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Advances in the synthesis of new magnesium doped Al_2O_3 phosphors and their luminescence characterization

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Abstract

In this work, the preparation method and thermoluminescence analysis of aluminium oxide doped with Mg^{2+} obtained by combustion cynthesis using urea is presented.. The prepared samples were confirmed through XRD Pattern and functional group analysis was done using FTIR. Morphological studies were carried out through SEM image. The TL glow curves of the annealed Al_2O_3: Mg samples presented a well-defined TL peak around 200 ºC after gamma irradiation.

Keywords: *Al_2O_3, Thermoluminescence, γ-ray*

1.0 INTRODUCTION

Aluminium oxide is one of the most commonly used and researched materials for luminescent dosimetry application. Conventional fabrication process of these dosimeters utilize Czochralsky or Vernuil crystal growth technique, which involve the use of high temperature (>2000^{0}C) and highly reducing atmosphere [1].

The polycrystalline α-Al_2O_3 is extensively used for ceramic application α-Al_2O_3 in the form of single crystal powders and thin layers on substrate are considered to be good thermoluminescecne phosphors due to their high radiation sensitivity simple glow curve, simple emission spectrum, wide dose range and relatively low atomic number [2]. Aluminium oxide nano particle can be prepared by various methods such as mechanical milling, Vapour phase reaction, co-precipitation, sol-gel, hydrothermal, homogeneous precipitation and combustion method. Each of this technique has its own merits and demerits [3].

Amongst these techniques, the combustion synthesis (CS) is particularly attractive because of its low cost, high yield and the ability to achieve high purity single phase complex oxide powders at low processing temperatures and short reaction times. In this technique, the heat released from the highly exothermic reduction-oxidation reaction between nitrates (the "basis" and dopant materials) and an organic fuel is used for sintering of the material. This report describes the luminescence response of Al_2O_3: Mg via Combustion method [4].

1.1 Materials and methods

The chemicals used for material preparation, such as aluminium nitrate (oxidizer) and Urea as (fuel) was of analytical grade and mixed with stoichiometric ratio. Magnesium nitrate (dopant) was mixed with desired molar ratio. The prepared solution was mixed using magnetic stirrer for 30 minutes. After obtaining homogeneous solution, this was introduced in to 350^{0}C preheated muffle furnace. Within few minutes fumes started coming out from the beaker. After five minutes huge amount of red colour fumes came out from the beaker indicating that combustion reaction was completed. The as synthesised powder was collected from the beaker. Structural studies were done through XRD analysis, and functional group analysis was studied using FT-IR Spectrum, Morphological studies were carried by SEM analysis, while dosimetric studies were done by Thermoluminescence technique.

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1.2 Characterization

The phase of crystalline powder was identified by powder X-ray diffraction using Cu K a radiation employing a scanning rate of 0.02 s^{-1}. FTIR studies were carried out with JASCO 460 PLUS FTIR spectrometer from 400 to 4000 cm^{-1} to identify the various functional groups present in the material. Morphologies of the samples were investigated by 3S7D EM47D analysis using Hitachi SEM400. The TL measurements were carried out with a heating rate of 10ºC s-1 using TLD reader model Harshaw 3500. The prepared sample was irradiated using Cobalt-60 Gamma cell model 220 Excel.

2.0 Results and Discussion

2.1 Structural Characterization –XRD

Fig. 1 shows the XRD Pattern for the Mg doped aluminium oxide prepared by combustion method; the patterns indicated the intense peak of Al_2O_3: Mg at 32.23º and 45.43º. All the other peaks were identical and matched with JCPDS 00-010-173. The major peaks located at 2θ= 45.43 was indexed as (113), which can be readily ascribed to the characteristic peaks of the rhombohedral structure with lattice constant a = 4.83 and b=12.87A

