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Study synthetic method, photoluminescence mechanism and optimistic applications of KAlSiO₄ Phosphor

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Abstract:

KAlSiO₄:Eu³⁺, Tb³⁺ phosphor synthesized first time by simple combustion method. The X-ray diffraction (XRD) study confirms that the KAlSiO₄ phosphor matrix successfully matches to standard JCPDS database file. Photoluminescence properties observed for rare earth Eu³⁺, Tb³⁺ at various concentration (x = 0.3, 0.5, 1.0, 1.3 mole %) shows an optimistic luminescence property. KAlSiO₄ matrix shows unique emissions of Eu²⁺ and Eu³⁺ ions when excited by 395 nm, where the utmost emission intensity was received when x = 1.0 mole%. The excitation spectra of KAlSiO₄:Eu³⁺ give proper peak position at 262 nm, 395 nm, and 465 nm corresponding to O²⁺→ Eu³⁺, ⁷F₀→⁵L₆, ⁷F₀→⁵D₂. While sharp emissions peaked at 593 nm and 613 nm are obtained by ⁷F₀→⁵D₁ and ⁷F₀→⁵D₂ transitions. On the other hand, KAlSiO₄:Tb³⁺ shows the excitation peak position at 352 nm, 370 nm, and 378 nm which gives the sharp green emission peak at 545 nm due to the ⁵D₄→⁵F₅ transitions. The particle size and elemental constitution determine using SEM-EDX analysis which is in the range of micrometers in size. The band gap and refractive index are determined using UV-visible spectroscopy. CIE chromaticity coordinate shows multicolor emission for KAlSiO₄:Eu³⁺ while the green color emission for the KAlSiO₄:Tb³⁺ phosphor. Photoluminescence (Pl) spectroscopy reveals the exciting luminescent properties of the KAlSiO₄:Eu³⁺, Tb³⁺ phosphor which may be applicable potential phosphor for fabrication of various light emitting devices.

Keywords: Simple combustion method, Photoluminescence (Pl), Aluminate phosphor.

1. Introduction:
In recent decade need and consumption of energy raise rapidly all over the world. Accordingly, conventional energy sources have been unable to fulfill this demand also hazardous to human life. Due to that phosphor base inorganic material is attracted immensely for solid-state lightning because of the luminance property. Various rare earths are used accordingly to the requirement of the light like Europium(Eu\(^{3+}\)), Dysprosium(Dy\(^{3+}\)), Samarium(Sm\(^{3+}\)), Terbium(Tb\(^{3+}\)) etc. This rare earth-doped inorganic phosphor has several advantages in comparison over conventional Tungston base lamps as well as compact fluorescent lamps with high luminous efficiency, cheap to manufacture, high life span, magnificent thermal stability, high color temperature, and less color rendering index. All this property is inorganic based phosphor becomes widely applicable for Light emitting diode (LEDs), solid-state lasers, solar panels, and sensors [1–3].

The \( f-f \) transition is one of the luminescence characteristics of rare-earth ions found in the 4\( f \) shell. To obtain good photoluminescence important characteristic is to get the emission in the visible range. Under n-UV excitation Eu\(^{3+}\) ions are typical 4\( f-4f \) transition doped ions and are often used as excellent activators for red phosphors due to the red emissions of \( ^5D_0 \rightarrow ^7F_J \) (\( J = 1, 2, 3, 4 \)) transitions [4]. The emission of Eu\(^{3+}\) ion occurs in two sharp bands one at 593 nm (orange band) and 613 nm (red band) corresponding to the \( ^5D_0 \rightarrow ^7F_1, ^5D_0 \rightarrow ^7F_2 \). The Eu\(^{2+}\) ion is considered a vital luminescence activator as it can emit a lot of light from the 4\( f \) ground state to the 5\( d \) level (e.g. Ultraviolet to red)[5]. Literature survey we noted that the inter-transition of 4\( f \) for the Eu\(^{3+}\) ions and the 4\( f-5d \) transition of Eu\(^{2+}\) ions are greatly influenced by the host in the crystal field. So the selection of a proper suitable luminescence host is essential for the enhancement of optical properties of the Eu\(^{2+}\) and Eu\(^{3+}\) ions. On the other hand, it was also found that the emission intensities of Eu\(^{2+}\) and Eu\(^{3+}\) ions have different emission behaviors depending on temperature[6–9]. The broad band is also obtained due to the charge transfer band which covers most of the visible region \( O^2-\text{Eu}^{3+} \). While the emission of Tb\(^{3+}\) ion was observed at 452 nm, 470 nm, 489 nm, and 545 nm respectively. Emission peaks observed at 489 nm and dominant 545 nm (green band) are ascribed due to \( ^5D_4 \rightarrow ^5F_6 \) and \( ^5D_4 \rightarrow ^5F_5 \) transitions.

