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Photoluminescence study of synthesized nontoxic phosphor for sustainable environment

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Abstract

A variety of inorganic compounds known as silicates has grown to be more popular as a result of their superior chemical resistance and transparency to visible light, which make them suitable for a wide range of uses. They are more expressively researched because to their excellent thermal and chemical stability, inexpensive price, and strong near-ultraviolet absorption. $\text{Ca}_2\text{MgSi}_2\text{O}_7:\text{Eu}^{2+}$, Dy^{3+} phosphor was synthesized by high-temperature solid-state reaction technique. This structure is a member of melilite group and revealed tetragonal, Akermanite structure with a space group $P-421m$. The excitation spectrum shows a broad absorption band at 200–400nm with 365nm wavelength single broad emission peak situated at 505nm was obtained. The prepared $\text{Ca}_2\text{MgSi}_2\text{O}_7:\text{Eu}^{2+}$, Dy^{3+} phosphors were characterized using photoluminescence excitation and emission spectra. Prominent green colour emission was obtained under ultraviolet excitation.

Keywords: Akermanite structure, phosphors

1. Introduction

Light exhibits remarkable behaviour in the diverse applications of material science and nanotechnology, and as a result, cross-cutting concerns are inevitably growing in importance as the world becomes more networked and dependent on renewable energy in the twenty-first century. One of the most important and fundamental components of the green ecosystem that offers further innovation for human consumption is the new phrase "Material Diversity". The fact that photoluminescence analysis only needs a minimal amount of the sample (nearly 20 mg), and does not require the sample to be in solution form for powdered phosphor materials gives it a similar advantage over other spectroscopic methods. With the use of this technique, materials can be investigated quickly. This method was also used to create Eu^{2+} doped and Dy^{3+} codoped di calcium magnesium di silicate phosphors, and the properties of the powder were examined with and without the addition of a flux such H_3BO_3 . It is generally agreed that Eu^{2+} is a most common emission centre in persistent phosphor hosted by the $4f^7 \rightarrow 4f^65d^1$ transition [1-3]. Matsuzawa *et al.*, it was stated that Eu^{2+} ions served as electron traps ($\text{Eu}^{2+} + e \rightarrow \text{Eu}^+$) while Dy^{3+} ions served as hole traps ($\text{Dy}^{3+} + \text{hole} \rightarrow \text{Dy}^{4+}$). Between the lower energy state (ground) and higher energy state (excited) state of Eu^{2+} ions, Dy^{3+} ions serve as deep hole trap levels [4, 5]. Silicates are highly transparent to visible light and possess great chemical resistance, they are a desirable class of inorganic materials that are employed in a variety of applications [6]. Because they have good near-UV absorption, high thermal and chemical stability, are inexpensive, and have excellent water resistance [4]. Akermanite phosphors serve their purpose in production because of their excellent physical and chemical stability properties. A calcium magnesium silicate phosphor would be a fantastic by product from the manufacturing of optical devices for the lighting industries [7, 8]. In the current work, we describe the high-temperature solid-state synthesis method used to produce the bright green-emitting $\text{Ca}_2\text{MgSi}_2\text{O}_7:\text{Eu}^{2+}$, Dy^{3+} phosphor, as well as its characterisation and luminous properties. On the basis of photoluminescence (PL), optical properties were also examined, with excitation and emission being thoroughly discussed.

2. Experimental studies

Sample Preparation

In our study, the prepared samples with stoichiometric ratio of $\text{Ca}_2\text{MgSi}_2\text{O}_7:\text{Eu}^{2+}$, Dy^{3+} were synthesized via conventional high-temperature solid-state synthesis route (shown in fig.1). Initially, all raw reagents such as CaCO_3 (99.99%), MgO (99.99%), SiO_2 (99.99%) and H_3BO_3 (99.99%) of Hi-media (AR grade) as well as rare earth ions Eu_2O_3 (99.99%) and

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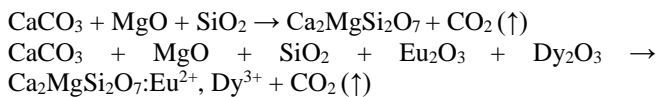
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Dy_2O_3 (99.99%) were used in present research investigations. Very little amount of boric acid [H_3BO_3] was used as a flux. Before being transferred to a silica crucible, the precursor chemical reagents were completely crushed in an hour in an agate crusher and pestle. Then the mixture was presintered at 950 °C and subsequently fired at 1150 °C in high-temperature muffle furnace for 2h in a weak reducing atmosphere with liberation of gaseous products. The weak reducing atmosphere have produced by using activated charcoal [4]. To transform Eu^{3+} into Eu^{2+} is the task of decreasing atmosphere. Further grinding into a fine powder was used to produce the finished product. The finished phosphor was produced as a white powder and stored in an airtight container for further characterisation studies including photoluminescence spectra.

