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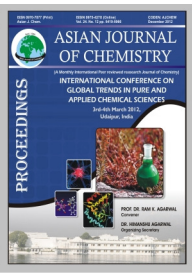

Combustion Synthesis and Thermo Luminescence in γ-Irradiated Borate phosphors Activated with Terbium(III)†

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The crystalline sample of $NaSrBO_3$ and $NaSr_4(BO_3)_3$ was successfully synthesized by a combustion method and for use of these material in a radiation dosimetry. Its thermo luminescence characteristics has also been studied. Formation of the compound was confirmed by studying the X-ray diffraction pattern. The thermo luminescence glow curve of the $NaSrBO_3$ doped with 0.01 mol of Tb has a simple structure with a single peak at 150 ºC, where as $NaSr_4(BO_3)_3$ doped with 0.01 mol of Tb give a weak peak at 187 ºC and prominent peak at 314 ºC. Thermo luminescence sensitivity of the both the phosphors for γ-rays is found as sensitive as that of LiF : Mg, Cu, P. Kinetic parameters and dose response of these materials also reported.

Key Words: Borates, Combustion synthesis, Luminescence, Kinetics.

INTRODUCTION

Inorganic borates have long been a focus of research not only because of their variety of structure type but also due to their large electronic band gap, transparency to a wide range of wavelength, high optical damage threshold and high optical quality[1]. Up to date, lots of investigations about thermo luminescence characteristics of borates and tetra borates have been carried out[2-5]. Although not all of these materials can be utilized in practice, at least the results obtained provide useful information concerning the defects and trap structure that are helpful in the search for new borate host thermo luminescence dosimetric materials.

Recently, Liu *et al*. and Wu *et al*. reported the synthesis of a novel borate, *i.e.*, $NaSrBO_3$ and $NaSr_4(BO_3)_3$ by high temperature solid state method[6,7]. From experience of our co-workers, combustion synthesis is a good low cost, one step and low temperature method for the synthesis of borates and silicates[8-13]. So we used combustion method for the synthesis of these borate compounds for the first time. In this paper, we reported the dosimetric characteristics of $NaSrBO_3$: Tb and $NaSr_4(BO_3)_3$: Tb phosphors under γ-ray irradiation by means of thermo luminescence emission spectrum.

EXPERIMENTAL

Earlier workers used highly sophisticated method for the synthesis of these compounds. There are no reports of using combustion method for the synthesis of such compounds. During this synthesis, the stoichiometric amounts of high purity starting materials, $NaNO_3$ (A.R.), $Sr(NO_3)_2$ (A.R.), H_3BO_3 (A.R.), $CO(NH_2)_2$ (A.R.), NH_4NO_3 (A.R.) were mixed thoroughly in agate mortar for *ca.* 0.5 h, so that the paste was formed. A stock solution of stoichiometric amount of dopant $Tb_2(SO_4)_4$ was then mixed in paste. It was put in the pre-heated furnace (550 ºC) after warming it for 5 min. The self heat generating redox reaction was completed and the fine powder of $NaSrBO_3$: Tb was finally obtained. This raw powder was sintered for 2 h at 750 ºC and quenched to room temperature on aluminum plate. The same procedure was repeated for the preparation of $NaSr_4(BO_3)_3$: Tb. Samples were exposed to γ-rays from a ^{60}Co source for exposures at room temperature. After the desired exposure, thermo luminescence glow curves were recorded for samples at a heating rate of 5 ºC/s.

RESULTS AND DISCUSSION

Figs. 1 and 2 represent the XRD pattern for the product synthesized and important lines in this pattern for the 2θ values were exactly matched with the XRD pattern reported[6,7]. The agreement indicates that $NaSrBO_3$ and $NaSr_4(BO_3)_3$ has been successfully prepared by using the modified combustion synthesis method.

The thermo luminescence glow curve of the $NaSrBO_3$ doped with Tb has a simple structure with a single peak at

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150 ºC, where as $NaSr_4(BO_3)_3$ doped with Tb give one weak peak at 183 ºC and a prominent peak at 314 ºC. Fig. 3 gives the comparison of the thermo luminescence glow curves of phosphors $NaSr_4(BO_3)_3$: Tb and $NaSrBO_3$: Tb with LiF: Mg, Cu, P exposed by gamma ray of dose 5Gy. Thermo luminescence sensitivity of the phosphors for gamma rays is found to be as sensitive as that of LiF: Mg, Cu, P; with this agreement we can say these phosphors are quite suitable for radiation dosimetry.

