ISSN: 0974-5823 Vol. 7 No. 7 July, 2022

International Journal of Mechanical Engineering

STUDY OF ABSORPTION AND EMISSION SPECTRA OF ER(III) DOPED BORAX GLASSES

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ABSTRACT :

In this work optical absorption and emission spectra of Er(III) doped borax glasses are presented absorption measurements in the range 300-900 nm were recorded at room temperature for $Na_2B_4O_7.10H_2O$ glass system and they doped with 0-2-wt%,0-4-wt%, 0-6-wt% and 0-8-wt% of rare earth of the type Er_2NO_3. The observed spectra have been analysed to calculate oscillator strength (P) the Judd-ofelt intensity parameters (T_λ) using basic and PASCAL compiled programmes the physical parameters like density, refractive index, number density, dielectric constant, inter - ionic reparation of these glasses were calculated as a function of dopant concentration.(4,6)

KEYWORDS : Borax glass, Erbium Ion, Judd-Ofelt

INTRODUCTION :

Rare earths optical characteristics are determined by their atomic structure. glass materials is not new. Glass doped with various rare earth ions are attracting attention since they are seen as promising materials for high power lasers. Optical properties like optical absorption and luminescence spectra of various rare earth (RE) ions doped erbium and mixed borate glasses have been extensively investigated in the recent years (8). Glass doped with trivalent rare earth erbium ion have become important optical material for use in the field of optical devices such as amplifiers and lasers. The properties of doped glasses depend on the concentration of the dopant ions as well as the chemicals environment of the host materials. The electrical configuration of the trivalent erbium ($4f^3$) ion is $4f^{11}$with the ground state being $^4I_{15/2}$. In the ultraviolet, visible and near infrared regions it produces a great number of absorption and emission transitions. The large numbers of energy levels of $4f^3$ configuration (41 level) (displayed only 26) (6 in UV and 20 in VIS regions). fine structure may be seen in the spectra of Er^{3+} in glasses acquired using high-resolution spectrographs even in the presence of substantial variation in band intensities all research on the fine structure of bands in the spectra of Er(III) composition, carried out for this transition intensities on the absorption spectra of Erst doped glasses, may be satisfactory explained by Judd-ofelt theory. The $^4G_{5/2,7/2,}$ $^4I_{9/2}$ band intensity is often utilised in different approaches to determine the composition and stability constant of Er(III) samples, in this paper we have reported the results of our investigation, characterises have been recorded.

EXPERIMENTAL SECTION :

The glasses having composition $Na_2B_4O_7$. $10H_2O$ and Er(III) were prepared by conventional melt quench techniques. The appropriate amount of chemicals were weighed, mixed and heat treated in open borosile glass crucible electric furnace at 550-600* C for about 30 minute. Then the temperature was raised up to 700-750*C and held for 30-45 minute. when the melt was thoroughly homogenized and attained the desired viscosity, it was poured onto a glass plate and pressed by another glass plate so that glass sample should be found to desired shape and size. The glass sample were then annealed at appropriate temperature for 15-30 minutes in order to preventing cracking on the glass plate and store in a desiccators prior to evaluation. All absorption spectra at room temperature were recorded in a UV-VIS recording spectrophotometer (Perkin Elmer Lambda 3B) by photon counting techniques. The emission measurement was done in ratio made (emission signal/reference signal) useful to compensate for changes in the intensity of excitation radiations.

THEORY :

Formula for the evaluation of the:

1. Oscillator Strengths:

The comprehensive quantitative study (5) of the intensities of rare earth absorption bands in glass may be made using the area under the peaks and the known concentration which may establish the oscillator strength (P) values for various prominent transitions;

$$P = 4.318 \times 10^{-9} \times \frac{2.303 \cdot m \cdot c^{z}}{N \cdot H \cdot e^{2}} \times \varepsilon.(\upsilon)\, d\upsilon$$

Where the empirical term in the equation (1a) may be reduced to

$P = 4.318 \times 10^{-9} \times \varepsilon.(\upsilon)\, d\upsilon$.

