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DEVELOPMENT OF NANOPHOSPHOR USING COMBUSTION TECHNIQUE

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ABSTRACT

The luminescent material at nano-level is called a Nano-phosphor, these phosphors converts different types of energy into electromagnetic radiation. The phosphors at nano-level develops unique characteristic properties, which makes it a potential candidate for applications like Solar cell device, LEDs, Display devices.etc. Further the optical properties of nanophosphor are dependent on size and morphology which in turn depends on the synthesis technique employed. Combustion technique for synthesis of nanophosphors is simplest of all conventional synthesis techniques and involves simple equipment, short processing time, low energy, and is an effective method for the production of homogeneous nano-crystals and do not involve any intermediate decomposition process

Present paper reports the synthesis of nanophosphors by combustion technique.

Keywords: Nanophosphor, combustion technique

INTRODUCTION

Phosphors are luminescent materials that emit photons upon excitation by an gamma ray, UV radiations, electron or X-ray beam. They consists of an inert host lattice, and an activator, typically a 3d or 4f electron metal such as Eu^{2+}/Eu^{3+}, Ce^{3+}, Tb^{3+}, Gd^{3+}, Yb^{3+}, Dy^{3+}, Sm^{3+}, etc[1-5]. The phosphors are classified into broad band (d−f electronic transition) and narrow band (transition between the f levels) emitters. The process of luminescence involves multiple steps like, absorption of energy at the activator site, relaxation of excited site by subsequent emission of a photon, thereby finally return to the ground state. The absorption of energy in phosphors takes place either by the host lattice or by activator (dopant) ions, while the emission of energy originates mostly from the dopant ions. In order to develop phosphors with specific properties sometimes a second dopant is added to host lattice, often called sensitizers, it can be used to absorb the energy and transfer it to the main dopant. Phosphors are promising materials for field emission, plasma displays, light-emitting devices, imaging applications, in solar panels etc. In comparison to bulk ,nanostructured phosphors may have higher packing densities, low light-scattering effects and find wide applications ranging from biomedical applications to aircraft applications.

Development of nanophosphors for specific applications requires which requires precise distribution of the dopands, in the material structure. Present paper reports combustion technique approach for development of nanophosphors.

EXPERIMENTATION

The combustion synthesis results in nanophosphors with microstructure and crystalline size ranging from several nanometers to several tens of nanometers and with a high degree of structural uniformity. It is less time consuming and low cost single step approach.For the synthesis of phosphor using Combustion synthesis, Metal nitrate, aluminium nitrate $Al(NO_3)_3.9H_2O$, silicate SiO_2, dopand(X) nitrate $X(NO_3)_3.6H_2O$, and urea NH_2CONH_2 (or any other fuel as per requirement) are used as starting materials and all starting materials used are taken of analytical grade[1]. Stoichiometric composition of the metal nitrates (oxidizers) and urea (fuel) is calculated using the total oxidizing and reducing valency of the components. Nitrate and urea in weighed quantities are mixed together and crushed into mortar for 15 min. to 30 min. to form a thick paste. The resulting paste is then transferred to a crucible and placed in a vertical cylindrical muffle furnace maintained at 500-800°C. Initially the mixture boils and undergoes dehydration followed by decomposition with the evolution of large amounts of gases (oxides of carbon, nitrogen and ammonia). The process is highly exothermic and causes spontaneous ignition to occur Fig-1, as a result the solution undergoes combustion with enormous swelling, producing white foamy voluminous ash Fig-2. The foamy product is then cooled to room temperature and

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milled to obtain the precursor powder, the precursor powder when grounded results in synthesis of nanophosphor. Depending on the flame temperature the particle size ranges from 50 nm-800nm and flame temperature is approximately 1600°C can be varied further by varying the fuel used.

Fig-1.Shows spontaneous ignition of reactants and formation of white foamy product in combustion technique.

MECHANISM OF CONTROLLING THE PHOSPHOR PROPERTIES

A strong literature review concludes that particle size, morphology and phase composition of the phosphors obtained as combustion synthesis products can be altered by varying the fuel, fuel to oxidizer ratio, and addition of precursors.

Microstructure: The reaction temperature and amount of gas released at the time of synthesis determines the microstructure of the product .With the increase in the temperature, the solid grain size increases with better sintered grain agglomerates. The solid grain size is observed to increase with increase in temperature. The gaseous products released during combustion breaks large clusters and create pores thereby creating a solid with varying particle size. As the hot gases escape from the sample a large amount of heat is removed thus solid product cools faster, with smaller grains. Therefore, the temperature and gas release may act as competitive factors in the microstructure formation. The temperature and amount of gas released depend on composition of the fuel and oxidizer[3-5].

