MEMORANDUM OF UNDERSTANDING (MoU)

This Memorandum of Understanding is made on the **17th day of October 2020 and it is valid up to 16th October 2025 (5 Years)**

BETWEEN

Dr. Nirupama S. Dhoble, Professor, Department of Chemistry. Sevadal Mahavidhylaya, Nagpur (First Party)

AND

Dr.Girish Mishra, Department of Applied Physics, School of Sciences, Jindal University, Raigarh, C.G. (Second Party)

BACKGROUND

A. Each of the Party owns and operates facilities for the provision of

1. Laboratories use

2. Students exchange for Research.

3. Use and Exchange of Research activities.

4. Collaborative Research Publication.

5. Ph. D. Students exchange program.

B. The Party currently have an arrangement with each other with respect to the training, borrowing, and Awareness of Knowledge material that each Member Council works together with resource sharing, Knowledge sharing and maintenance of a shared resources.

C. Each of the Party agrees that the MOU shall be collectively known as **"To Exchange of Research activities and Collaborative Research Publicatiob".**

D. The Party desire to formalise their agreement and understanding in relation to the Network and have agreed to enter into this Memorandum of Understanding in this regard. However, the Party agree that this Memorandum shall not create any legal obligations and whilst recognising that there are no enforceable obligations between them the Party agree to perform their obligations pursuant to this Memorandum in good faith and to the best of their abilities.

AND THE PARTIES AGREE:

1.1 **Interpretation**

1.1.1 The Background set out above forms part of this Memorandum and the Party agree that the Background is true and accurate.

1.1.2 Unless the contrary intention appears:

SEVADAL MAHILA MAHAVIDYALAYA NAGPUR

Principal
Sevadal Mahila Mahavidyalaya
Umrer Road, Nagpur-9.

1.1.2.1 Words noting the singular shall include the plural and vice versa.

1.1.2.2 Reference to any gender shall include every other gender and words denoting individuals shall include corporations and vice versa.

1.1.2.3 Reference to any Act of Parliament, statute or regulation shall include any amendment currently enforce at the relevant time and any Act of Parliament, statute or regulation enacted or passed in substitution therefore.

1.1.2.4 Headings are for convenience of reference only and do not affect the interpretation or construction of this Memorandum.

1.1.2.5 A requirement in this Memorandum for liaison and consultation is a requirement for full and frank discussion and includes a requirement where necessary and appropriate, for full disclosure of relevant information and material.

2. **Term**

2.1 The term of this Memorandum shall be of five (5) years commencing on **15/06/2021** and expiring on the **14/06/2026**, unless otherwise agreed or extended by the Party in writing.

2.2 The term shall be reviewed by the Party not more than twelve (12) months and not less than six (6) months prior to the expiration of the term subject to the term being reviewed prior to this period.

3. **Negotiate In Good Faith**

The Party agree that they will cooperate with each other and at all times act in good faith and with the joint objective of successfully and expeditiously concluding and carrying out all of the arrangements and agreements contemplated in this Memorandum.

4. **The Party Obligations**

E. The Party agree that each of them shall have the following obligations in respect of **"To Demonstrate and Hands-on training of Laboratory equipment".**

F. **Second Party(Administer)**

On behalf of the Other Member Councils, the Second party agrees;

4.1.1 **Administration**

4.1.1.1 to administer the work in accordance with this Memorandum and the Operating Guidelines; and

4.1.1.2 to be accountable to the Other Party in a manner determined for the administration of the MOU and the facilitation of the MOU;

4.1.2 **Finances**

4.1.2.1 Network Costs and the Administration Cost is mandatory to administer (Second Party)

4.1.2.2 to prepare with the assistance from the Other Member Councils, in accordance with this Memorandum, the budgets for the Network; and

SEVADAL MAHILA MAHAVIDYALAYA NAGPUR

Principal
Sevadal Mahila Mahavidyalaya
Umrer Road, Nagpur-9.

4.1.2.3 to meet all auditing requirements for all monies received and paid for in relation to the Network;

4.1.3 **Membership of the Committee**

4.1.3.1 the Chief Executive Officer or delegated officer is a Principal and the nominee to the Committee is a Concern Department Head;

4.1.3.2 to appoint a representative (Should be a Faculty of Concern Department) from each party;

4.2 **All Member Councils**

The Party agree:

4.2.1 **Reporting**

To consider reports and recommendations from its respective representatives on the Committee in relation to the administration of the MOU.

4.2.2 The Committee shall at its first meeting (and annually thereafter) appoint amongst the representatives a Chairperson who shall hold office for a term of one (1) year but is eligible for reappointment for a further term, unless he/she resigns in which case the Committee shall appoint a new Chairperson to chair the meetings.

4.2.3 In the event that the appointed Chairperson is absent from a Committee meeting the representatives present shall appoint an acting Chairperson, who shall preside over that meeting or until the Chairperson is present.

5. **Operational Guidelines**

5.1 Upon execution of this Memorandum, the Chief Executive Officer or delegate of each of the Party shall prepare and implement Operational Guidelines which the Chief Executive Officers or delegates shall be capable of amending from time to time as the Chief Executive Officers or delegates see fit.

5.2 Notwithstanding the provisions of this Memorandum, the Party agree that the Operational Guidelines shall be the operative document that facilitates the operational management of the MOU.

5.3 The Party shall delegate to their respective Chief Executive Officers such powers as are required and necessary to prepare and amend the Operational Guidelines and to manage the network in accordance with the Operational Guidelines.