Silicate is cheap inorganic material so silicate-based phosphor materials are inexpensive phosphor material to use as luminescence materials for LEDs lightening or optoelectronic devices. They have good thermal stability and long service life [10]. In the literature survey, we found the
Aluminate host material considered a luminescence center due to its excellent chemical and thermal stability [11–13]. In the present work, the photoluminescence property of KAlSiO$_4$:Eu$^{3+}$ and KAlSiO$_4$:Tb$^{3+}$ phosphors were studied. Excellent luminescence characteristic is shown by the KAlSiO$_4$:Eu$^{3+}$, Tb$^{3+}$ phosphor which proves that it can be one of the potential materials for solid-state ecofriendly listening and white (w-LED). The X-ray diffraction (XRD), Ultraviolet-Visible Spectroscopy (UV-Vis), Scanning Electron microscopy (SEM), and Photoluminescence (PL) spectroscopy analysis were studied for the reported phosphor.

2. **Experimental Analysis:**

KAlSiO$_4$:Eu$^{3+}$, Tb$^{3+}$ phosphor prepared successfully first time by simple combustion method. The raw material needed for the synthesis process is aluminium nitrate, calcium nitrate urea as fuel, and europium dioxide as rare earth. All these ingredients are weighed with an appropriate stoichiometric ratio and mixed in a mortal pestle. To convert rare earth oxide into nitrate form Eu$_2$O$_3$ and Tb$_4$O$_7$ were taken in small test tubes and nitric acid was used. All the raw material mixture in the mortal postal was stirred properly until mixture attained the uniformity. Thereafter the mixture was collected in a china disk and kept in a preheated open muffle furnace at 500-550°C. After 10-15 minutes the solution boiled properly, and dehydration and decomposition phenomena occur by evolving large amounts of gases like carbon dioxide, ammonium dioxide, and hydrogen. The white color voluminous and foamy powder is formed which is collected and allowed to cool down up to the room temperature. Thereafter sample was crushed in a mortar pestle and taken in a muffle furnace for 12 hours at 600°C to remove the impurity of urea. Finally after cooling the annealing sample was crushed for 10 minutes in a mortal pestle sample was collected and used for various characterization. The reaction that takes place during synthesis is shown as:

\[(a) \text{K(NO}_3\text{)} (99.99\%) + \text{Al(NO}_3\text{)}_3\cdot 9\text{H}_2\text{O} (99.99\%) + \text{Eu}_2\text{O}_3 + \text{HNO}_3 \]

\[\text{CO(NH}_2\text{)}_2 \rightarrow \text{KAlSiO}_4: \text{Eu}^{3+} + \text{CO}_2 \uparrow + \text{NO}_2 \uparrow + \text{O}_2 \uparrow + \text{H}_2 \uparrow \quad (1)\]

\[(b) \text{K(NO}_3\text{)} (99.99\%) + \text{Al(NO}_3\text{)}_3\cdot 9\text{H}_2\text{O} (99.99\%) + \text{Tb}_4\text{O}_8 + \text{HNO}_3 \rightarrow \text{KAlSiO}_4: \text{Tb}^{3+} + \text{CO}_2 \uparrow + \text{NO}_2 \uparrow + \text{O}_2 \uparrow + \text{H}_2 \uparrow \quad (2)\]

