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Rare Earth Doped Gadolinium Oxide Phosphor Synthesized by Combustion Method using Glucose as Environment Friendly Fuel

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Abstract— *The development of green synthesis route method for the synthesis of nanoparticles or nanophosphor using echo friendly chemicals and plant product have received attention in the recent times as it is environment friendly and economical method. Gd_2O_3: Er^{3+}, Yb^{3+} Nanophosphor have been prepared using glucose both as fuel and oxidizer. The obtained Gd_2O_3: Er^{3+}, Yb^{3+} Nanophosphor are studied by X-ray diffraction (XRD), Energy dispersive analysis of X-rays (EDAX), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), and Photoluminescence techniques (PL).*

1. INTRODUCTION

In the last few decades, have witnessed a rapid advancement in various techniques for the fabrication of nanophosphor. Gd_2O_3: Er^{3+}, Yb^{3+} nanophosphor extensively studied as it has numerous applications to its credit [1-5]. There are various chemical based methods available for the synthesis of Gd_2O_3: Er^{3+}, Yb^{3+} nanophosphor [3]. But there is a growing concern towards use of these chemicals as they are reported to be very toxic for the environment. Apart from the toxicity, these chemical based methods are also not cost effective, a major disadvantage for synthesis of nanoparticles at the industrial scale.

Due to these problems, various eco-friendly approaches for the synthesis of Gd_2O_3: Er^{3+}, Yb^{3+} are being adopted by us. Among them, plants and plant extracts seem to be the best option as Plants are nature's "chemical factories". They are cost efficient and require little or no maintenance.

A vast repertoire of secondary metabolites is found in all plants which possess red ox capacity and can be exploited for biosynthesis of nanoparticles. As a wide range of metabolites are presented in the plant, the nanoparticles produced by using plants are more stable and the rate of synthesis is faster in comparison to micro organism.

Glucose is a simple monosaccharide found in plants whose five hydroxyl groups are arranged in a specific way along its six carbon backbone. The use of carbohydrates for the synthesis of nonmaterials has recently become an active research area. Gole A et al used glucose as a reducing agent to prepare gold nanoparticles.

Raveendran P et al used D-glucose as the reducing agent and starch as a capping agent to prepare Ag nanoparticles. M.R. Othman et al., 2010, deal with Synthetic Hydrotalcite Prepared from Modified Combustion Method Using Glucose as Fuel [6-9].

At present, Gd_2O_3 is an excellent host matrix due to its lower phonon energy, better chemical durability and thermal stability [3, 10-12]. Lanthanide-doped oxide nanoparticles are of special interest as potential materials for an important new class of nanophosphor. Gd_2O_3 nanoparticles is a promising host matrix for multiphoton and for different luminescence related applications [3,9]. The gadolinium oxide is doped with Er^{3+} ions and sensitized with Yb^{3+} ions have been widely studied. Because not only Er^{3+} ions possesses a favourable metastable energy levels with longer excited states, but also Yb^{3+} ions have a large and can efficiently transfer the excitation energy to Er^{3+} ions [3, 5, 7, 10-14].

We report a simple and economical method for the preparation of Gd_2O_3: Er^{3+}, Yb^{3+} nanophosphor using glucose as fuel and oxidizer. Glucose has been selected as the fuel because it is abundant, natural, renewable and biodegradable. Since it is biodegradable, it may also help in reducing cytotoxicity problem of nano materials, a major limitation for their biological applications and could extend the applications of Gd_2O_3: Er^{3+}, Yb^{3+} nanophosphor to for luminescence devices.

In this paper Gd_2O_3: Er^{3+}, Yb^{3+} nanophosphor have been prepared by combustion synthesis using glucose as a fuel. The structural properties were analyzed by XRD and SEM. The upconversion luminescence properties were observed under 945nm excitation

2. EXPERIMENTAL

2.1 Combustion Synthesis of Gd_2O_3: Er^{3+}, Yb^{3+} Nanophosphor

Gadolinium Nitrate, Erbium Nitrate and Ytterbium

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Nitrate were used as starting raw materials. Glucose was used as a fuel for synthesis of the phosphor in eco-friendly manner, as it does not release any harmful gases. All the precursor materials are mixed according to the stoichiometry ratio and fired at 600°C and annealed at 900°C for 2hour. Finally Gd_2O_3: Er^{3+}, Yb^{3+} nanophosphor were obtained.

Muffle Furnace **Image of the product obtained at 600°C**

Fig. 1: Muffle furnace and Image of the product obtain at 600°C

2.2 Structural Characterization

Powder X-ray diffraction (XRD) patterns were recorded with an X-ray diffractometer (D8-Advance Bruker) using Cu Kα radiation (λ=1.5405 Å).The morphology and size of the Gd_2O_3: Er^{3+}, Yb^{3+} were determined by using this XRD pattern. XRD data were recorded over the range 25°-60° at room temperature shown in figure 2. The particle size was determined using the Scherer's formula. [15, 16]. The Particle was found to be 15nm [3].