5.4 The Parties agree to negotiate and cooperate with each other at all times and to act in good faith in the operation of the Operational Guidelines and to comply with its terms.

The Parties agree that the terms and conditions of this Memorandum may be varied upon written agreement of the proposed variation by **all** the Member Councils.

6. **Liability**

6.1 The **Second Party** shall indemnify and keep indemnified the other Party against all actions, costs, claims, damages, charges in respect of injury, loss or damage resulting from any negligent act or omission of The **First Party** Council;

SEVADAL MAHILA MAHAVIDYALAYA NAGPUR

Principal
Sevadal Mahila Mahavidyalaya
Umrer Road, Nagpur-9.

7. **Acknowledgement**
The Party acknowledge and agree that each of the Party may in its own right engage the other Member Council staff for their services; however any agreed costs incurred by the Council in doing so shall be borne solely by the respective Party.

EXECUTED as a Memorandum of Understanding

THE SEAL of **THE First Party COUNCIL** was hereunto affixed in accordance with its Constitution and by the authority of its directors: Name: **Dr. Nirupama S. Dhoble, Professor, Department of Chemistry. Sevadal Mahavidhylaya, Nagpur**	Sign & Seal Nsdhoble 17/10/20 **Dr. (Mrs.) N. S. Dhoble** **Professor, Chemistry, Department** **Sevadal Mahila, Mahavidyalaya**

THE SEAL of the **Second Party COUNCIL** was hereunto affixed in accordance with its Constitution and by the authority of its directors: Name: **Dr.Girish Mishra, Department of Applied Physics, School of Sciences, Jindal University, Raigarh, C.G.**	Sign & Seal OP JINDAL UNIVERSITY ★ PIN 496109 ★ PUNJIPATHRA, RAIGARH (C.G.)

****

SEVADAL MAHILA MAHAVIDYALAYA NAGPUR

Principal
Sevadal Mahila Mahavidyalaya
Umrer Road, Nagpur-9.

To,

Date: 19/10/2022

The Registrar
Ph.D. Cell,
OP Jindal University,
Raigarh – 496109 (India)

Subject: Thesis submission of **Mrs. Chaitali Manohar Mehare**

Date of RDC: **August 29, 2020**

Registration No.: **Doctorate\2019\PhD(Chem)\0001**

Dear Sir,

I have been working for research work on **"Chemical route synthesis and luminescence characterization of rare-earth activated TLD and LED Phosphors."** in Department of Physics, OP Jindal University, Raigarh. My Supervisor **Dr. Girish C. Mishra** and Co-supervisor **Dr. S. J. Dhoble and Dr. N.S. Dhoble** are satisfied with the results of my research and believes that the work to be suitable and sufficient for submission of Ph.D. thesis to the OP Jindal University, Raigarh. All required documents and 3 copies of thesis are submitted with the cover letter.

Enclosures:

1. Thesis (03 Copies)
2. Softcopy of Thesis
3. Plagiarism Detection certificate
4. Registration letter
5. Copy of Published one Research Paper
6. Student Approval Form for Uploading of Ph.D. Thesis on SHODHGANGA

Yours Sincerely
Mrs.Chaitali Manohar Mehare
Research Scholar,
Department of Chemistry,
OP Jindal University,
Raigarh-496109, India

Received
BK Langotry
19/10/22

OP JINDAL UNIVERSITY

Under the Supervision of

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Under Co-supervision of

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Umrer Road, Nagpur-9.

Chemical route synthesis and luminescence characterization of rare-earth activated TLD and LED Phosphors

A THESIS

Submitted to the

OP Jindal University, Punjipathra, Raigarh

For the award of the Degree of

Doctor of Philosophy

in Chemistry

Under the School of Science

By

Mrs. Chaitali Manohar Mehare

Under the Supervision of

Dr. Girish Mishra
Professor & Associate
Dean of SoS,
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OPJU
UNIVERSITY OF STEEL TECHNOLOGY AND MANAGEMENT

OP Jindal University, Punjipathra, Raigarh (C.G.), India
October 2022

SEVADAL MAHILA MAHAVIDYALAYA NAGPUR

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Chemical route synthesis and luminescence characterization of rare-earth activated TLD and LED Phosphors

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M.Sc. (Physics)

Under the Supervision of

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Professor & Dean of SoS,
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October 2022

RADIATION EFFECTS & DEFECTS IN SOLIDS
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Luminescence characteristics of O^{6+} ion beam and γ-ray irradiated $Ca_9La(PO_4)_5(SiO_4)F_2$:Eu phosphor

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ABSTRACT

Fluorapatite $Ca_9La(PO_4)_5(SiO_4)F_2$: Eu with variable molar concentrations of Eu^{3+} (0.05–1.0 mol%) were synthesised by the solid-state reaction method and their photoluminescence (PL), thermoluminescence (TL) characteristics were studied after irradiating the samples with γ-rays and 75 MeV O^{6+} ion beam. The formation of the material was confirmed using X-ray diffraction pattern followed by Scanning electron microscopy and Fourier transform infra-red (FTIR) spectrum. The morphology of the synthesised powder was observed to be polycrystalline constituted by microcrystalline particles. FTIR spectrum shows characteristic bands, 563 cm^{-1} for bending vibration υ_4 and 1035 cm^{-1} for stretching vibration υ_3. PL spectra show absorption bands at 395 and 466 nm corresponding to $^7F_0 \rightarrow {}^5L_6$ and $^7F_0 \rightarrow {}^5D_2$ transitions and the emission band was seen at around 595 and 616 nm describing $^5D_0 \rightarrow {}^7F_j$ transitions (j = 1,2). Furthermore, TL glow curves of both γ-rays and 75 MeV O^{6+} ion beam irradiated samples show a prominent peak at around 145°C with a small hump at around 245°C. The concentration 0.2 and 1 mol% was found to be the best concentration for studying TL properties of $Ca_9La(PO_4)_5(SiO_4)F_2$: Eu irradiated with γ-rays and 75 MeV O^{6+} ion-beam respectively.