The chemical reaction of this process is given as follows:



Sample Characterization

By using the solid-state reaction technique, the $\text{Ca}_2\text{MgSi}_2\text{O}_7:\text{Eu}^{2+}, \text{Dy}^{3+}$ powder sample was thoroughly prepared. It was presintered at 950 °C and then fired at 1150 °C in a high-temperature muffle furnace for two hours in a weak reducing atmosphere. The measurement of the Photoluminescence (PL) excitation & emission spectra were carried out using a Spectrofluorophotometer (SHIMADZU, RF-5301 PC) with a Xenon lamp as the excitation source.

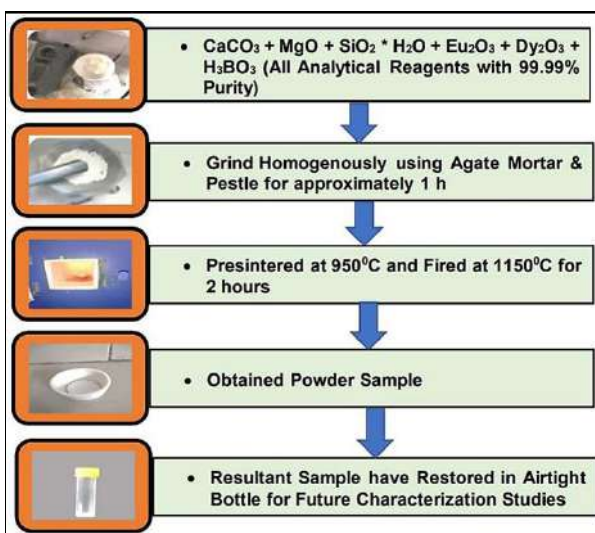


Fig 1: Material Synthesis Process

3. Results and Discussion

Photoluminescence Spectra

The photoluminescence approach has become a primary way in a variety of materials chemistry domains thanks to advancements in nanoscience. When photons are absorbed under the stimulation of external energy, a substance will produce light on its own, a process known as photoluminescence. To examine luminescence characteristics of materials, such as their excitation and emission spectra, photoluminescence is a contactless, non-destructive method [9]. Jiang *et al.* reported that the possible sites for incorporating Eu^{2+} in $\text{Ca}_2\text{MgSi}_2\text{O}_7$ lattice are Ca^{2+} sites, or the Mg^{2+} sites or the Si^{4+} sites, Mg^{2+} (0.58 Å) and Si^{4+} sites (0.26 Å) are small, but Ca^{2+} (1.12 Å) is equal to the size of Eu^{2+} (1.12 Å). So, Eu^{2+} ions hardly incorporate into tetrahedral [MgO_4] and [SiO_4] and only incorporate into [CaO_8] anions complexes in host

[10]. $\text{Ca}_2\text{MgSi}_2\text{O}_7:\text{Eu}^{2+}, \text{Dy}^{3+}$ is known as an efficient phosphor with good stability, which also shows green emission with great stability and persistency [4, 11].

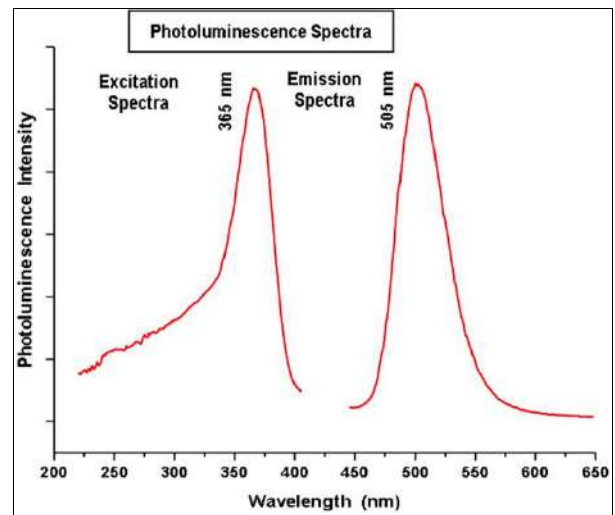


Fig 2: Excitation and emission spectra of synthesized $\text{Ca}_2\text{MgSi}_2\text{O}_7:\text{Eu}^{2+}, \text{Dy}^{3+}$ Phosphor