To determine the phase and crystallinity the X-ray diffraction (XRD) done using the Rigaku mini flex d 600 X-ray powder diffractometer with Cu Ka radiation (λ=0.154056) operated at 40 kV,15
milliamp. The XRD pattern was observed with step size 0.02°. The rest of will refinement is done to obtain the lattice parameter. To confine the morphology of synthesized phosphor SEM analysis is used. Photoluminesce analysis is obtained using the RF-5301 PC Spectroflurometer where the 50 W xenon flash lamp is used as the excitation source. The photoluminescent characterization was observed at normal room temperature.

3. Characterization Technique:

3.1 XRD Analysis:

The pure KAlSiO$_4$ prepared phosphor match with standard JCPDS database file 00-002-0584 with upmost peak obtained for $\theta = 28.62^\circ$. Fig. 1 shows a proper comparison of pure KAlSiO$_4$ with JCPDS which reveals that the reported phosphor was synthesized successfully.
3.2 SEM-EDX:

Fig.2 indicates the Scanning electron microscopy (SEM) micrographs of the KAlSiO₄ phosphor synthesized using the simple combustion technique. The SEM micrograph interprets the affluence by asymmetrical size grain-type particles. The phosphor-grained type particles are revealed micrometer in size which is seen in Fig.2 (a,b,c,d) at different magnifications which shows many similarities with agglomerates. The tremendous gaseous particles during the reaction due to the exothermic cause result that fluffy morphological particle formation expected by the combustion synthesis technique evolved during formation expected by combustion synthesis.

![Figure 2: (a, b, c, d) SEM micrographs of KAlSiO₄ phosphor at different magnification](image)

Although the objects are brought closer together due to their size, the detected objects have different dimensions and are only a few micrometers in size. The given morphology
reveals the phosphor may be a useful candidate for WLEDs and display devices. The phosphor material Element constitution is shown in Fig.4. All the elements in the proposed phosphor materials are included which are confirmed by energy dispersive spectroscopy (EDS) analysis [16]. The atomic % and wt.% of precursors included in the phosphor are shown in the inserted table of Fig.3.

![Figure 3: EDS spectra of KAlSiO4 phosphor (inserted table shows weight % and atomic % of KAlSiO4 phosphor precursor)](image)

### 3.3 UV-Visible Analysis:

Band composition, as well as the band gap, can be determined using Ultraviolet (UV) – a visible spectroscopic technique for crystalline and amorphous materials. The main reason behind the difference between the energy is to ejection of photons with more energy as compared to the material energy band. Due to that, atomic vibration as well as the band gap in the material was interpreted by using the absorption spectra. The equation used determines the absorption coefficient as:

\[
(\alpha h\theta)_m = h\theta - E_g
\]

Here, \(\alpha = \text{absorption coefficient}\), 
\(h\theta = \text{photon energy}\),
\(E_g = \text{bandgap energy}\)
The transition parameter can take values 1/2 or 3/2 for indirect transition and 2 or 3 for allowed and direct forbidden transition [17,18]. Fig.4 represents the band gap determined from the UV-visible spectroscopy data for the KAlSiO$_4$ which is calculated by intercept obtained by a straight line as 3.37 eV. Optical behavior investigation of phosphor material and Jud-Ofelt (JO) which are very important luminescence parameters are calculated using the refractive index (n) of the provided material. Herve and Vandamme provided a mathematical formula to estimate the refractive index (n)[19]:

$$n = \sqrt{1 + \left(\frac{A}{E_g + B}\right)^2}$$

(4)

Here,

$A \& B = \text{constants (13.6 \& 3.4 eV)}$
\( E_g = \text{Energy band gap obtained from UV – Visible spectrum} = 3.37 \text{ eV} \)

So, using the above relation refractive index noted for the KAlSiO\(_4\) phosphor is 2.2439.