ARTICLE HISTORY
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KEYWORDS
$Ca_9La(PO_4)_5(SiO_4)F_2$; thermoluminescence; photoluminescence; w-LEDs; phosphor

1. Introduction

Over the past few years, many inorganic compounds activated by rare earth metals, such as silicates, phosphates, borates, aluminates and sulphides, have attracted great attention for their applications in different fields (*1–13*). Furthermore, these days, the synthesis of different novel phosphors has become the current topic of the research community due to their excellent luminescent properties required for solid-state lightening. Some of these competent phosphors are Apatite-type phosphors with favourable chemical and thermal stability and excellent luminescent properties (*14*). Apatite compound represents a similar structure as the natural mineral fluorapatite $Ca_{10}(PO_4)_6F_2$. It is having general chemical formula as $A_{10}(PO_4)_6Z_2$, where A represents cations such as Ca^{2+}, Mn^{2+}, Ba^{2+}, Sr^{2+}, Fe^{2+}, Mg^{2+} and Pb^{2+} and Z represents F, Cl, Br or O. Moreover, $[PO4]^{3-}$ can also be replaced

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LUMINESCENCE WILEY
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RESEARCH ARTICLE

Thermoluminescence dosimetry properties and kinetic analysis of $K_3Ca_2(SO_4)_3F:Dy^{3+}$ phosphor

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Abstract

A trivalent Dy^{3+}-activated $K_3Ca_2(SO_4)_3F$ fluoride-based phosphor was synthesized using a solid-state reaction method and characterized for its thermoluminescence (TL) application. The crystal structure and surface morphology of the as-synthesized material was analyzed using X-ray diffraction and scanning electron microscopy. A series of the $K_3Ca_2(SO_4)_3F:Dy^{3+}$ phosphor was irradiated using γ-rays from a ^{60}Co source and TL glow curves were recorded using a Nucleonix 10091 TL reader. The glow curve of the prepared phosphor showed a prominent single peak at 278°C. TL characteristics were maximum intensity at 1 mol% of Dy^{3+} ion with a single TL glow peak. The TL glow curve revealed linearity with increase in exposure dose range from 0.1 kGy to 3.0 kGy. Theoretical analysis of the TL glow curve of the γ-ray-irradiated sample was carried out using a computerized glow curve deconvolution method and trapping parameters such as activation energy and frequency factor were calculated using the initial rise method and Ilich's method. The synthesized Dy^{3+}-doped $K_3Ca_2(SO_4)_3$ phosphor revealed excellent TL properties and was found to be a potential candidate for dosimetric applications.

KEYWORDS

activation energy, dosimetry, frequency factor, kinetic parameter, thermoluminescence

1 | INTRODUCTION

Recently, high performance thermoluminescence (TL) materials have received more attention in technology fields due to an increasing demand for TL dosimeters (TLD), which have wide application in industrial, environmental, personal, and clinical ionization radiation protection.[1] Thermoluminescence is a phenomenon of crystalline materials that absorbed energy from electromagnetic radiation or other ionizing radiation that is then re-emitted as light upon heating and which can be utilized for radiation dosimetry.[2,3] The emission intensity of light revealed by phosphors on heating gives an idea of the irradiation dose given to it. A theoretical model for TL analysis was first proposed by Randall and Wilkins.[4] According to this model, electrons are trapped during excitation in some lattice sites. When crystals are heated, electrons are released thermally into the conduction band and are finally recombined with holes at the recombination sites, resulting in TL emission, which is represented by the TL glow curve. Thermoluminescence does not refer to thermal excitation, but to stimulation of luminescence in a sample that has been excited in a different way. The TL material cannot emit light again by simply cooling the sample and reheating it another time. It should first be re-exposed to ionizing radiation to again produce light. Generally, TL phosphors useful for dosimetry application must satisfy some important characteristics such as high TL dose sensitivity and accuracy, show linearity of dose–response over a wide range. Also they should not exhibit any thermal quenching, be inexpensive, free from hygroscopic and toxicity properties, show negligible UV light response, be reusability, and be easy to process.[5,6] Dosimetric characteristics of a TL phosphor are mainly influenced by their trapping parameters such as activation energy (E), frequency factor (s) and order of kinetics (b), which describe the defect centres responsible for TL emission. Mixed sulphate-based phosphors have excellent TL characteristics due to

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Tailoring the luminescent properties of $Ca_9La(PO_4)_5(SiO_4)F_2$:1 mol%Eu^{3+} phosphor via doping of chloride, molybdate, vanadate, sulfate, and tungstate ions

Chaitali M. Mehare[1,5] · Yatish R. Parauha[1] · Vibha Chopra[2] · Sudeshna Ray[3] · N. S. Dhoble[4] · Chandan Ghanty[5] · S. J. Dhoble[1]

