Int. Res. J. of Science & Engineering, 2018; Special Issue A2 :161-164
ISSN: 2322-0015
SJIF Impact Factor 4.11
UGC Approved Journal No. 63628
RESEARCH ARTICLE
OPEN ACCESS

Synthesis and Dosimetry Characterization of $CaF_2:Ce^{3+}$ Phosphor Material

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Manuscript Details

Available online on http://www.irjse.in
ISSN: 2322-0015

Editor: Dr. Arvind Chavhan

Cite this article as:
Punse VS and Arsad SS. Synthesis and Dosimetry Characterization of $CaF_2:Ce^{3+}$ Phosphor Material, *Int. Res. Journal of Science & Engineering,* January 2018; Special Issue A2 : 161-164.

ABSTRACT

With the help of simple, fast as well as cost effective process of wet chemical method followed by reactive atmospheric process, $CaF_2:Ce^{3+}$ can be successfully synthesized. The XRD analysis shows the desired phase of CaF_2 and the photoluminescence spectra shows excitation and emission spectra satisfactorily.

Keywords: Dosimetry, PL (photoluminescence), wet chemical method, OSL (optically stimulated Luminescence), RAP (reactive atmospheric process).

INTRODUCTION

Luminescence is the process of emission of optical radiation from a material except incandescence. The material absorbs energy, store fraction of it, convert and emit it in the optical radiation. When an organic and inorganic material absorb some form of energy by any means, it tries to attain equilibrium by disposing part of extra energy absorbed by way of heat, chemical or structural changes and luminescence. Phosphor materials convert UV radiation into visible radiation. Lamp Phosphor is mostly white in colour and they should not absorb the visible radiation. Optically Stimulated Luminescence (OSL) is a related phenomenon in which the luminescence is stimulated by the absorption of optical energy, rather than thermal energy. In the history, the Optically Stimulated Luminescence (OSL) is used for radiation dosimetry.

METHODOLOGY

CaF_2: Ce^{3+} phosphor was synthesized by Wet Chemical method followed by Reactive Atmospheric Process. In this method we used $CaCO_3$ [1.00 gm. (as $1 mole = \frac{1 * molewt.}{100} \cong 1.00\ gm.$)] as a precursor. The calcium carbonate ($CaCO_3$) was taken in Teflon beaker. We added of $Ce(SO_4)_3$ (stock solution) + HNO_3 + HCl. A little amount of double distilled water then HCl was added in beaker. Then heat was given to become transparent solution. Then 2-3 ml hydro-fluoric acid (HF) was added in it to get precipitation. Then solution was kept to evaporate and to get dry powder for 24 hrs. We crushed the dried powder sample and transferred to a glass tube and about 1% of wt. RAP agent (i.e. ammonium fluoride NH_4F) was added. The tube was closed by a tight stopper and kept the glass tube in the pre-heated muffle furnace at 500°C for 1 hr. The stopper was removed and the powder was transferred to a pre-heated graphite crucible. After heating in the graphite crucible for 1hr. the resulting melt phosphor was rapidly quenched to room temperature. This is known as Melt and Quench process. The complete process discussed above was represented as a flow chart in fig. 1.