3.4 Photoluminescence Analysis:

3.5 3.4(a) Photoluminescence properties KAlSiO\(_4\): Eu\(^{2+}\), Eu\(^{3+}\):

The excitation spectra obtained for \( x = 1.0 \) mole \% of KAlSiO\(_4\):Eu\(^{3+}\) phosphor are shown in Fig. 5 excitation peak at 260 nm, 395 nm, and 465 nm correspondingly. The initial band in peaking at 260 nm which is attributed to O (2p) \( \rightarrow \) Eu\(^{3+}\) due to charge transfer is the important one to the UV excitation while used as a phosphor. The excitation peak was noticed at 395 nm due to \( ^7F_0 \rightarrow ^5L_6 \) while the excitation peak at characteristic peaks was noticed at 465nm corresponding to [20].

![Excitation spectrum](image)

*Figure 5: The excitation spectrum KAlSiO\(_4\):Eu\(^{3+}\)*

Fig.6 represents the energy level diagram explaining the transition between the level which is responsible for excitation and emission. Photoluminescence (PL) emission spectra for the Eu\(^{3+}\) activated KAlSiO\(_4\) phosphor at excitation wavelengths of 262 nm, 395, and 465 nm are shown in Figures 7, 8, and 9 respectively. KAlSiO\(_4\) matrix shows unique emissions of Eu\(^{2+}\) and Eu\(^{3+}\) ions when excited by 395 nm, spectra reveal that broad bands extend from 410 nm to 575 nm were
optimum obtained at 436 nm, as well as two emissions bands at 593 nm and 614 nm. The broadband is caused by $^4F_6 \rightarrow ^5D_1^4F_7$ transitions, while the sharp emissions peaked at 593 nm and 613 nm are caused by $^7F_0 \rightarrow ^5D_1$ and $^7F_0 \rightarrow ^5D_2$ transitions, correspondingly [21]. For excitation 465 nm, no broad band was observed but two important peaks were observed, the first emission peak is located at 593 nm corresponding to the $^5D_0 \rightarrow ^7F_1$ transition, and another intense peak is located at 613 nm which can be associated with the $^5D_0 \rightarrow ^7F_2$ transition of Eu$^{3+}$ ion. The emission characteristics of KAlSiO$_4$:Eu$^{3+}$ is measured for various concentration (x = 0.5, 0.7, 1.0, 1.3, and 1.5 mole %).

![Energy level Diagram (a) Eu$^{3+}$ and (b) Tb$^{3+}$](image)

Figu6: Energy level Diagram (a) Eu$^{3+}$ and (b) Tb$^{3+}$
Figure 7: The emission spectrum of KAlSiO₄:Eu³⁺ phosphor at $\lambda_{\text{ext}} = 262$ nm

Figure 8: The emission spectrum of KAlSiO₄:Eu³⁺, Eu²⁺ phosphor at $\lambda_{\text{ext}} = 395$ nm
The emission intensity increases as we increase the concentration of Eu3+ ions (x = 0.5 to 1.0 mole %) if increase the concentration then emission intensity declines without any change in peak pattern. At x = 1.0 mole% utmost intense peak obtained means the concentration quenching phenomenon occurs for KAlSiO₄:Eu³⁺ phosphor at 1.0 mole%. The valence states are mainly responsible for the luminescence properties of trivalent europium ion-activated phosphors.

Figure 9: The emission spectrum of KAlSiO₄:Eu³⁺ phosphor at λ_{ex} = 465 nm
Concentration Quenching:

The non-radiative transition between the Eu\(^{3+}\) ions is the basic reason responsible to obtain the concentration quenching. The non-radiative transition between the Eu\(^{3+}\) ion levels primarily occurs due to the exchange interaction, radiative reabsorption, and multipolar interaction.