The oscillator strength (P) for each spectral band may be calculated using the formula

$$P = 4.318 \times 10^{-9} \times \frac{m^{o} \cdot M_{x} \cdot M_{y}}{m' \cdot I \cdot C}$$

Which may further reduced to

$$P = 4.318 \times 10^{-9} \times \frac{S \cdot M_{x} \cdot M_{y}}{C}$$

Where :-

P = calculated oscillator strength for a specific f-f transition.

1 = thickness of the sample in case of disk (constant)

C = concentration of Ln (III}

S = area in sq. cm of the band (m^{0}/m')

m° = mass of band area

m' = mass in sq. cm of the paper

M_x = rate of change of energy along the base line (in cm) i.e., ($\Sigma\Delta E$/cm),

where ΔE - difference in Energy of beginning and end of the peak

M_y = rate of change intensity of absorption per sq. cm (Absorption coefficient of sensitivity).

2 Judd-Ofelt parameters:

Judd and Ofelt [1-2] have derived an equation for the oscillator strength (P) of a transition between a ground state $f^{n}\psi_{j}$, and an excited state $f^{n}\psi_{j}'$, of the Ln (III) ions in glass which may be given as

$P = \Sigma T_{\lambda} v (f^{n}\psi_{j} \| U^{\lambda} \| fn\psi_{j}')^{2}$ where (λ = 2,4,6)

A useful alternative parameterization of Judd - Ofelt expression may be adopted for simplicity as

$$P = \frac{8\Pi m c}{3h} \times \frac{\sigma}{2J+1} \Sigma\ T_\lambda\ v\ (\ f^n \psi j \parallel U^\lambda \parallel f^n \psi j')^2 \text{ where } (\lambda = 2,4,6)$$

Where (λ) in rhs of the equation are Tensor Operators, the values for which are obtained from literature for the evaluation of theoretical values of oscillator strength.

$P = \Omega_2 U^2 + \Omega_4 U^4 + \Omega_6 U^6$

The calculated values of oscillator strengths may be used to determine the (T_λ) values using earlier equations. This involves marking of v (in cm^{-1}) values for each spectral band and obtaining a sum of their products with the Tensor Operator values ψ^λ. The product thus may be subjected to a three parameter matrix calculations to obtain τ_λ .

$P = \tau_2 .\upsilon .U^2 + \tau_4 .\upsilon .U^4 + \tau_6 .\upsilon .U^6$

The Judd Ofelt parameters may be determined using the expression - $T_\lambda = (2J + 1)\ \tau_\lambda$
Where J is the total orbital angular momentum and (2J + 1) is the multiplicity factor.

RESULT AND DISCUSSION :

The physical phenomenon like refractive index for these glasses was measured using conventional He-Ne Laser beam technique. The densities have been measured via way of means of the usage of Archimedes technique the usage of benzene because the immersive liquid.

Table 1. -- Measured values of Refractive Indices for different rare earth doped borax glasses-

Galss Samples	Concentration of RE Ions in mole dm^3	Rfefractive Indices
ME1	0.104419	1.506
ME2	0.115577	1.531
ME3	0.168786	1.524
ME4	0.230087	1.562

The Various physical parameters like the density and refractive index for given composition are given in above table and absorption spectra of Er(III) doped glasses are shown in figure
Below 1,2,3 and 4