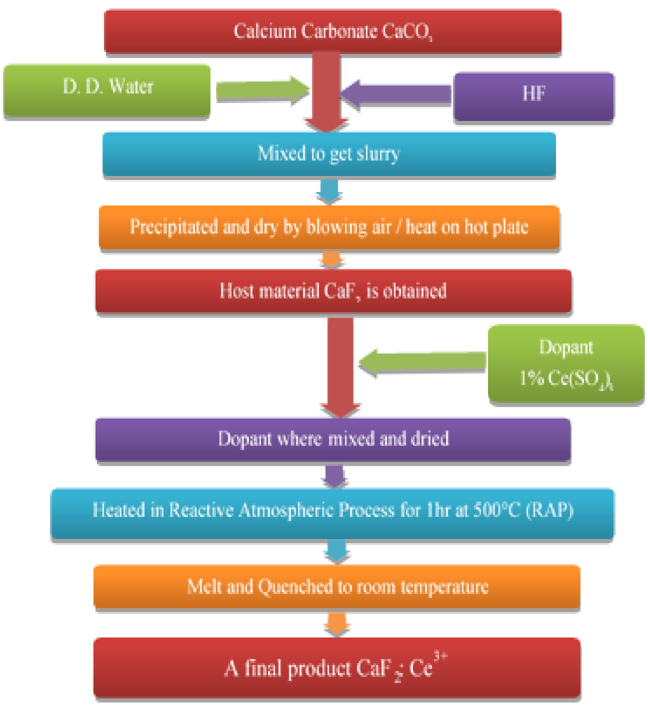

Fig.1. Flow chart of CaF_2: Ce^{3+} prepared via RAP.

RESULTS AND DISCUSSION

PL Analysis

The figure shows ground state configuration of Ce^{3+} ion, one 4f electron and exited state configuration one 5d electron with empty 4f shell. The $4f^1$ yields two levels viz. $^2F_{5/2}$ and $^2F_{7/2}$ due to spin orbit coupling and the $5d^1$ exited state configuration is split by crystal field in 2 and 5 components. The Ce^{3+} emission occurs from the lowest crystal field component of $5d^1$ configuration to the 4f ground state levels. Since 4f → 5d transition is parity allowed and spin selection is not appropriate, the emission transition is fully allowed one. We got the Excitation of CaF_2: Ce^{3+} at 258 nm and 303 nm for 336 nm Emission. Figure 2 and shows the excitation and emission spectrum of CaF_2: Ce^{3+}.

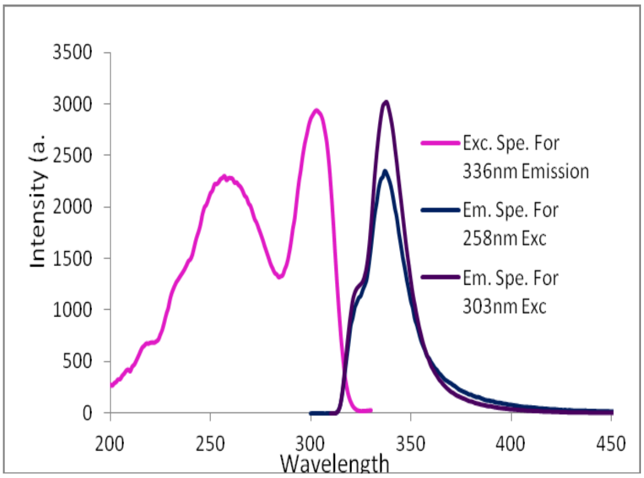

Fig.2. Comparison of excitation spectrum for 336 nm emission and emission spectrum for 258 nm 303 nm excitation.

OSL Analysis

By studying optically stimulated luminescence (OSL) responses of different time interval for radiation doses, we observe that as the time period for radiation dose increases the area covered by the peak/graph increases. And if we increased the time period dosimetry the intensity will also increases. The OSL response is linear as shown in following figures.

The figure 3 shows OSL response for the doses of time period of 10 sec, 15 sec, 20 sec, and 25 sec respectively.