![Figure 10: The 3D emission spectrum of KAlSiO\(_4\):Eu\(^{3+}\) phosphor (a) at \(\lambda_{ext} = 262\) nm (b) \(\lambda_{ext} = 395\) nm (c) \(\lambda_{ext} = 465\) nm](image-url)
Figure 11: Concentration quenching effect observed for KAlSiO₄:Eu³⁺ phosphor

According to the research data, if the value of critical distance (Rc) value is less than 5 Å, the energy changes depending on the exchange rate, but when the critical distance (Rc) value is greater than 5 Å then the energy transferred due to the electric multiple interactions [22]. The critical distance plays an important role to study the energy transfer mechanism between Eu³⁺ ions. Blasse noted that the critical distance (Rc) is nearly equal to two times the radius of a sphere with the volume of the unit cell,

It was pointed out by Blasse that the critical distance (Rc) is approximately equal to twice the radius of a sphere with the volume of the unit cell, represented by the equation as [23]:

$$R_c = 2 \left( \frac{3V}{4\pi X_c Z} \right)^{1/3}$$  \hspace{1cm} (5)

Here, V stands for the volume of the unit cell, Xc stands for the critical concentration of Eu³⁺ ions, and Z stands for the number of available sites in the unit cell 7dopant. For Eu³⁺ activated KAlSiO₄
phosphor taking the values of $V = 5372.64$, $Xc = 1.0$, $Z = 54$. The calculated value of critical distance ($Rc$) was $2.875 \text{ Å}$. So the primary reason for the concentration quenching phenomenon occurs due to the exchange interaction for $\text{KAlSiO}_4:\text{Eu}^{3+}$ phosphor. Van Uitert's theory is useful to understand the phenomenon of concentration quenching. Dexter formula given as[24]:

$$\frac{I}{x} = K \left[ 1 + \beta(x)^{\theta/3} \right]^{-1}$$  \hspace{1cm} (6)

i.e. $log\frac{I}{x} = c - \frac{\theta}{3} log x$

Where $x$ represents the concentration of the activator ion, $\frac{I}{x}$ represents the emission intensity per concentration of the activator ion. $\beta, K,$ and $c$ are constants and $\theta$ can vary as corresponding to exchange interaction, dipole–quadrupole interaction, dipole-dipole interaction, and quadrupole-quadrupole interaction respectively.

![Figure 12: Log(x) vs Log(I/x) plot (a) at $\lambda_e = 260 \text{ nm}, \lambda_e = 395 \text{ nm and } \lambda_e = 465 \text{ nm of KAlSiO}_4:\text{Eu}^{3+}$ phosphor (b) $\lambda_e = 352 \text{ nm and } \lambda_e = 378 \text{ nm of KAlSiO}_4:\text{Tb}^{3+}$ phosphor](image)

As per Van Uitert's theory, the value of $\theta$ plays a significant role to indicate the electric multipolar characteristics. When, $\theta = 3$ for the energy transfer among the exchange interaction, while $\theta = 6$ for dipole–dipole (d–d) interactions, $\theta = 8$ for dipole–quadrupole (d–p) interactions, and $\theta = 10$ for quadrupole-quadrupole (q–q) interactions [25]. The logarithmic plot between the Log(X) and Log(I/X) at emission intensity 614 nm for excitation 260 nm, 395 nm, and 465 nm is shown in
Fig. 13. The graph is linearly fitted having slope determined to be 0.80014, 0.84666 and 0.84386 i.e. $\theta = 0.84386$. So the $\theta = 2.53158$ value is nearly equal to 3. So in the KAlSiO$_4$:Eu$^{3+}$ phosphor concentration quenching occurred due to the possible exchange interaction.