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Abstract
We report here, the $Ca_9La(PO_4)_5(SiO_4)F_2$:1 mol%Eu^{3+} phosphor via doping of chloride, molybdate, vanadate, sulfate, and tungstate ions that were synthesized by high-temperature solid-state reaction method. The phase formation was confirmed by X-ray diffraction (XRD) measurements. Morphological studies were performed using scanning electron microscopy. Photoluminescence and thermoluminescence properties of the synthesized phosphors were systematically studied. The PL excitation spectra of host material show peaks at 395 nm and 466 nm corresponding to $^7F_0 \rightarrow {}^5L_6$ and $^7F_0 \rightarrow {}^5D_2$ transitions of Eu^{3+}, respectively. Further photoluminescence properties also studied after doping of molybdate, vanadate, sulfate, and tungstate ions in host material. When excited at 395 nm and 466 nm, PL emission spectra show emission band at around 595 nm and 616 nm, which attributes to $^5D_0 \rightarrow {}^7F_1$ and $^5D_0 \rightarrow {}^7F_2$ transitions, respectively. Further TL glow curves of all the synthesized phosphors were studied when exposed to γ-rays.

1 Introduction

For luminescence applications, host materials that can be excited under UV or visible excitation and those which possess large band gap are suitable matrices, into which a small concentration of foreign ions called activators can be incorporated [1]. In the modern era, rare earth (RE)-doped phosphors are widely applied in different areas such as solid-state lighting, display devices, dosimetric application, fingerprint detection biomarker, solar cell, etc. [1-3]. RE-doped phosphors gained more attention and popularity due to their effective and tremendous advantages such as high luminescence efficiency, color purity, and long emission lifetimes. In the recent few years, thousand types of phosphors were analyzed to improve the qualities of the existing phosphors [4-6]. Especially, a number of Eu^{3+}-doped phosphors were investigated [7-11]. According to literature, Eu^{3+} is a rare earth ion of immense interest. It is used in lighting and display technologies such as electroluminescence cells, plasma display panels, high-efficiency fluorescent lamps, light-emitting diodes, and waveguides as it shows remarkable photoluminescence (PL) properties [12, 13]. Eu^{3+}-doped phosphor materials give sharp PL emission in the orange-red color region, which is very useful for studying the nature of metal coordination in various systems due to its non-degenerate emitting $^5D_0$ state [14].

In the recent scenario, LEDs are modern lighting technology and top-most choice in solid-state lighting devices. LEDs have tremendous qualities and give a high-performance comparison to other incandescent and fluorescent lamps. LEDs have marvelous advantages such as low cost, eco-friendliness, long lifetime, high luminescence efficiency brightness, and energy-saving qualities [15-20]. At present, the existing method of fabricating WLEDs by combining blue InGaN chip with yellow-emitting YAG:Ce phosphor produces white light that lacks red component, resulting high correlated color

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Synthesis and characterization of Eu^{3+} doped $Ca_9La(PO_4)_5(SiO_4)FCl$ fluoroapatite phosphor for white LED

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ABSTRACT

The fluoroapatite $Ca_9La(PO_4)_5(SiO_4)FCl$:1 mol% Eu^{3+} phosphor was synthesized by conventional solid state reaction. In the present work keeping concentration of F_1Cl_1 constant and $(PO_4)^{3-}$ of the material was replace by $(MoO_4)^{3-}$. The phase purity and surface morphology was evaluated through X-ray diffraction and scanning electron microscope technique. The emission and excitation spectra were investigated using photoluminescence spectroscopy. The excitation and emission spectra indicate that prepared phosphor effectively excited by 278 nm, exhibits emission peak at 595 nm and 616 nm corresponds to yellow and red colour attributes to $^5D_0 \rightarrow {}^7F_1$ and $^5D_0 \rightarrow {}^7F_2$ transitions respectively. The above result reveals prepared phosphor is excellent red phosphor in white light emitting diode application.

Selection and Peer-review under responsibility of the scientific committee of the 11th National Conference on Solid State Chemistry and Allied Areas.

1. Introduction

Recently in comparison with conventional incandescent or fluorescent lamp white light emitting diode (w-LED) receive promising attention in the field of solid state technology due its unique characteristics includes, intense luminous efficiency, long operational stability, mercury free, eco-friendly, low power consumption reveals wide application prospects [1–3]. In general, white LEDs (w-LEDs) available in market can be manufactured by combining yellow emitting phosphor with blue InGaN chip, However this type of w-LEDs suffer limitation includes low colour rending index(CRI) and high correlated color temperature (CCT) due to deficiency of sufficient red emission [4,5]. This limitations is overcome by adopting alternative approach for the formation w-LEDs, by means of coupling of near- ultraviolet (n-UV) InGaN- based chip with tricolor (RGB) phosphor, but still has disadvantage of low efficiency due to re-absorption of blue light by red and green phosphor [6]. It leads to development of alternative red or tunable phosphor with excellent stability and suitable excitation wavelength in the n-UV region. Recently, apatite-type based phosphor received more attention as a host luminescence materials owing to their remarkable luminescent efficiency and excellent chemical and thermal stability [7,8].