The excitation and emission spectra of $\text{Ca}_2\text{MgSi}_2\text{O}_7:\text{Eu}^{2+}, \text{Dy}^{3+}$ phosphor prepared was shown in Figure 2. The broadband emission spectra centered at 505 nm (Green region) observed under the ultraviolet excitation of 365 nm correspond to the Eu^{2+} emission arising due to transitions from sublevels of $4f^65d^1$ configuration to $^8S_{7/2}$ level of the $4f^7$ configuration but with Eu^{2+} occupying different lattice sites. Since the crystal field can greatly affect the $4f^65d^1$ electron states of Eu^{2+} , it suggests that the crystal field is not changed much with the compositional variation [4, 12-13]. The emission spectra are identical in shape and the bands differ only in intensities. After stimulation by UV light, ground states of Eu^{2+} stimulation occurs as a result of electron and hole pairs generation from the ground state $4f$ to excited $4f5d$ state. Some free holes transported into the conduction band are captured by the Dy^{3+} traps [14]. Our results strongly imply that the popular “hole transfer” models.

Material Diversity and Environmental Protection

During the 21st century, scientific and technological progress have been closely linked to national advancement, and in recent years, this connection has gotten even stronger. In order to understand the chain mechanisms of material analysis, a large area of bio material engineering researches physics, chemistry, and the methods of innovative material modelling. This field applies fundamental ideas to luminescence behaviour. Human resources that placed a higher importance on mental and spiritual purity than on material success. In order to maintain a clean and natural environment, our brand-new, state-of-the-art optical device system, which is made of rare earth minerals, has the ability to absorb and control environmental pollution sources. When linked with business operations, it helps build a balanced industrial framework that has greater potential, better utilises the readily available natural nanomaterial resources, and upholds the planet's environmental sustainability.

Materials consider the diversity of habitats as well as human society. Rare-earth doped nano phosphors have shown to be a very interesting issue in a number of technological and

environmental application sectors. Many applications for white LEDs with phosphor modifications are made possible by their exceptional key properties, including their long operational lifetime, clean energy, higher brilliance, improved luminous efficiency, chemical stability, compactness, and environmental friendliness.

Light sensors are used to get physical information about an object without physical contact or manipulation. Recently, communication has become a part of our daily lives. An abundance of nano sensor materials detects circumstances, and communication keeps the weather updated. One of the most inventive and cutting-edge is silicate-based nanomaterials, and it has been designed to give a quick overview of the potential uses of a fast communication network system.

Using silicate-based nano-sensor optical devices, which are noise-free and noise-free, the transmission of higher frequency, faster, and better transmitted messages has been expedited via this channel. The materials utilised to make electronics with this phosphor are more eco-friendly and energy-efficient. As a result, research and development in the domain of nanostructured silicate-based nanomaterial's is extensive and diverse and has been growing rapidly over the past several years on a global scale.

4. Conclusions

In a summary, biomaterials and biodiversity have the same conservative components. It makes reference to the variety of human existence and the overall energetic exchanges that take place. It is a fundamental part of humanity's eco-friendly, sustainable behaviour. It plays a number of crucial ecological tasks related to precipitation, climate change, environmental adaptation, and dealing with new pests. From the results presented here, it can be concluded that $\text{Ca}_2\text{MgSi}_2\text{O}_7:\text{Eu}^{2+}$, Dy^{3+} phosphors were prepared easily by via the solid-state reaction route. The broadband PL emission peaks exhibited maximum intensity of photoluminescence signals centered at 505 nm show efficient emission colour in green region, which is the most sensitive to the human eyes. Observed under the ultraviolet excitation of 365 nm correspond to the Eu^{2+} emission arising due to transitions from sublevels of $4f^65d^1$ configuration to $^8\text{S}_{7/2}$ level of the $4f^7$ configuration but with Eu^{2+} occupying different lattice sites. No emission peaks of Eu^{3+} were observed in the spectra. This suggests that under the reducing environment, all of the Eu^{3+} ions in the matrix had been converted to Eu^{2+} ions. This synthesized material is Eco-friendly and non-toxic. Moreover, near UV-LED conversion phosphor, medication delivery, white light emitting phosphor, long-lasting phosphor, tissue engineering, bone material, cancer illness detection, image processing of computer science, etc. are among the advantageous characteristics for applications.

