some irregular aggregations were found in the image. Photoluminescence emission were at 395, 520 and 790 nm corresponding to UV, green and IR regions under excitation for 360 nm.

## I. INTRODUCTION

Alkaline earth metal oxides combined with aluminium oxide are of great interest in material science because of use as long duration photoluminescence and thermoluminescence pigments. They have potential use as refractory oxides in the steel industry and binder materials in the cement industry [1]. Many efforts have been made to discover host materials as well as activators with high performance for phosphor applications. Sol-gel method represents an attractive and easy alternative method to conventional synthesis method, such as ceramic firing [2-4], precipitation [5, 6], or ion exchange on supported oxides [7]. The sol-gel process is an efficient technique for the preparation of phosphors due to the good mixing of starting materials and relatively low reaction temperature resulting in more homogeneous products than those obtained by direct solid state reactions. With sol-gel technique, a low temperature (950°C) has been reported for the successful preparation of  $\text{MgAl}_2\text{O}_4$  powders [8]. In this work, preparation of  $\text{SrAl}_4\text{O}_7:\text{La}$ , structure, morphology and luminescence were reported. In recent years, rare earth (RE) doped nanomaterials has attracted wide use in various applications as thin film electroluminescent (TFEL) devices, optoelectronic or cathodoluminescent devices. RE-doped insulators are used in telecommunications, lasers and amplifiers, medical analysis and phosphors, etc. Generally rare earth doped aluminates have greater impact on defect centers within the band gap. The emission of light from the ultra violet, visible and Infrared depends on the host material properties [14-18].

## II. EXPERIMENT

As the starting materials, strontium acetate  $[(\text{CH}_3\text{COO})_2\text{Sr}\cdot 2\text{H}_2\text{O}]$  and aluminum acetate  $[\text{C}_4\text{H}_6\text{AlO}_4\cdot 4\text{H}_2\text{O}]$  were used as the precursors. All starting materials were of the high purity. The procedure of synthesizing nanoparticles is thoroughly described as follows: 98 wt% of 2M Strontium acetate  $[(\text{CH}_3\text{COO})_2\text{Sr}\cdot 2\text{H}_2\text{O}]$  was dissolved in 25 ml of 2-methoxyethanol with vigorous stirring. Simultaneously, 1 wt% of 2M Lanthanum nitrate  $\text{La}(\text{NO}_3)_3\cdot 6\text{H}_2\text{O}$  was dissolved in 25 ml of 2-methoxyethanol with vigorous stirring. 1 wt% of 2 M Aluminum acetate  $(\text{C}_4\text{H}_6\text{AlO}_4\cdot 4\text{H}_2\text{O})$  was dissolved in 25 ml of 2-methoxyethanol with vigorous stirring and subsequently, it was added to the first solution to reach 50 ml in total. Then it was stirred for 30 min at room temperature for the second time. Ammonia was slowly added to this solution with constant stirring until a pH of 10.5 was achieved. After stirring of the solution for 30 min, acetic acid and ethylene glycol in the ratio 1:1 was added to the solution. The sol was heated at 80 °C while being mechanically stirred with a magnetic stirrer. As the evaporation proceeded, the sol turned into a viscous gel.

The gel was aged for 2 h and then dried at 100 °C for about 5 h. The resulting materials were well grinded and annealed at 950°C for 2h to obtain SrAl<sub>4</sub>O<sub>7</sub>:La nanopowders. Figure.1 shows the flowchart for the preparation of SrAl<sub>4</sub>O<sub>7</sub>:La nanopowders.