The compounds belongs to apatite family will be *iso*-structural in nature, compose of hexagonal symmetry (space group of $P6_3/m$) consisting general formula $A_{10}[PO_4]Z_2$ where A- indicates divalent cations includes $Ca2^+$, Ba^{2+}, Mg^{2+}, Pb^{2+}, Sr^{2+}, Fe^{2+}, Mn^{2+} etc. Z- represent F, Cl, Br or O. With consideration of structural morphology $[PO_4]^{3-}$ can be substituted by $[SiO_4]^{4-}$, $[BO_4]^{5-}$ and $[VO_4]^{3-}$ [6,9,10]. The compounds with apatite structure reveals the capability of substitution by versatile ions and forming the changeable solid state solution apatite structure, attributes to the tunable luminescence followed by excellent luminescent properties, hence gain more interest for the synthesis novel inorganic framework with new compound belong to apatite structure.

In the present work we report the synthesis of $Ca_9La(PO_4)_{5-x}(MoO_4)_x(SiO_4)F_1Cl_1$:1mol% Eu^{3+} fluoroapatite type phosphor by solid state reaction method, further $[PO4]^{3-}$ of the host is replace by $[MoO4]^{3-}$ and their luminescent properties are investigated. The formation of as-prepared phosphor was further confirmed by X-ray diffraction (XRD) and scanning electron microscopy (SEM) analysis.

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2214-7853/
Selection and Peer-review under responsibility of the scientific committee of the 11th National Conference on Solid State Chemistry and Allied Areas.

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Synthesis of novel Eu^{2+} activated $K_3Ca_2(SO_4)_3F$ down-conversion phosphor for near UV excited white light emitting diode

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Photoluminescence
CIE chromaticity diagram

ABSTRACT

In the present paper, we have successfully synthesized Eu^{2+} activated $K_3Ca_2(SO_4)_3F$ phosphor by two-step solid-state reaction method at high temperature (800 °C). Pure crystalline formation, morphological behavior, and their vibration bonds of synthesized Eu^{2+} activated $K_3Ca_2(SO_4)_3F$ phosphor were verified by the X-ray diffraction (XRD), Scanning Electron Microscopy (SEM) and Fourier transform Infrared Spectrum (FT-IR). The photoluminescence (PL) spectrum and CIE coordinate with color purity also characterized. In PL emission spectra clearly represented that broad excitation band from 250 nm to 400 nm ranged. The center of this PL excitation spectra observe at 326 nm, but some parts of these spectra lies to 350 nm−400 nm. This excitation wavelength is very useful for the generation of white light because it may be used as near UV light. PL emission represents broad emission spectra from 400 nm to 550 nm centred at 440 nm. Most part of these PL emission spectra lies in the blue region of the spectrum. PL spectra arise from the transitions between the 5d and 4f orbital's transition of Eu^{2+} ions. EVI parameters such as Stokes Shift (ΔEs), the Huang-Rhys factor (S),effective phonon energy (ħω) and the Zero-phonon line (ZPL) are calculated. In our present work, we are calculated that the value of Huang −Rhys factor constant (S) is 3.74 that means coupling is intermediately strong. CIE chromaticity coordinate of $K_3Ca_2(SO_4)_3F$:xmol%Eu^{2+}[x = 0.5, 2.0, 3.0, 5.0, 7.0, 10mol%] phosphor were also calculated by using OSRAM SYLVANIA color calculator 1931. By using these CIE chromaticity coordinate was calculated the value of color purity for each concentration of Eu^{2+} ions. After seeing all results of synthesized phosphor material we are concluded that it may be a better option used as commercial phosphor for obtaining white light. So it may be a promising candidate for NUV WLEDs.

1. Introduction

In the age of digitization, the energy shortage more times felt when the electrical power is generated on this planetis inefficiently consumed for lighting applications. If energy is not utilized judiciously and wisely for lighting then many problems are clearly viewed on the planet because of the world population daily increased and industrialization regularly improved [1,2]. Rare earth activated inorganic phosphor has attracted a lot of attention due to their excellent features. Rare earth activated inorganic phosphor widely applied in the field of luminescence and their research has a high impact on the energy and environmental sectors [3–5]. It is also widely used in the field of Hg free fluorescent lamps, plasma display panels, indoor lighting, cathode-ray tubes, solar cell, fingerprint detection, biosensing, phototherapy, plant growth, white light-emitting diodes (WLEDs) and Dosimetric applications [3–10]. Solid-state lighting (SSL) based devices are predicted to play a crucial role in the coming few years. They offer to save huge amounts of electrical energy and reduce carbon emissions by almost 28 million metric tons per year globally [11]. In recent years, phosphor converted white light-emitting diodeshasrevealed extraordinary features and it becomes the best choice in lighting technology due to their advanced technology and excellent properties such as compact size, high luminous efficiency, energy savings, long operation life-time, and environment-friendliness, etc [2,12–14],which promise significant reductions in power consumption and pollution from fossil fuel power plants [12]. Generally, LEDs are used as an indicator, rear lamps for vehicles,

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Photoluminescence and thermoluminescence characteristics of $CaAl_2Si_4O_{12}:Dy^{3+}$new phosphor prepared by combustion synthesis

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ABSTRACT

The present study reported synthesis of Dy^{3+}activated $CaAl_2Si_4O_{12}$ phosphor via combustion techniques. The formation of crystal structure and surface morphology was analysed by X-ray diffraction pattern and scanning electron microscopy. The photoluminescence spectrum reveals, the prepared phosphor material exhibits an excellent emission at 422 nm, with two peaks around 479 nm (blue region) and 575 nm (yellow region) monitor at excitation wavelength of near UV 369 nm. In addition, CIE color chromaticity confirms the emission locate at the blue light region, revealed suitability of prepared phosphor in UV excitable blue emission for white light emitting diode. The Thermoluminescence characterization of prepared phosphor irradiated with a ^{60} Co γ- ray source at dose rate of 7.2 kGy/hr was further carried out using a Nucleonix TL 1009I TL reader. The tapping parameter such as activation energy (E) and frequency factor (s) was calculated using Ilich's method.