Fuel to oxidizer ratio: The fuel to oxidizer ratio is a key parameter for tailoring of excitation, and emission intensities of phosphors. When the fuel to oxidizer ratio was 1 or higher, highly crystalline phosphors were formed. Use of different organic compounds such as: (i) alanine (ii) asparagine, serine (iii) methyl cellulose (ii) ammonium acetate, ammonium citrate and ammonium tartarate have been explored as fuels. The use of complex fuels in CS favours formation of nanosize particles. In combustion synthesis glycine serves as fuel during the reaction, being oxidized by nitrate ions. Urea (NH2CONH2) is an attractive fuel for originating the formation of powders with crystallite sizes in the submicron/nanosized range and act as a complexing agent for metal ions because it contains two amino groups located at the extremes of its chemical structure.

PRECURSOR CHEMICALS

The product homogeneity can be enhanced by the use of chemical precursors like inert salt. The addition of an inert salt in a reactant mixture may result in the formation of well dispersed nanoparticles with a prominent increase in surface area. The salt act as an inhibitor of the agglomeration These are readily soluble in water, thermally stable at high temperatures. [3-6]

RESULTS AND DISCUSSION

Some of the phosphors were synthesised using combustion technique and were investigated.

X-ray diffraction (XRD) of the prepared phosphor was recorded in a range of 20–80° of Bragg angle 2θ using a Bruker D2 phaser X-ray diffractometer with Cu target (λ = 0.154 nm).Fig-3. The different diffraction peaks of phosphor are in complete agreement with those of JCPDS Card No. 21-1152 with no indication of other raw forms. This indicates formation of a single phase, pure crystalline compound with the same structure of MgAl2O4 Spinel. Fig-4 shows the SEM image of combustion synthesised phosphor. It is observed that the crystallites are well distributed and the average size of phosphor particles is 44nm. The excitation and emission spectra of phosphor obtained by combustion synthesis is reported to show prominent luminescence shown in Fig-5.Hence, it is anticipated that the present phosphor system is suitable for green emitting white LED applications

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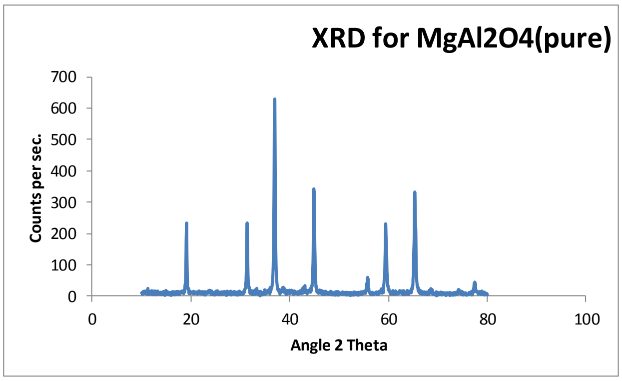

Fig-3 Shows XRD for phosphor developed by combustion technique

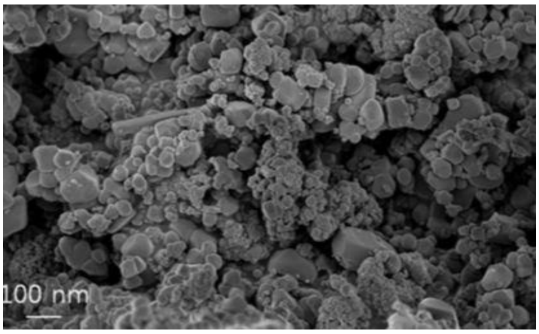

Fig-4: Shows SEM image of Phosphor were particle size is approximately 44nm

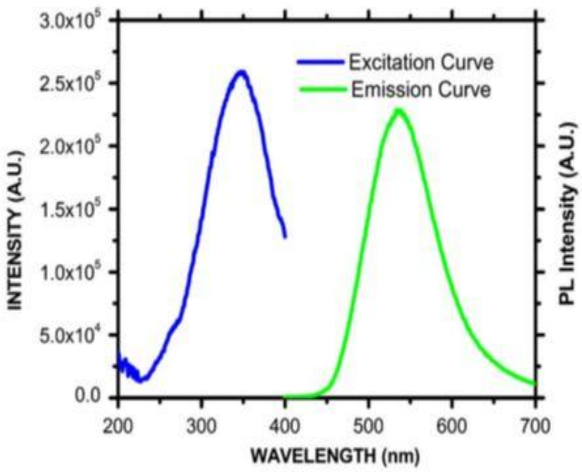

Fig-5: Shows emission and absorption spectra of a Phosphor

FUTURE SCOPES/CONCLUSION

It can be viewed [1-6] that Combustion technique is competent technique in synthesis of nanophosphor due to superior nature of the particulate properties and the simplicity and cost effectiveness of the process. It lays a means of preparing a novel phosphor comprising of doped simple and complex compounds with pre-designed morphology for different applications. The materials thus prepared are suitable for use as display devices, radiation dosimetry, bio-image sensors.etc.

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