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6. References

1. Blasse G. Fluorescence of Eu^{2+} -Activated Alkaline-Earth Aluminates. *Philips Res. Reps.* 1968;23:201.
2. Yamazaki K, Nakabayashi H, Kotera Y, Ueno A. Fluorescence of Eu^{2+} -activated binary alkaline earth silicate. *Journal of the Electrochemical Society.* 1986;133(3):657.
3. Dubey SK, Sharma S. A Brief Review to Study of Preparation and Photoluminescence (PL) Properties to Finding Possibilities of Divalent Europium Doped Barium Magnesium Silicate Based Phosphors. *IJSRED*, 2020;9:12.
4. Sharma S, Dubey SK, Diwakar AK. Luminescence investigation on $\text{Ca}_2\text{MgSi}_2\text{O}_7:\text{Eu}^{2+}$, Dy^{3+} phosphor. *International Journal of Materials Science.* 2021;2:8-15.
5. Matsuzawa T, Aoki Y, Takeuchi N, Murayama Y. A new long phosphorescent phosphor with high brightness, $\text{SrAl}_2\text{O}_4:\text{Eu}^{2+}$, Dy^{3+} . *Journal of the Electrochemical Society.* 1996;143(8):2670.
6. Lin L, Yin M, Shi C, Zhang W. Luminescence properties of a new red long-lasting phosphor: $\text{Mg}_2\text{SiO}_4:\text{Dy}^{3+}$, Mn^{2+} . *Journal of Alloys and Compounds.* 2008;455(1-2):327-330.
7. Sharma S, Dubey SK. The significant properties of silicate based luminescent nanomaterials in various fields of applications: a review. *International Journal of Scientific Research in Physics and Applied Sciences.* 2021;9(4):37-41.
8. Dubey SK, Sharma S, Pandey S, Diwakar AK. Luminescence Characteristics of monoclinic ($\text{Ba}_2\text{MgSi}_2\text{O}_7:\text{Dy}^{3+}$) phosphor. *North Asian International Research Journal of Sciences, Engineering & I.T.* 2021;7(11):45-55.
9. Jiang L, Chang C, Mao D, Feng C. Concentration quenching of Eu^{2+} in $\text{Ca}_2\text{MgSi}_2\text{O}_7:\text{Eu}^{2+}$ phosphor. *Materials Science and Engineering: B.* 2003;103(3):271-275.
10. Singha A, Dhar P, Roy A. A nondestructive tool for nanomaterials: Raman and photoluminescence spectroscopy. *American journal of physics.* 2005;73(3):224-233.
11. Yen WM, Weber MJ. *Inorganic phosphors: compositions, preparation and optical properties.* CRC press, 2004
12. Shi C, Fu Y, Liu B, Zhang G, Chen Y, Qi Z. The roles of Eu^{2+} and Dy^{3+} in the blue long-lasting phosphor $\text{Sr}_2\text{MgSi}_2\text{O}_7:\text{Eu}^{2+}$, Dy^{3+} . *Journal of luminescence.* 2007;122:11-13.
13. Lin L, Zhonghua ZHAO, Zhang W, Zheng Z, Min YIN. Photo-luminescence properties and thermo-luminescence curve analysis of a new white long-lasting phosphor: $\text{Ca}_2\text{MgSi}_2\text{O}_7:\text{Dy}^{3+}$. *Journal of Rare Earths.* 2009;27(5):749-752.
14. Jia W, Yuan H, Lu L, Liu H, Yen WM. Crystal growth and characterization of Eu^{2+} , Dy^{3+} : SrAl_2O_4 and Eu^{2+} , Nd^{3+} : CaAl_2O_4 by the LHPG method. *Journal of Crystal Growth.* 1999;200(1-2):179-184.