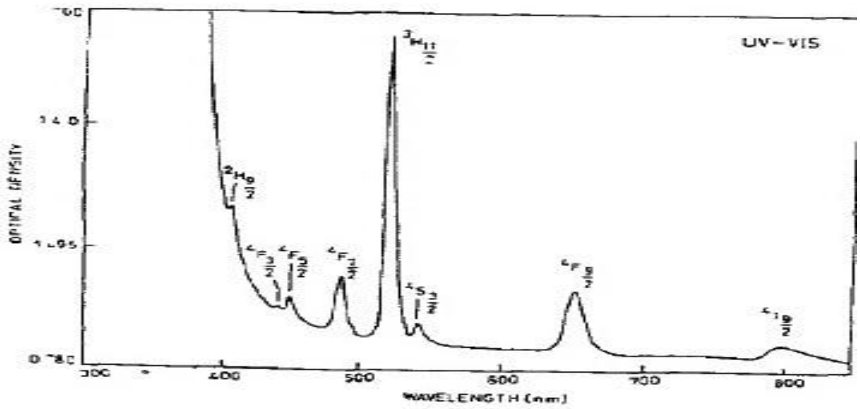

Fig (1):- UV / VIS Absorption spectra of Er^{3+} in borax glass (ME1)

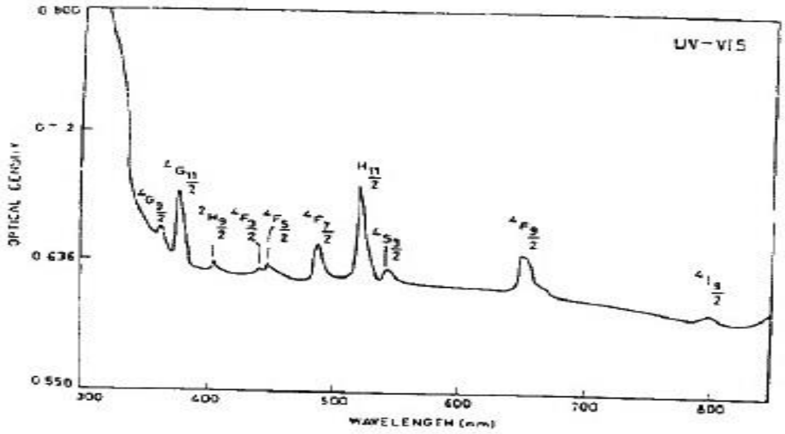

Fig (2):- UV / VIS Absorption spectra of Er^{3+} in borax glass (ME2)

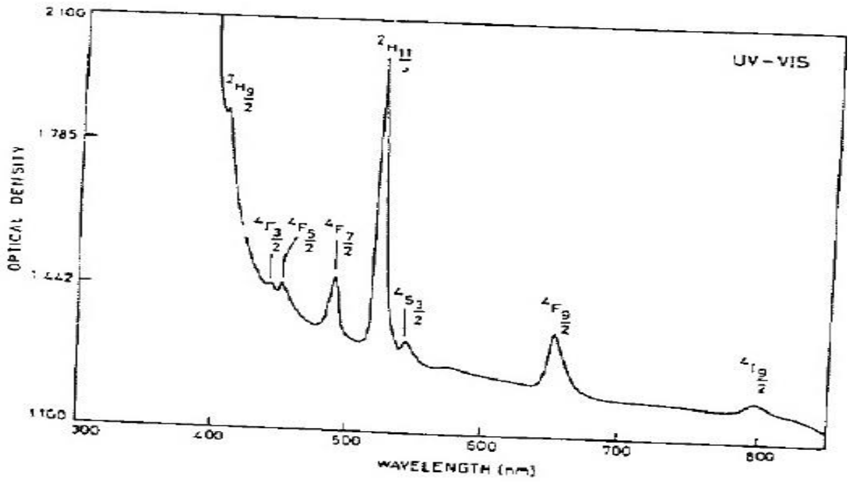

Fig (3):- UV / VIS Absorption spectra of Er^{3+} in borax glass (ME3)

