

Green Synthesis of Sodium Aluminate Nanophosphor and Study of Its Photoluminescence Properties

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INTRODUCTION

Sodium Aluminate (NaAlO_2) nanophosphor was prepared from analytical grade Sodium Nitrate (NaNO_3) and Aluminium Nitrate ($\text{Al}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$) by solution combustion method at 450°C using honey as a fuel. The prepared sample was characterised by X-ray diffraction technique (XRD), UV-Visible and Photoluminescence (PL). The X-ray diffraction analysis was carried out using Bruker AXS D8 Advance X-ray diffractometer with Cu-Target ($\text{Cu}/\text{K}\alpha$ radiation of wavelength $\lambda = 1.54060\text{\AA}$). Data have been collected by step scanning 2θ from 10° to 90° at room temperature. The crystalline structure of the resulting sample was investigated. The XRD pattern shows several peaks, which are in complete agreement with those of the standard PXRD pattern [3]. The average particle size was estimated using Debye Scherrer's formula and found to be 23 nm. The average inter planar spacing is found to be 2.483\AA . UV-visible studies were carried out using Cary 60 model spectrometer and an absorption was found at 210 nm. By using Tauc equation the band gap energy of the sample was found to be 4.148 eV. The photoluminescence (PL) data was recorded using Fluorescence Spectrophotometer (FP-8300) with Xe lamp as light source. The PL emission spectra of the NaAlO_2 phosphor excited at 230 nm contain intense emission peaks at 376 nm, 435 nm and 553 nm.

Keywords: Photoluminescence (PL), Sodium Aluminate phosphors, combustion.

EXPERIMENTAL METHOD



Figure 1

The flow chart for material preparation and characterization is shown in fig.1 Analytical grade Sodium Nitrate $\text{Na}(\text{NO}_3)$, Aluminium Nitrate $\text{Al}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$, Honey ($\text{C}_6\text{H}_{12}\text{O}_6$) were used as the starting materials. The starting materials were weighed according to the stoichiometry based on molarity. All weighed quantities of each nitrate and honey were mixed together and sterilized 30 minute at 90°C the sterilized solution was transferred to 500 ml beaker and introduced into a muffle furnace maintained at 450°C temperature. Initially the mixture boils and undergoes dehydration followed by decomposition with the evolution of large amount of gases (oxides of carbon, nitrogen). The process being highly exothermic continues and the spontaneous ignition occurs. The solution underwent smouldering combustion with enormous swelling, producing grey foamy and voluminous ash. The ash was taken out from Muffle furnace and left to cool down to room temperature. Then the ash put into mortar and crushed. The crushed sample kept for calcination at 1100°C 60 minute and left to cool down to room temperature for 11 hours.

Powder X-ray Diffraction

The crystalline structure and particle size of the NaAlO_2 samples was investigated by X-ray diffraction analysis (XRD model D8 Advance Bruker AXS) using $\text{Cu}/\text{K}\alpha$ radiation ($\lambda = 1.54060\text{\AA}$). Data have been collected by step scanning 2θ from 10° to 80° and 9.6 s swept time at each step at room temperature. The XRD pattern of NaAlO_2 nanophosphor is shown in Fig. 2. The diffraction peaks were found to be similar and it was completely agreement with those of the standard XRD pattern [3].

The average particle size was estimated using Debye Scherrer’s formula as follows

$$D_{\text{xrd}} = \frac{0.94\lambda}{\beta \cos \theta} \text{ m}$$

where λ is wavelength of x-ray (1.5406 Å),

θ is the scattering angle of the main peaks used for calculation,

β is the corrected peak at full width at half maximum (FWHM) intensity.

The average particle size $\langle D_{\text{xrd}} \rangle = 23 \text{ nm}$.