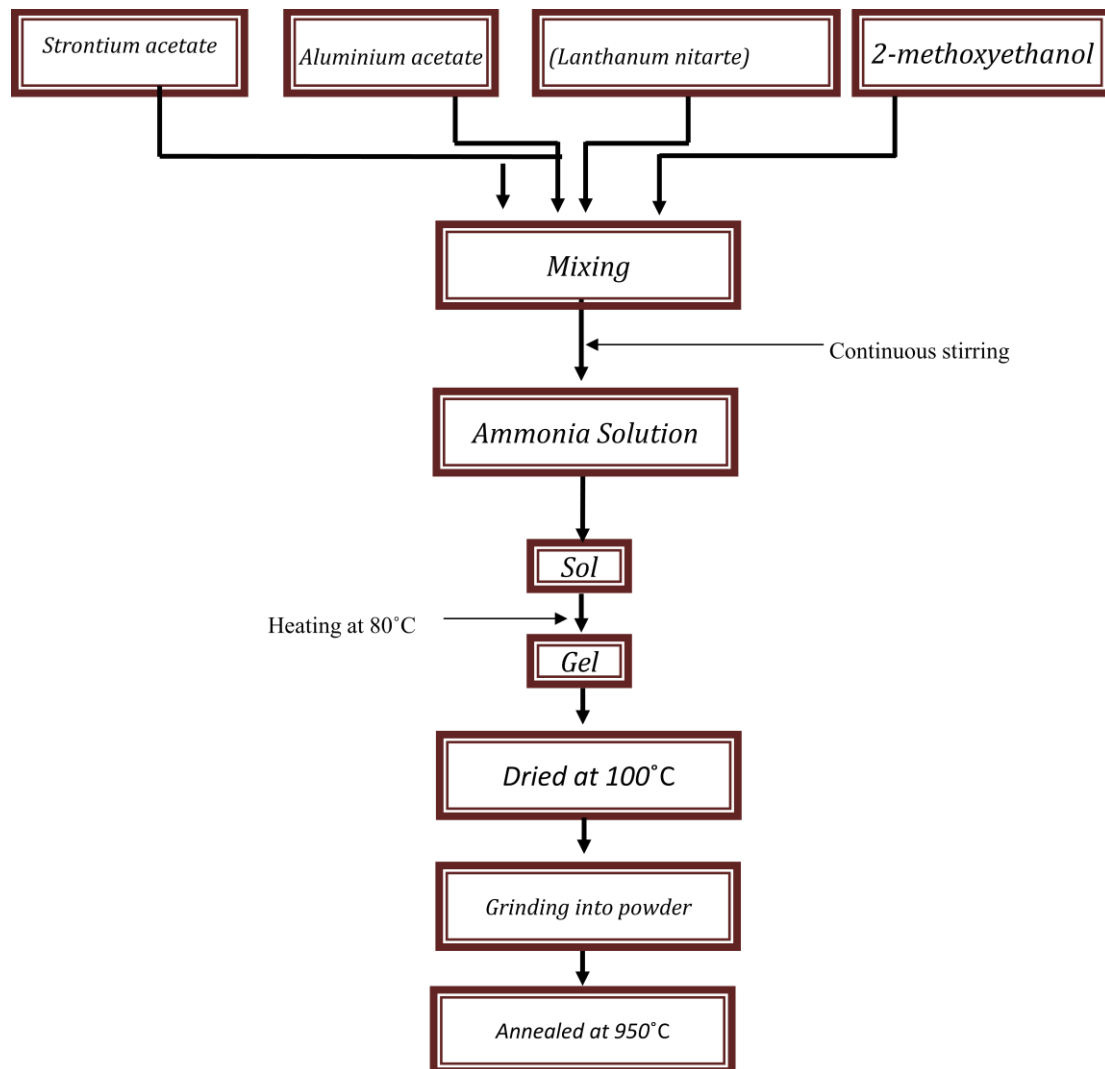


Fig 1 flow chart for the preparation of SrAl<sub>4</sub>O<sub>7</sub>:La

Characterizations such a X-ray diffraction (XRD) analysis, Fourier transform infrared (FTIR), scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS) and photoluminescence emission spectra (PL) were studied and compared for the prepared samples. Conformation of pure SrAl<sub>4</sub>O<sub>7</sub> was verified by XRD analysis. The morphology was examined by SEM analysis. The compositions of the products were determined by EDS. The photoluminescence properties were studied by Photoluminescence (PL).

### III. RESULTS AND DISCUSSION

#### 1 STRUCTURAL STUDY

##### 1.1 XRD

Figure.2 shows the X-ray powder diffraction patterns of SrAl<sub>4</sub>O<sub>7</sub> doped with lanthanum. According to the JCPDS card no. 25-1289, the XRD patterns indicate that the crystal structure of SrAl<sub>4</sub>O<sub>7</sub> is monoclinic. The particle size was estimated using the Debye Scherrer formula [9]:  $D = K\lambda/\beta \cos \theta$  Where, D is the size of the particle, K=0.99 is the size factor,  $\beta$  is the full width of half maximum,  $\lambda$  is the wavelength of X-ray radiation

used and  $2\theta$  is the angle at which the maximum intensity was observed. The particle size obtained is 77. The sharp peak indicates that nanoparticles are well crystallized