1. Introduction

The crucial need of energy saving and environmental protection issue, facilitate the research on the development of white light-emitting diodes (w-LEDs) for lighting due to their unique characteristics includes, long life-span, high luminous efficiency, good operational stability, energy saving, fast switching, color quality as well as environmental-friendly characteristics which can expected to replace conventional source of light for world-wide in near future [1–5]. Recently, the development of inorganic compounds, especially the rare-earth-doped luminescent materials, has been received more attention owing to their potential applications in the field of lamp industries, field emission display (FEDs), radiation dosimetry, solid state laser and white light-emitting diodes (WLEDs) [6–10]. In the recent year there is extensive investigation of phosphors are already carried out includes aluminates [11], orthosilicates [12], nitrides [13,14], oxides [15,16], sulphides [17] etc. Normally, the initial composition of the host materials, dopant concentrations and processing conditions define the luminescent characterization of rare earth doped activated materials [18]. Among the various reported host phosphors, the alumina-silicate have received more attention owing to its numerous merit such as excellent luminous efficiency, long life time, low cost and remarkable physical and chemical stability [19,20]. Initially, first w-LED was invented by combination of blue LED with yellow phosphor ($YAG:Ce^{3+}$) however poor color rendering index and high correlated color temperature limit its further commercialization [21]. Further approach adopted is to combine UV LED with RGB (red, green, blue) phosphor but it's lower luminescent efficiency owing to strong absorption of blue light by red and green component of phosphors which further hindered its utilization which intensively drive the attention toward the development of single phase white light emitting phosphor [22,23]. A single-host white-emitting phosphor usually reveals broad or multiple emission peaks in the visible region and hence paid crucial inclination for development of novel broadband or multi-peak emitting UV or n-UV excitable w-LED with color stability [24,25]. In recent decades, the rare earth doped activated phosphor gain prime position in various filed such as lighting, photosynthesis enhancement, and photodynamic for cancer therapeutics [26–28].The trivalent Dy^{3+} ions exhibits two intense peaks in blue and yellow region at about wavelength 479 nm corresponding to the $^4F_{9/2}\rightarrow{}^6H_{15/2}$ and 575 nm corresponding to the $^4F_{9/2}\rightarrow{}^6H_{13/2}$ transition representing its potential application for white light emission [29,30]. The silicate host phosphor doped with Dy^{3+} ions shows wide application for generation of white light by simply varying the ratio of blue and yellow part of intensities [31,32]. Moreover it plays as very important role in many long lasting phosphor such as $BaAl_2Si_2O_8$

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Synthesis and photoluminescence properties of novel red-emitting $KMg_4(PO_4)_3$: Eu^{3+} phosphors for UV- excited white-light emitting diodes

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Abstract. The trivalent Eu^{3+} activated $KMg_4(PO_4)_3$ phosphor has been successfully prepared via solid state diffusion technique. The phase formation and structural morphological studies carried out by XRD pattern and SEM analysis. The photoluminescence excitation spectra centred at 395 nm attributed to $^7F_0 \rightarrow {}^5L_6$ energy transition levels. PL emission spectra centred at 593 nm and 613 nm corresponds to $^5D_0 \rightarrow {}^7F_J$(J=1,2) transitions of Eu^{3+} in the host respectively. The experimental results showed that Eu^{3+} singly doped $KMg_4(PO_4)_3$ phosphor under UV excitation gives intense red emissions. The critical Eu^{3+} quenching concentration (QC) was determined to be 1.0 mol% along with excellent CIE coordinates of (0.6326, 0.3670). All the above results exhibits, the prepared phosphor is promising material as UV excitable red emitting phosphor for w-LED.

Keywords: Phosphor; Down conversion; Luminescence; Chromaticity coordinates; W-LEDs

1. Introduction

In the recent year trivalent rare-earth (RE^{3+}) ions doped inorganic based phosphor received more attention as luminescent materials owing to their wide application in the various field such as w-LEDs, medical applications, non-inversion thermometry, solar energy conversion, temperature sensors, field emission displays and solid state lighting (SSL), due to existence of emissions attributes to electronic transitions in the $4f_n$ configurations [1–3]. In the present era energy saving is the prime issue and hence major inclination towards w-LEDs in display technology owing to its excellent performance, low power consumption, durability, high compatibility, energy saving, as well as are of highly economical [4,5].In order to realize the excellent luminescent materials, it must exhibits some important characteristics such as prominent emission efficiency under n-UV/blue excitation, good thermal and chemical stability as well as narrow band emission with good absorption. In general two approach are adopted to achieve pc-w-LEDs include (i) combination of yellow emitting (YAG:Ce^{3+}) phosphor with blue emitting (InGaN) chip but owing to lack of red emission it shows high CCT and poor CRI which hinder its commerce alization.(ii) This limitation can be overcome with the approach of combination of RGB phosphor with n-UV or blue excitation chip to improve the optical properties[6]. The poor thermal stabilities and aging rates of the different phosphors also restrict their applications in w-LEDs [7,8]. Moreover, various components of inorganic luminescent phosphor materials encompass with borates [9], Aluminate[10], vanadates [11], tungstates [12], silicates [13] and phosphates [14] have been studied for generation of