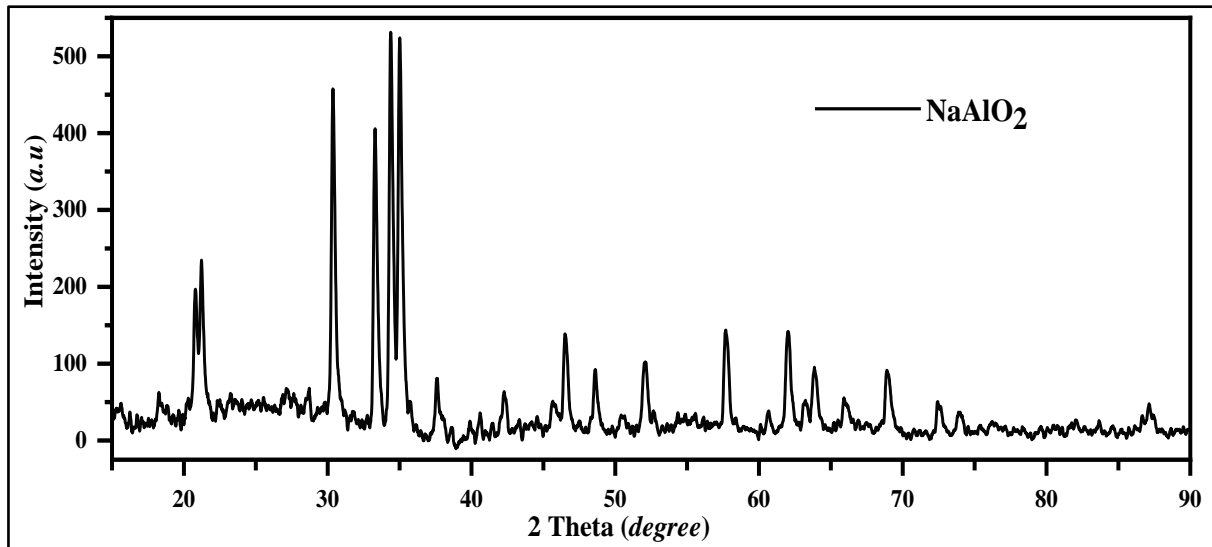


Figure 2

UV-Visible Spectroscopic Study and Evaluation of the Band Gap Energy

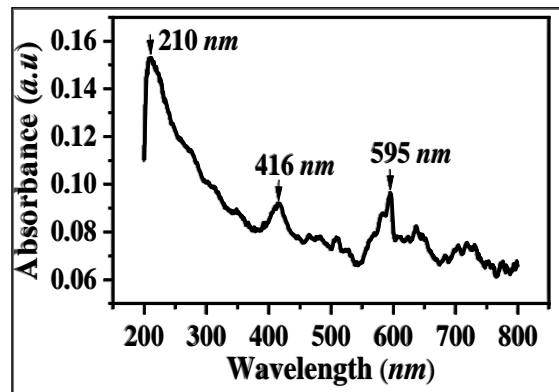


Figure 3

Fig.3 shows the UV–visible absorption spectrum of NaAlO₂. The sample shows a strong absorption peak at 210 nm in the UV region.

The band gap energy (E_g) was estimated by the method proposed by Wood and Tauc. Using the following Tauc equation

$$(h\nu\alpha) \propto (h\nu - E_g)^n$$

where ‘ α ’ is the absorbance,

‘ h ’ is the Planck’s constant,

‘ ν ’ is the frequency,

‘ n ’ is a constant associated to the different types of electronic transitions

($n = 1/2, 2, 3/2$ and 3 for in-direct allowed, direct allowed, direct forbidden and indirect forbidden transitions, respectively)..

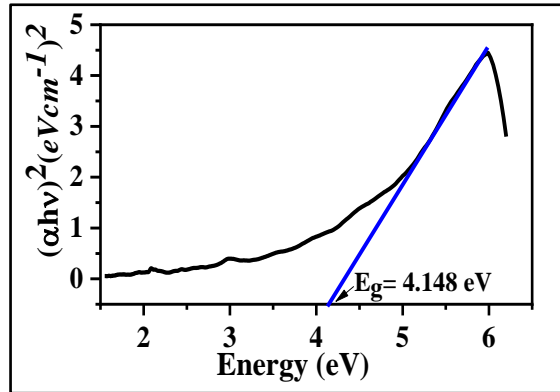


Figure 4

Fig.4 shows the bandgap energy of the sample. In order to find the band gap energy, $(\alpha h\nu)^2$ versus photon energy is plotted and extrapolating the linear region of the graph and obtaining the point of intersection on the energy axis, where $(\alpha h\nu)^2 = 0$. The bandgap energy (E_g) for NaAlO_2 nanophosphor was found to be 4.148 eV.

Photoluminescence Spectrum

The PL emission spectrum of the NaAlO_2 phosphor shown in Fig.5. Due to the excitation of NaAlO_2 phosphor at 230 nm, its emission spectra contain intense emission peaks at 376 nm in UV region, 435 nm and 553 nm in visible region which corresponds to blue and green colour respectively. The energies corresponding to 376 nm, 435 nm and 553 nm, where prominent peaks occur are 3.3 eV, 2.85 eV and 2.24 eV respectively.

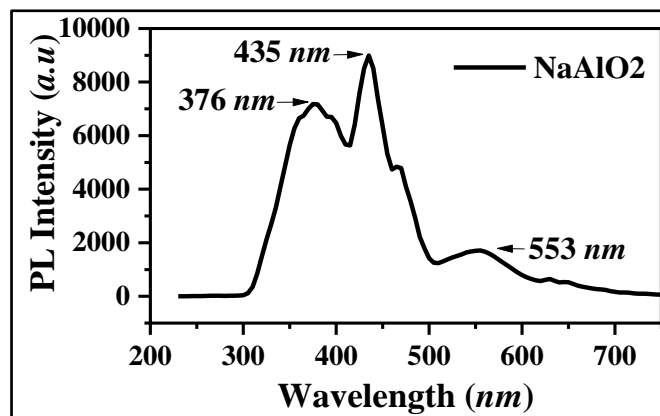


Figure 5

Conclusion

The nanoparticles of Sodium Aluminate (NaAlO_2) was successfully synthesized by solution combustion method. The powder XRD analysis confirms the NaAlO_2 particles are of nano size. The bandgap energy was found to be 4.148 eV. The PL spectra showed good emission intensity, which confirms the suitability of synthesized sample for display devices.

References

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