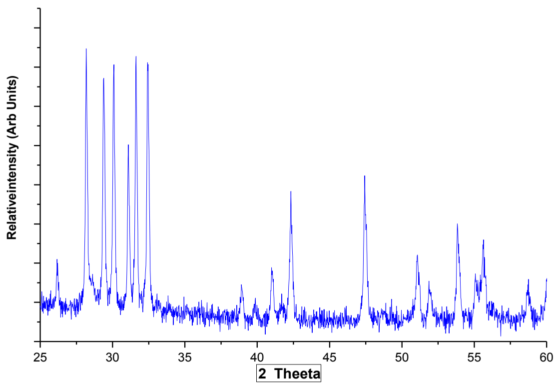

Fig. 2: XRD pattern of Gd_2O_3: Er^{3+}, Yb^{3+}

2.3 SEM Results

Figure 3 shows the SEM images of Gd_2O_3:Er^{3+},Yb^{3+} nanophosphor.

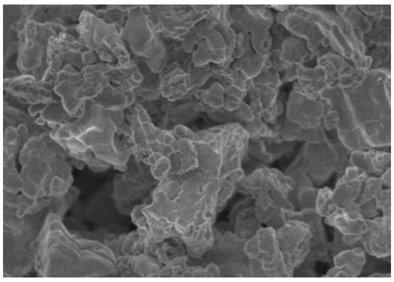

Fig. 3: SEM result of Gd_2O_3:Er^{3+}, Yb^{3+}

2.4 TEM Results

Figure 4 shows the TEM images of Gd_2O_3:Er^{3+},Yb^{3+} nanophosphor. The particle size of prepared particles was found to be 13.48 nm by TEM results and identical with the XRD results.

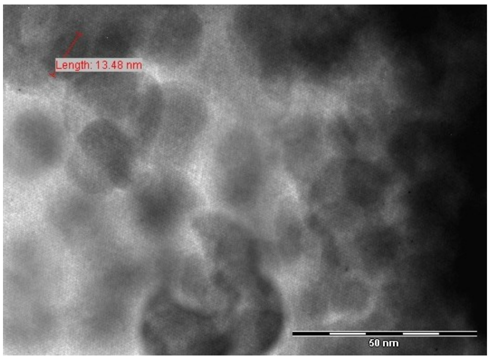

Fig. 4: TEM result of Gd_2O_3:Er^{3+}, Yb^{3+}

2.5 Upconversion Luminescence Spectra of Gd_2O_3: Er^{3+}, Yb^{3+}

Figure5 shows the upconversion luminescence spectra of Gd_2O_3: Er^{3+}, Yb^{3+} nanophosphor, gives 945nm excitation. These spectra consists of two groups of upconversion emission peaks, (525-560) nm and (630-645) nm, which are attributed to $^2H_{11/2}$, $^4S_{3/2}\rightarrow{}^4I_{15/2}$ transition for green emission and $^4F_{9/2}\rightarrow{}^4I_{15/2}$ transition for red emission of Er^{3+} ions [14,17-18]. The upconversion mechanism in Er^{3+} and Yb^{3+} codoped system is well known and occurs via a two photon process of energy transfer Yb^{3+} to Er^{3+} ions.

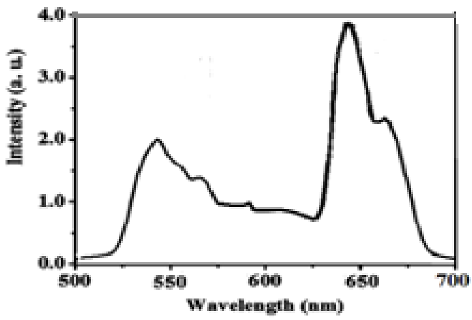

Fig. 5: The emission intensity of the broad green and sharp red emission of the Er^{3+} ion (λ_{exc} = 945 nm, room temperature) in Er^{3+} /Yb^{3+} co-doped Gd_2O_3 nanophosphor

3. CONCLUSIONS

From XRD patterns, the particle size has been calculated. The size of particle was found in the range of 15 nm calculated by Debye Scherer formula. Upconverting phosphor fine particles Gd_2O_3: Er^{3+}, Yb^{3+} has been prepared by combustion synthesis, using urea as a fuel. In UC we found green emission was board and weaker than that of red emission via a two photon process of energy transfer Yb^{3+} to Er^{3+} ions

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