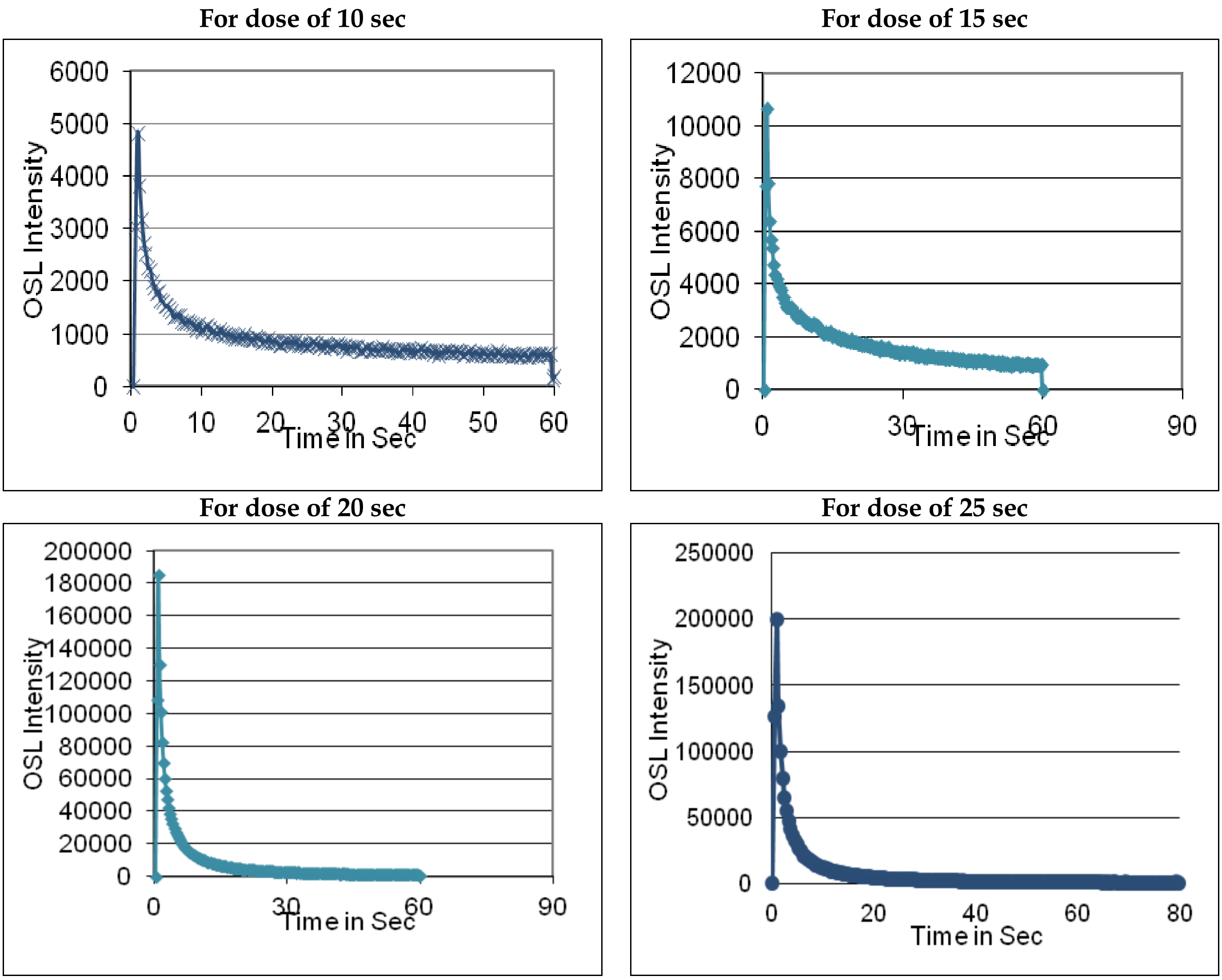

Fig.3. OSL Response of doses for different time periods.

CONCLUSION

The CaF_2: Ce^{3+} phosphor was successfully synthesized by Wet Chemical Method followed by Reactive Atmospheric Process. The process of synthesis was simple, fast and cost effective. We have analysed that the XRD pattern which indicates the presence of a cubic phase for $CaF_{2.}$ The Photoluminescence Spectra shows excitations at 258 nm and 303 nm for 336 nm Emission. The best luminescent material obtained though the above process, as we got very good Optically Stimulated Luminescence (OSL) response, which is linear with time.

Acknowledgement:
We are thankful to radiation therapy unit, government super speciality hospital, Amravati dist. Amravati (Maharashtra) for radiation doses. One of the authors V. S. Punse is thankful to Head, Department of Physics, Shri Shivaji Science College, Amravati and Head, Department of Physics, Sant Gadge Baba Amravati University, Amravati for providing necessary facilities.

Conflicts of interest: The authors stated that no conflicts of interest.

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