3.4(b) Photoluminescence properties KAlSiO$_4$:Tb$^{3+}$

![Figure 13: represents the excitation spectra of KAlSiO$_4$:Tb$^{3+}$ phosphor](image)

Photoluminescence (PL) excitation spectrum manifests three peaks with peak positions of 352 nm, 370 nm, and 378 nm respectively nearby the UV range. Peaks obtained at 352 and 370 nm are caused by $^7F_6 \rightarrow ^5L_9$ transitions, whereas 378 nm are caused by $^7F_6 \rightarrow ^5D_3$ transitions explained energy level diagram and emission spectrum shown in Fig. 14($\lambda_{ext} = 352$ nm) and Fig.15($\lambda_{ext} = 352$ nm).
We record the PL emission spectra at these wavelengths 352nm and 378 nm which are shown in Figure. The emission peaks are located at 452 nm, 470 nm, 489 nm, and 545 nm respectively. Emission peaks observed at 489 nm and 545 nm are ascribed to $^5D_4 \rightarrow ^5F_6$ and $^5D_4 \rightarrow ^5F_5$ transitions [26,27]

![Emission Spectra](image)

*Figure 14: The emission spectrum of KAlSiO$_4$:Eu$^{3+}$ phosphor $\lambda_{ext} = 352$ nm*
3.5 CIE coordinates, CCT, and Color Purity:

**Figure 15:** The emission spectrum of KAlSiO₄:Eu³⁺ phosphor \( \lambda_{\text{ext}} = 378 \text{ nm} \)

**Figure 16:** The 3D emission spectrum of KAlSiO₄:Tb³⁺ phosphor (a) at \( \lambda_{\text{ext}} = 252 \text{ nm} \) (b) \( \lambda_{\text{ext}} = 378 \text{ nm} \)
The color coordinate and color purity of the given phosphor is determined using the Commission International de l’Eclairage (CIE) coordinates in 1931 shown in Fig. 17. The chromaticity coordinated noted for KAlSiO₄:Eu³⁺ (x = 1 mole%) for excitation wavelength \( \lambda_e = 395 \text{ nm} \) and \( \lambda_e = 465 \text{ nm} \) while KAlSiO₄:Tb³⁺ (x = 1 mole%) for excitation wavelength \( \lambda_e = 352 \text{ nm} \) and \( \lambda_e = 378 \text{ nm} \) using the CIE software. The CIE coordinate obtained for a given sample in the table comes in the blue and red regions.

The CCT values noted for the given sample using the McCamy’s Empirical formula using the equation [28]:

\[
CCT = -437n^3 + 3601n^2 - 686n + 5514.32
\] (7)

Where \( n = (x - x_e)/(y - y_e) \) here \( x_e = 0.332 \) and \( y_e = 0.186 \) chromaticity epicenters and \( x \) and \( y \) CIE coordinates [29]. CCT was discovered to have a value shown in table no. 1. The color purity of the sample is determined by the following equations [30]:

\[
CP = \frac{\sqrt{(x-x_i)^2 + (y-y_i)^2}}{\sqrt{(x_d-x_i)^2 + (y_d-y_i)^2}} \times 100
\] (8)
Where, \((x = 0.221, y = 0.1718)\) represents the sample CIE coordinate, \((x_i = 0.333, y_i = 0.333)\) is the illuminated point coordinates while \((x_d = 0.1661, y_d = 0.0093)\) dominant emission (395 nm) coordinates. The color purity obtained for 1.0 mole\% KAlSiO₄:Eu³⁺ sample is 53.95 % is less due to multicolor emission and similarly for 465 nm excitation wavelength 84.04 % as shown in table no.2.

