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Spectral studies of SM (III) ions doped in borax glasses

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ABSTRTACT
In this work, Sm(III) ions doped in borax glass on the (80-x)$Na_2B_4O_7.10H_2O$-20CaO_3-(x)Sm_2O_3 system, where x is 0 wt% to 4 wt% has been successfully made by melt quenching techniques. The optical properties of the glass have been investigated by using luminescence spectroscopy. During luminescence study, the influence of composition on the emission intensities will be obtained the high intensity can occurs when the glasses prepared with 2 wt% of Sm(III) in excitation wavelength 250nm. The emission spectrum can be attributed to the transition level from $^4G_{5/2} \rightarrow {}^6H_{5/2}$, $^6H_{11/2}$ *level and emission spectrum have been considered as a function of Sm(III) concentration and have been measured on this paper.*

Keywords: Borax glass, Samarium, Luminescence.

INTRODUCTION

The spectral properties of rare earth ions strongly depend on the legend field originating from the surrounding environment of the host material. In order to improve the properties for a specific application and to understand the basic mechanism involved in the interaction between the rare earth ions and its surrounding host material, different rare earth ions have been investigated in a number of crystals (1,2) and glasses (3,4) at different temperature. Samarium ions with $4f^5$ electronic configuration usually exists in triply ionized Sm(III) state and its spectrum has been studied by several workers in solid phases(5). Spectra of Sm(III) in Sodium borate glasses(6), fluorophosphates (7), silicates (8) and in KyP_4O_{12} crystals(9). The present paper reported the study of the energy level transition and emission spectra of Sm(III) ions in a borax glasses.

EXPERIMENTAL SECTION

The glass samples of (80-x)$Na_2B_4O_7.10H_2O$-20CaO_3-(x)Sm_2O_3 were prepared by melting the thoroughly mixed material in an electric furnace at 630 to 700 ^{0}C for about 30 min. in a borosile glass crucible. The starting materials used were regent grade. The glass samples were annealed at 350 ^{0}C for 2h and good optical properties were measured by using Perkin Elmer Lambda LS-55 Luminescence spectrometer in the range from 200 – 900 nm. Absorption spectra measured in the UV/VIS regions with a Perkin Elmer Lambda 3B spectrometer under room temperature.

RESULT AND DISCUSSION

1. Judd-Ofelt analysis: - The absorption spectra of the Sm(III) doped borax glasses consists of transitions from the ground state $^6H_{5/2}$ to a number of excited states. In total 17 excited studies have been identified and assigned which are similar to those of Sm(III) in other glasses(10-11). From the absorption bands, the transition energies and experimental oscillator strengths f_{exp} have been estimated as shown in table(1) and fig (1) shows the emission spectra of Sm(III) doped borax glasses, consisting of the transitions $^4G(4)_{5/2} \rightarrow$ ^6H_J (where J = 13/2, 11/2, 9/2, 7/2 and 5/2) at room temperature. The result for f_{cal} calculated from judd-ofelt parameters of Sm(III) doped glasses are shown in table (1). This factor was chosen in such a way that the fexp from the $^4G(4)_{5/2}$-----$^6H_{5/2}$ emission is identical with the f_{exp} from the $^6H_{5/2} \rightarrow$ $^4G(4)_{5/2}$ absorption. The result for f_{exp} from emission is included in table (1). The f_{exp} value for the 21 transitions both form absorption and emission studies together with the value of the refractive index were fitted by a least squares program to yield the best fit values for the judd-ofelt parameters (12,13).

Fig (1):- Luminescence spectra of Sm(III) doped in borax Glasses.

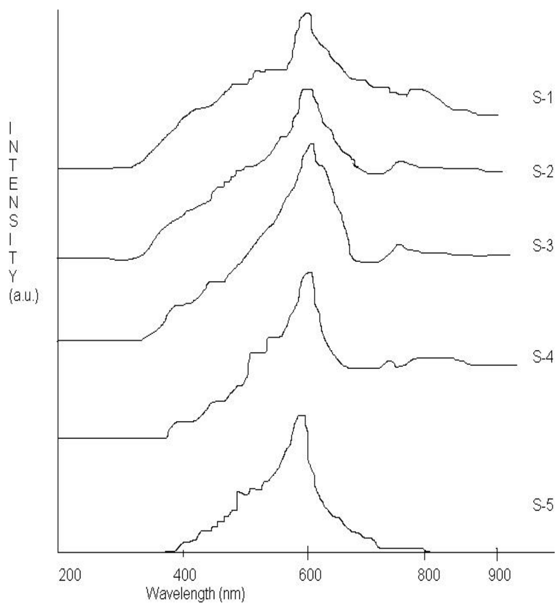


Table (1):- Transition energies (cm^{-1}) and oscillator strength ($x10^{-6}$) for Sm(III) doped borax glasses are shown in table