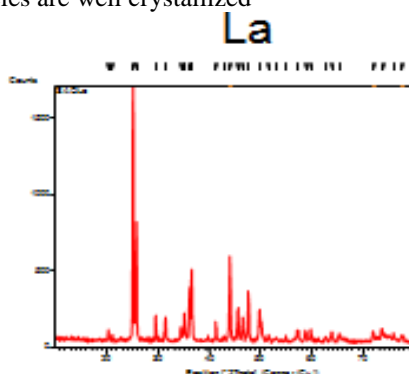


Fig .2 XRD patterns of  $\text{SrAl}_4\text{O}_7$  doped with lanthanum

## 2 MORPHOLOGICAL STUDY

### 2.1 SEM

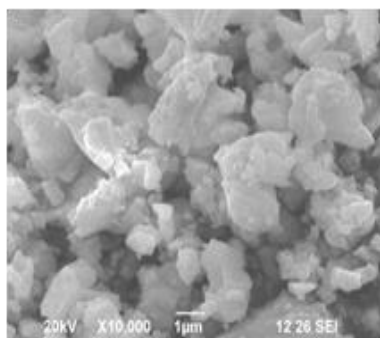


Fig.3 SEM images of  $\text{SrAl}_4\text{O}_7$  doped with lanthanum

Figure.3 shows the SEM images of  $\text{SrAl}_4\text{O}_7$  doped with lanthanum. The surface morphology was in the form of granular structure with somewhat round shape and were interlinked with each other, leading to the formation of bigger particles. Also it was found that some irregular aggregations were formed in the image. The morphology was investigated with SEM.

### 2.2 EDS

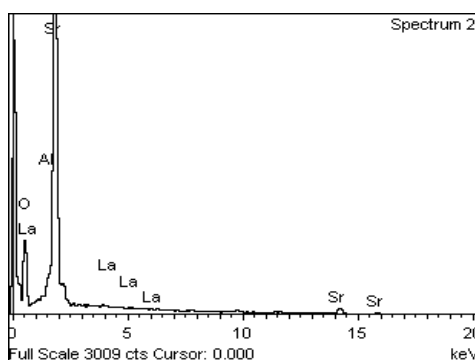


Figure.4 EDS of  $\text{SrAl}_4\text{O}_7$  doped with lanthanum

Figure.4 shows the EDS of  $\text{SrAl}_4\text{O}_7$  doped with lanthanum. Two peaks at 0.25 KeV, and 2 KeV were characteristic peaks of strontium metal; one peak at 5.1 KeV was due to La metal; and one peak at 0.6 KeV was due to oxygen

### 3 OPTICAL STUDY

#### 3.1 PHOTOLUMINESCENCE

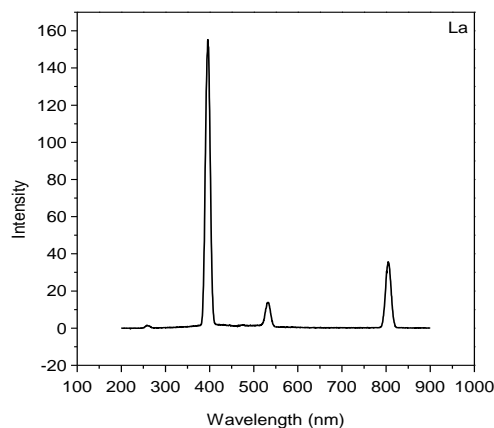


Fig.5 PL graph of  $\text{SrAl}_4\text{O}_7$  doped with lanthanum

Rare-earth doped long persistence materials have been widely studied due to their many advantages, such as high luminescent brightness, long afterglow time, good chemical stability, and environmental friendliness. Alkaline earth aluminates are one of the best hosts for rare-earth ions. Figure.5 shows the PL of  $\text{SrAl}_4\text{O}_7$  doped with lanthanum. The PL under 360 nm excitation showed three peaks at 395 nm, 520 nm, and 790 nm corresponding to uv, green and IR region of spectrum, respectively. The strong peak showing blue emission at 395 nm was due to the exciton emission, and weak green emission at 520 nm was due to oxygen interstitial. The strong UV emission corresponds to the exciton recombination related near-band edge emission of nanoparticles. The green emissions are possibly due to surface defects in the nanoparticles.

Lanthanide-doped strontium aluminate nanophosphors have the remarkable ability to combine two or more low energy photons to generate a single high-energy photon by an anti-Stokes process and hold great promise for a broad range of applications, ranging from high-resolution bio imaging to modern photovoltaic technologies. In contrast to conventional luminescent probes, lanthanide-doped aluminate nanophosphors exhibit excellent photo stability, continuous emission capability, and sharp multi-peak line emission. They have luminescence decay times on the order of microseconds, which are much longer than those of organic dyes and quantum dots.

### IV. CONCLUSION

In the present work, pure strontium aluminate nanophosphors with 1 weight percentage of lanthanum were prepared by sol-gel method and characterized by SEM, XRD, EDS, and PL. The XRD patterns revealed the monoclinic structure, and the size of the particle was found by using the Debye Scherer relation. The surface structure of the samples was analyzed by the SEM images. It showed that the particles were of somewhat round shape and were interlinked with each other, leading to the formation of bigger particles. Also it was found that some irregular aggregations were formed in the image. The peaks of EDS showed the composition of strontium, aluminum, lanthanum and oxygen. The PL under 360 nm excitation for showed three peaks at 395 nm, 520 nm, 790 nm corresponding to blue, green and IR region of spectrum respectively.

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