<table>
<thead>
<tr>
<th>Rare Earth</th>
<th>Excitation wavelength</th>
<th>x</th>
<th>y</th>
<th>u'</th>
<th>v'</th>
<th>CCT</th>
<th>Duv</th>
<th>Du·v'</th>
<th>Symbol</th>
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<tbody>
<tr>
<td>Eu³⁺</td>
<td>395 nm</td>
<td>0.221</td>
<td>0.1718</td>
<td>0.1914</td>
<td>0.3347</td>
<td>428917</td>
<td>0.0421</td>
<td>-0.062</td>
<td>●</td>
</tr>
<tr>
<td>Eu³⁺</td>
<td>465 nm</td>
<td>0.6137</td>
<td>0.3859</td>
<td>0.3834</td>
<td>0.5424</td>
<td>10475</td>
<td>0.0023</td>
<td>0.0034</td>
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<tr>
<td>Tb³⁺</td>
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<td>0.2315</td>
<td>0.561</td>
<td>0.0999</td>
<td>0.5447</td>
<td>5580</td>
<td>0.113</td>
<td>0.131</td>
<td>●</td>
</tr>
<tr>
<td>Tb³⁺</td>
<td>378 nm</td>
<td>0.2251</td>
<td>0.5067</td>
<td>0.1043</td>
<td>0.5284</td>
<td>5669</td>
<td>0.1036</td>
<td>0.1186</td>
<td>■</td>
</tr>
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</table>

Table 1: CIE coordinate obtained using the Osram Sylvania software for (a) KAlSiO₄:Eu³⁺ sample at \(\lambda_{ext} = 395 \text{ nm}\), \(\lambda_{ext} = 465 \text{ nm}\) (b) KAlSiO₄:Tb³⁺ sample at \(\lambda_{ext} = 352 \text{ nm}\), \(\lambda_{ext} = 378 \text{ nm}\)

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>(\lambda_{ext})</th>
<th>x</th>
<th>y</th>
<th>(x_d)</th>
<th>(y_d)</th>
<th>CP</th>
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<tr>
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<td>395 nm</td>
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<td>0.1661</td>
<td>0.0093</td>
<td>53.9511</td>
</tr>
<tr>
<td>2</td>
<td>465 nm</td>
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<td>0.3859</td>
<td>0.6728</td>
<td>0.3270</td>
<td>84.0485</td>
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<tr>
<td>3</td>
<td>352 nm</td>
<td>0.2315</td>
<td>0.561</td>
<td>0.2684</td>
<td>0.7206</td>
<td>63.513</td>
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<tr>
<td>4</td>
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<td>0.5067</td>
<td>0.2691</td>
<td>0.7199</td>
<td>62.643</td>
</tr>
</tbody>
</table>

Table 2: Color purity for emission KAlSiO₄:Eu³⁺, Tb³⁺ phosphor

Conclusion:

In this article, we report KAlSiO₄:Eu³⁺, Tb³⁺ phosphor, synthesized first time successfully by simple combustion method. The photoluminescence analysis reveals that the reported phosphor has exciting luminescence behavior which may good candidate for use the of luminesce material for solid-state lightening. The band gap is determined using UV-visible spectroscopy. The XRD analysis, pure matrix match identically with standard JCPDS database file. The KAlSiO₄ matrix shows unique emissions of Eu²⁺ and Eu³⁺ ions when excited by 395 nm. Microgram obtained by
SEM analysis reveals the phosphor particle is an irregular grain type particle that is micrometer range in size. EDX analysis concluded all the elements are present in the reported phosphor. The CIE chromaticity coordinates for KAlSiO$_4$:Eu$^{2+}$/Eu$^{3+}$ co-activated phosphor multicolor coordinates which means shifted in blue region at $\lambda_{ext} = 395$ nm and the red region at $\lambda_{ext} = 465$ nm. On the other hand, KAlSiO$_4$:Tb$^{3+}$ in the green region at $\lambda_{ext} = 352$ nm and $\lambda_{ext} = 378$ nm. The Photoluminescence (PL) properties made this reported phosphor useful for the fabrication of white LEDs and solid-state lighting applications.

**Declarations**

**Ethical approval**

This article does not contain any studies involving human participants performed by any of the authors.

**Conflict of interest**

The authors declare that they have not any kind of conflicts of interest.

**Contributions**

The authors contributed to the synthesis as well as characterization of material, the analysis of the results, and the writing of the manuscript.

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**Availability of data and materials**

Data provided by the author analyzed during this study also material synthesized in laboratory personally.

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