Transition	Energy Value	F_{exp} Value	F_{cal} Value
(Absorption)			
$^6H_{5/2} \rightarrow$ $^6H_{15/2}$	6308	0.280	0.028
$^6F_{1/2}$	6551	0.795	0.691
$^6F_{3/2}$	6699	2.081	2.286
$^6F_{5/2}$	7280	4.330	4.119
$^6F_{7/2}$	8091	6.691	6.901
$^6F_{9/2}$	9187	4.901	4.628
$^6F_{11/2}$	10611	0.340	0.705
$^4G(4)_{5/2}$	17810	0.092	0.012
$^4F(3)_{3/2}$	18940	0.011	0.009
$^4G(4)_{7/2}$	19891	0.029	0.104
$^4M_{15/2}$	21100	1.229	0.868
$^4I(3)_{13/2}$	21580	0.331	0.017
$^4F(3)_{5/2}$	22230	0.031	0.162
$^4M_{17/2}$	22771	0.240	1.017
$^6P_{3/2}$	24118	0.681	1.142
$^6P_{5/2}$	24790	6.395	7.288
$^6P_{7/2}$	26678	1.485	2.278
(Emission)			
$^4G(4)_{5/2} \rightarrow ^6H_{11/2}$	14189	0.081	0.144
$^6H_{9/2}$	15493	0.137	0.321
$^6H_{7/2}$	16719	0.255	0.452
$^6H_{5/2}$	17761	0.041	0.021

2. The radiative transition probabilities and branching ratios fall all levels have been calculated by the judd-ofelt theory. Detailed analysis of radiative properties including radiative transition probabilities, branching ratios, lifetimes and emission cross sections are available for five different Sm(III) doped borax glasses. The calculated radiative life times of $^4G(4)_{5/2}$ for the different sets of judd-ofelt parameters are shown in table (2).

Table (2):- Judd-Ofelt parameters ($\Omega_\lambda x\ 10^{-20} cm^2$) for Sm(III) doped borax glasses for the $^4G(4)_{5/2}$ level

Sample No.	Composition Wt%			Ω_2	Ω_4	Ω_6	Σ (rms Deviation)	τ_R
	Borax	CaO	Sm_2O_3					
S-1	80	20	0.0	2.11	7.21	5.20	± 0.28	2.12
S-2	79	20	1.0	2.08	7.19	4.91	± 0.21	2.09
S-3	78	20	2.0	2.06	7.23	5.10	±0.23	2.13
S-4	77	20	3.0	2.00	7.21	5.01	±0.21	2.10
S-5	76	20	4.0	2.01	7.08	5.15	±0.27	2.05

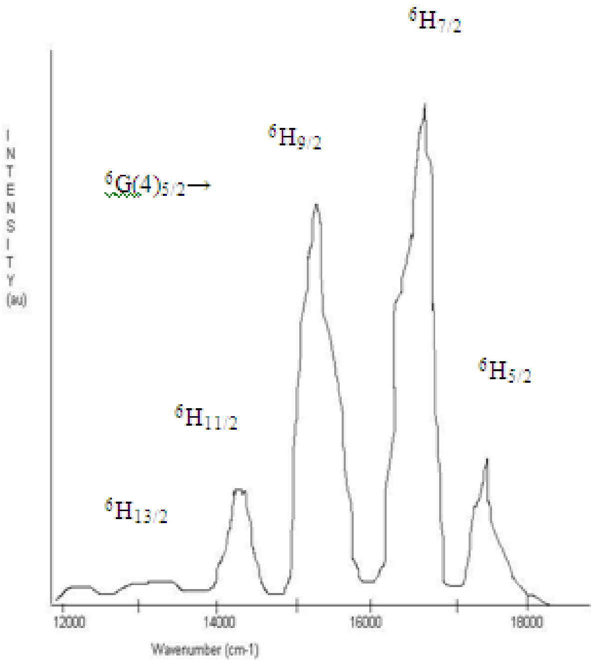
3. Fluorescence study:- A typical glass composition that has been successfully made is shown in table (2) and the luminescence spectra of Sm(III) doped borax glasses are shown in fig (2). The spectrum shows many peak lines. The wavelengths of the assigned emission peaks are given in table (3). The observed emission peaks near 567 and 690 nm, are assigned to the transition $^4G_{5/2} \rightarrow ^6H_{5/2}$ and $^4G_{5/2} \rightarrow ^6H_{11/2}$ respectively. However as the Sm_2O_3 content increases to 1.0 wt% the emission intensity are decreases as the Sm_2O_3 content increases. However the emission intensity is decreases as the Sm_2O_3 concentration increased further. It was noted that the emission intensity is depending on the Sm_2O_3 concentration. Table (3) shows that the transition level from

$^4G_{5/2} \rightarrow {^6H_{5/2}}$, $^6H_{11/2}$ level decreases in energy. It can be assumed that the transition process is due to the non-radiative energy transfer mechanism (14).

Table (3):- Fluorescence line of Sm(III) doped in borax glass matrix on excitation wavelength of given value

Transition	Wavelength (nm)	Energy (cm^{-1})
$^4G_{5/2} \rightarrow {^6H_{5/2}}$	567	1810
$^4G_{5/2} \rightarrow {^6H_{11/2}}$	690	1430

Fig(2):- Emission spectrum of Sm(III) doped in borax Glasses



CONCLUSION

The radiative and fluorescence properties of Sm(III) doped borax glass have been interpreted satisfactorily in the frame of judd-ofelt theory. However, it was shown that the transitions involved in the determination of judd-ofelt parameters must be selected carefully due to parameter dependencies on the nature of multiplets. The emission spectra of glass system exhibits emission from the $4G_{5/2}$ level to the 6H multiplet level. They are $^6H_{5/2}$ and $^6H_{5/2}$ transitions in the wavelength around 570 and 690 nm. However, the emission spectra slightly are shifted due to small amount of Sm_2O_3.

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