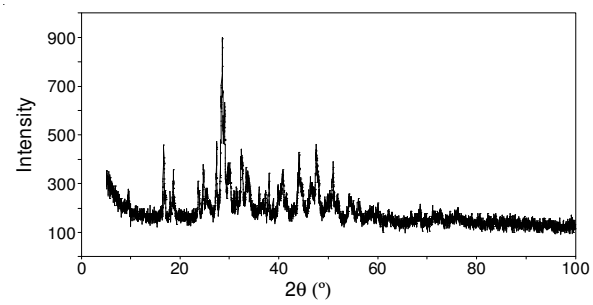

Fig. 1. XRD pattern for $NaSrBO_3$:Tb Phosphor prepared by combustion synthesis

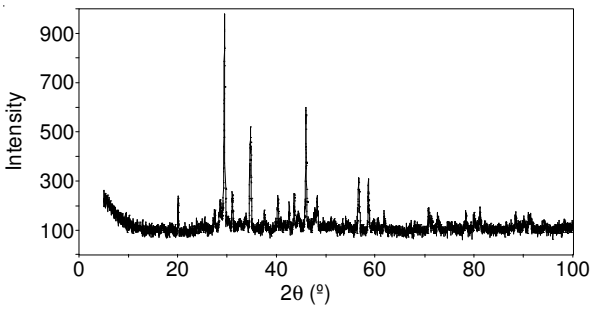

Fig. 2. XRD pattern for $NaSr_4(BO_3)_3$: Tb Phosphor prepared by combustion synthesis

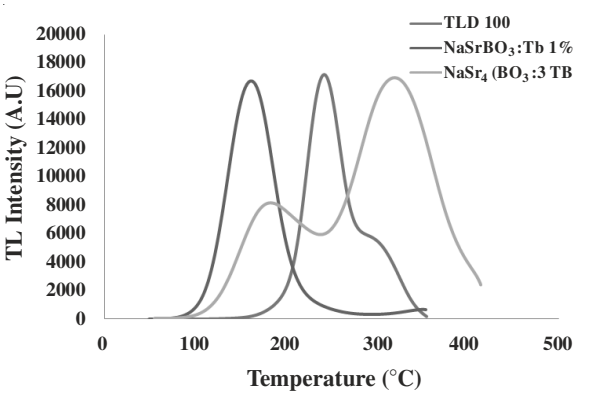

Fig. 3. Comparison of $NaSrBO_3$:Tb and $NaSr_4(BO_3)_3$: Tb with commercial phosphor LiF: Mg, Cu, P

The thermo luminescence kinetic parameters *i.e.* ativation energy and frequency factor were found out by using peak shape method as given in Table-1. To study the thermo luminescence response to various doses *viz.*, 10, 15, 20 and 25 Gy of these phosphors four samples were irradiated simultaneously for each level of dose. Each data point corresponds to the mean of the five readings. The linearity is observed in the range from 10 Gy to 25 Gy as shown in Fig. 4. By the computer fitting the linear correlation coefficient was found to be 0.987.

TABLE-2
TL PARAMETERS FOR $NaSr_4(BO_3)_3$:Tb AND $NaSrBO_3$:Tb

Phosphor	Order of kinetics	E (eV)	s (S^{-1})	T_m (ºC)
$NaSrBO_3:Tb^{3+}$	Second	0.913	8.86×10^{10}	161
$NaSr_4(BO_3)_3$: Tb^{3+}	Second (weak peak)	0.590	4.93×10^{6}	183
	Second (prominent peak)	0.885	5.59×10^{5}	314

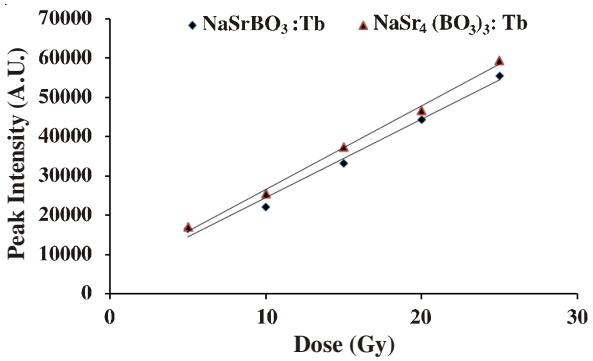

Fig. 4. Response to γ-ray dose of $NaSrBO_3$:Tb and $NaSr_4(BO_3)_3$:Tb

Conclusion

The combustion synthesis is successfully employed for the preparation of new TLD potential phosphor $NaSr_4(BO_3)_3$:Tb and $NaSrBO_3$:Tb. The XRD profile of $NaSr_4(BO_3)_3$ and $NaSrBO_3$ is found to show good agreement with the literature[6,7]. The Comparison of thermo luminescence glow curves shows that the phosphors $NaSr_4(BO_3)_3$:Tb and $NaSrBO_3$:Tb activated with 0.01 mol of terbium as sensitive as that of LiF: Mg, Cu, P, this agreement proved that these phosphors are suitable for radiation dosimetry.

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