Recent development of Eu^{3+}-doped phosphor for white LED application: A review

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Abstract. The phosphor converted w-LEDs gain crucial attention in solid state lighting (SSL) for generation of illumination owing to their numerous meritorious advantages such as superior life time, excellent efficiency, compactness, reliability and power saving consumption as well as environmental friendly. The quality of w-LEDs in lighting and display is influence by host phosphorand the choice of activator. So greatlyattemptwere dedicated to developed inventiveuni-nucleiluminescent phosphor materials compose of chromatic stability, optimum CRI and low correlated color temperature. This review elaborate theintroduction ofEu3+rare earth activated red emitting phosphor assigned to 5D0→7FJ (J= 1,2,3,4) energy levelsand its fundamental merit for w-LEDs.This article represent the analyseof combination of differenttypes of Eu3+ activated luminescent materials by traditional and novel methods and its impact on photoluminescence for SSL.

Keywords: Phosphor; Europium rare earth ions; Energy transfer mechanism; photoluminescence; w-LED.

I. Introduction

In the modern society and digitalization, energy saving and environmental protection gain world-wide attention. In the past decades, luminescence materials shows crucial utilization for development of display technology [1]. On the basis of absorption and emission of radiant energy luminescence are classified into categories namely up-conversion and down conversion emission mechanism[2]. The active centre and active medium plays very important role in order to visualize and realize efficient luminescence. The phosphors materials applicable for commercial purpose must possess certain meritorious characteristics like long operational life, remarkable energy efficiency, high CRI, considerably environmental friendly. Moreover the conventional source of light includes incandescent lamp, halogen and xenon lamp owing to their large energy consumption and environmental issue are replace by light emitting diode[3]. It should be expected that widespread utilization of LED source of light in comparison with traditional light source reduce worldwide consumption of electricity and exclusion of mercury support the environment which gives additional boost to the development of LEDs for lighting[4]. The development of this eco-friendly technology help in reduction of global power requirements as well reduces utilization of fossil fuels. There are various chronology reported for the development optimum luminescence performance of phosphor for w-LED application required for solid state lighting applicable for lighting and display backlight sources [5]. Commercially, phosphor converted w-LEDs can be obtained when blue emitting InGaN based semiconductor chip coated with yellow light emitting YAG:Ce phosphor results generation of white light [6]. However, it shows poor color rendering indices (CRI~ 70-80) along with high correlated color temperature (CCT ~4000-7500 K) but due to deficiency of red component in the spectral region hinder its utilization for indoor lighting[7]. To overcome the flows alternative method is adopted involving the combination of near ultraviolet (n-UV) LED chip with tri-chromatic red, green and blue (RGB) light emitting phosphor has been proposed[8].Unfortunately phosphor mixture revealed strong re-absorption of the blue light by the green and red phosphor as well as non-uniformity in luminescent properties, resulting deficient in

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Study of thermoluminescence and trapping parameter evaluation of $K_3Ca_2(SO_4)_3F$: Mn^{2+} phosphor in perspective of TLD application

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ABSTRACT

The series of Mn^{2+} single doped fluoride-based $K_3Ca_2(SO_4)_3F$ phosphor was prepared by the conventional high temperature solid-state reaction method. The formation of phase purity and morphology was studied by the XRD and SEM analyses. The prepared material was irradiated by γ-rays from ^{60}Co source and the thermoluminescence (TL) characteristic was carried out by Nucleonix 1009I TL reader. The prominent TL dosimetry peak observed for $K_3Ca_2(SO_4)_3F$:1mol% Mn^{2+}, annealed at 800°C centred at 217°C, revealed deeper traps. The TL exhibits a linear response as a function of dose rate up to 4 kGy. The computerised glow curve deconvolution (GCD) method, employed for the analysis of TL glow curve, shows the kinetics of the first order. The trapping parameters were evaluated using Chen's peak shape method, initial rise method and Ilich method. The results exhibit that the synthesised phosphor was found to be a potential candidate for radiation dosimetry applications.

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Phosphor; radiation dosimetry; trapping parameter; glow curve; exposure

1. Introduction

The phenomenon of light emission from crystalline materials, such as semiconductor or insulator, under heat treatment on previously irradiated material by highly ionising radiations, is described as thermoluminescence (*1*).The radioactive radiations, which are commonly applicable in the medical or nuclear field, show a hazardous effect on human beings and hence there is a serious need for the monitoring of radiation doses. Several technical methods for radiation detection, such as ionisation chamber, GM counter, etc., were used; however, among them TLD phosphor revealed promising applications over this owing to their enormous characteristics such as their smaller size, cost effective, ease in handing and fast readouts. Recently thermoluminescence dosimetry (TLD) received more attention in various areas such as environmental issues, industries as well as medical applications and protection. The thermoluminescence materials revealed excellent susceptibility for both personal and environmental monitoring, available in considerable smaller in size and hence easily adaptable for both manual and automatic processes, also these materials revealed

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Improvement of self-activated luminescence properties of $Ca_2KZn_2(VO_4)_3$ down-conversion materials by SSR method based on co-doped Eu^{3+},Dy^{3+} rare earth ions concentrations