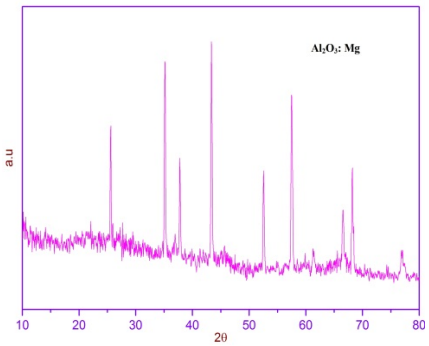

Fig. 1 XRD pattern of Mg doped Al_2O_3

2.2 Functional group Analysis

The FTIR spectrum of Mg doped Al_2O_3 nanoparticle is shown in Fig 2. A strong peak observed at 3457 cm^{-1} is assigned to the O-H stretching. The peak assigned at 2348 cm^{-1} asymmetric stretching mode of C=O, 1382 cm^{-1} represents carbonyl group stretching, the peak at 445 cm^{-1} Al-O stretching, 440 cm^{-1} represents of Mg-O stretching upon verification with the present database.

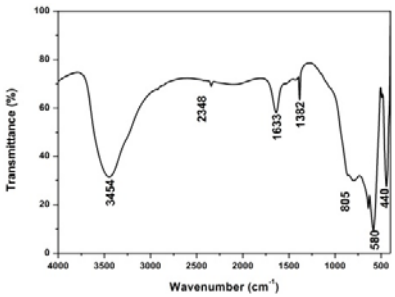

Fig: 2 FTIR Spectrum of Al_2O_3: Mg

2.3 Morphological Analysis

The morphology and structure of the prepared particle was studied using scanning electron microscope (SEM) images and is shown in Fig 3. It shows platelet structure. Since could not measure particle size through SEM Image.

2.4 Thermoluminescence glow curve Analysis

For TL analysis of synthesized nanomaterial, 2 mg weighed sample was taken. In the TL analysis of the synthesized nanomaterial, thermoluminescence was measured at a heating rate of 5°Cs^{-1} in the temperature

range 25°C - 500°C for 10Gy dose. The dosimetric peak was observed at 200 °C. TL glow peak of nanomaterial depends on different parameters such as the nature of the nanomaterial characteristics like sample crystallinity

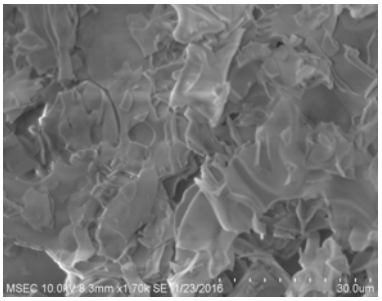

Fig. 3 SEM images of Al_2O_3: Mg

and impurity content. Dose d epnednece studies of the glo peak at 200C showed linear change in luminescence intensity with irradiation of synthesized Al_2O_3: Mg. Hence this phosphor may be useful cable for radiation dosimetric application.

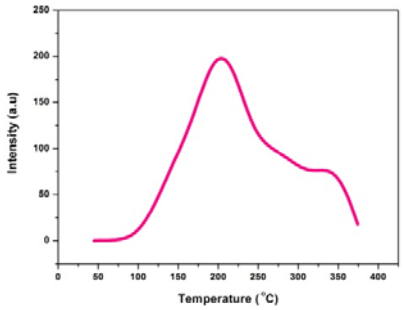

Fig: 4 TL Glow curve of Magnesium doped Al_2O_3

Conclusion

Magnesium doped aluminium oxide nanopowder was prepared successfully by combustion method .Structural studies confirmed though XRD pattern showed that the prepared Al_2O_3:Mg powder in rhombohedral structure. Lattice parameters were calculated. Functional groups were analysed by FTIR spectrum. Morphological studies were done by scanning electron microscope. Most of the particle had platelet structure. The gamma irradiated sample exhibited TL with the dosimetric peak at 200^0C, which may be useful for medical dosimetric application.

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