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ABSTRACT

In this study, a self-activated and co-doped Eu, Dy with $Ca_2KZn_2(VO_4)_3$ (CKZVO) phosphors were synthesized by conventional solid state reaction method. The powder X-Ray diffraction study confirm the formation of single phase cubic crystal structure with space group $Ia\bar{3}d$. The surface morphology of as-synthesized phosphor was verified by SEM analysis. The FTIR spectrum shows characteristic bonds, for bending vibration and asymmetric stretching vibration. In photoluminescence under the UV excitations the CKZVO phosphor display greenish blue emission due to the VO_4 transitions ions in host matrix. The PL characteristic of CKZVO: Dy^{3+} phosphors exhibits intense emission centred at 480 nm (blue) and 573 nm (yellow color). Moreover, CKZVO: Eu^{3+} phosphor exhibits strong emission at 500 nm (green) and 615 nm (Red) under UV excitation. Further co-doping of Dy^{3+}, Eu^{3+} in the host matrix reveals a strong emission in blue, green, yellow and red region. The chromaticity coordinates of the samples were in near white region. All the results exhibit that CKZVO: Dy^{3+}, Eu^{3+} phosphor might be a potential material for NUV-based white light-emitting diodes.

1. Introduction

In recent years, the commercially available (RE^{3+}) ions activated with inorganic based phosphor received voluminous attention owing to their numerous application in various fields such as ranging color displays, WLEDs, medical diagnosis, non-inversion thermometry, solar energy conversion, field emission displays and solid state lighting (SSL) due to their emissions arising from the abundant transitions in the 4fn configurations [1–3]. In the recent, current interest is inclined toward the development of white light-emitting diodes for energy conservation, owing to its marvellous advantages includes, high efficiency, low power consumption, long lifetime, and high compatibility along with economical and ecological characteristics [4,5]. In addition, these LEDs exhibits wide applications in medical and architectural field for lighting purposes. The W-LEDs are normally manufactured by the yellow emitting YAG: Ce^{3+} phosphor in combination with blue LED chip, but this approach reveals certain disentangles like low color rendering index (CRI) and high color temperature (CCT) and hence, there is serious need to search alternative technique to generate white light which adopted to be combination of primary color (RGB) with a near UV LED chip. But this suffer drawback of re-absorption of red light in various type of phosphor which hindered its popularity and hence need to resolve [6,7]. Undeniably, development of an effective phosphor material that overlay a broad spectral emission range in red, green and blue regions (400 nm to 750 nm) combining with UV light-emitting chip might be prominent way to overcome the above complications [8–10].

Vanadate belong to chemical component of tetrahedral (VO_4) groups with negative (-3) charge and the central metal ion that encompass by four oxygen ions in tetrahedral (T_d) symmetry which is known to be for an efficient luminescent nucleus [11]. The ions have same charge as that of host phosphor and roughly the same size can be easily substitute for each other in the host matrix. The vanadate based luminescent materials is commonly known to be as self-activated phosphor, and the property of $(VO_4)_3$ group to be act as sensitizer to the rare earth ions. In addition, the superior chemical and thermal stability along with low synthesis temperature produce vanadate phosphors as encouraging phosphor materials [12]. The various inorganic based phosphor materials includes borates [13], Aluminate [14], vanadates [15], silicates [16] and phosphates [17] etc. will reported as luminescent host materials .

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Influence of rare earth ions on luminescent properties of self-emitting $KCa_2Mg_2(VO_4)_3$ phosphors for lighting application

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Highlights

- A novel self-activated $K_2Ca_2Mg_2(VO_4)_3$ phosphors was prepared by solid-state reaction method.
- The luminescence properties of rare earth ions (Dy^{3+}, Eu^{3+}) doped and undoped $K_2Ca_2Mg_2(VO_4)_3$ phosphors have been examined.
- The energy transfer between VO_4^{3-} and Dy^{3+}/Eu^{3+} was investigated.
- The optical band of $K_2Ca_2Mg_2(VO_4)_3$ phosphor was 4.60 eV.

Abstract

The influence of rare earth (RE) ions on the photoluminescence (PL) properties of self-emitting $KCa_2Mg_2(VO_4)_3$ phosphors were studied in detail. In this investigation, RE doped and undoped $KCa_2Mg_2(VO_4)_3$ phosphors have been successfully synthesized by solid-state reaction (SSR) method. The phase purity, structural, vibrational and luminescence properties have been investigated by different techniques. $KCa_2Mg_2(VO_4)_3$ phosphor shows self-luminescence properties, it exhibits broad emission in the range of 400–650 nm under 346 nm excitation. Interestingly, with the doping of Dy^{3+} ions in $KCa_2Mg_2(VO_4)_3$, we have noted that emission intensity increases in the initial stage up to 0.3 mol% concentration of Dy^{3+} ions, after that concentration quenching observed. In addition, luminescence properties of Eu^{3+} doped $KCa_2Mg_2(VO_4)_3$ phosphors were also investigated for multiple excitation wavelengths. They shows energy transfer behaviour between VO_4^{3-} and Eu^{3+}. The Commission Internationale de l'Elcairage (CIE) coordinates of RE doped and undoped $KCa_2Mg_2(VO_4)_3$ phosphors have been calculated using OSRAM SYLVANIA color calculator. Overall investigations and their outcomes, it was clearly proved that prepared phosphors have huge potential for future generation lighting technology.

Previous
Next

Keywords