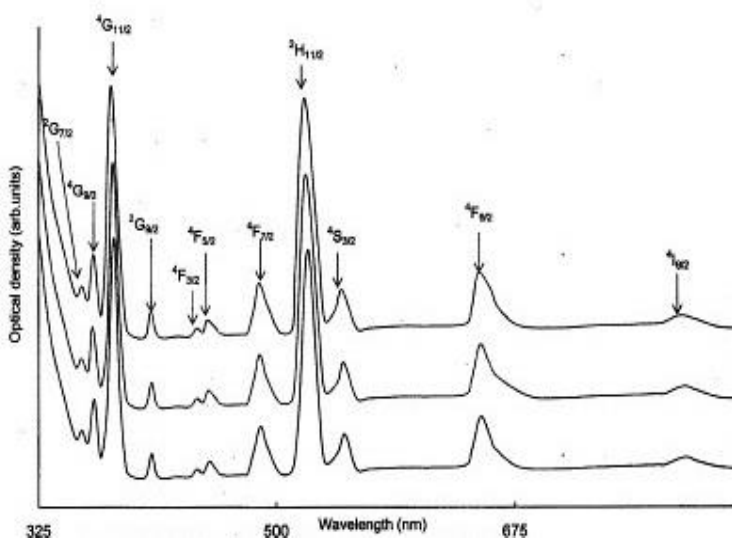

Fig (4):- UV / VIS Absorption spectra of Er^{3+} in borax glass (ME4)

There are several groups of line characteristics of 4f-4f absorption of trivalent Er(III) which corresponds to $^4I_{9/2}$ to the $^4F_{9/2}$, $^4S_{3/2}$, $^2H_{11/2}$, $^2G_{9/2}$ and $^2G_{7/2}$ respectively. The experimental and calculated oscillator strength values in table-2 shows a very good agreement according to Jorgensen and reisfeld .

Table -2 Oscillator strength values and Judd-Ofelt parameters for Er(III) ions in Borax glass matrix-

Oscillator strength values for Er (III) doped in Borax glasses						
S. No.	**Assignment**	**$E_{spect.}$**	**Oscillator strength * 10^{-9}**			
			ME1	**ME2**	**ME3**	**ME4**
1.	$^2G_{7/2}$	28130	27411	27441	27445	27455
2.	$^4G_{9/2}$	27366	27315	27325	27329	27330
3.	$^4G_{11/2}$	26433	26518	26520	26528	26530
4.	$^2G_{9/2}$	25036	25577	25571	25579	25585
5.	$^4F_{3/2}$	23024	22544	22544	22546	22549
6.	$^4F_{5/2}$	22645	22110	22118	22120	22124
7.	$^4F_{7/2}$	20955	20505	20525	20529	20535
8.	$^2H_{11/2}$	19827	19310	19315	19320	19323
9.	$^4S_{3/2}$	19102	18900	18910	18940	18942
10.	$^4F_{9/2}$	16722	17100	17150	17179	17183
11.	$^4I_{9/2}$	13204	14500	14525	14541	14548
$T_2(10^{-20}cm^2)$			6130	5932	6123	6051
T_4 $(10^{-20}cm^2)$			30.6	27.5	30.5	30.3
T_6 $(10^{-20}cm^2)$			623	621	634	638

Table –2 shows the recorded value of oscillator strength for all assignment of Er doped borax environment that is the susceptibility of the medium to the changed environment of four glasses of Er(III) for their possible prominent assignment. We have observed the value of oscillator strength in general increase with concentration of material. In the above table we have got a sequence of assignment which is agreement of the relative population of these levels in the ground and excited states.

CONCLUSION :

A new borax glasses doped with different concentrations of Er(III) are presented. All the samples obtained exhibits god thermal stability against devitrification (Δ T ≥70*C). The Judd-ofelt symmetry parameters composing oscillator strength have also shown the expected trends of $T_2<T_4<T_6$ which is in agreement with the general features of 4f-shell, The refractive indixes for all glasses failed to show any significant change in the second place of decimal. We have observed the value of oscillator strength in general increase with concentration of material. These features make it for possibilities to explore good candidate for laser action.

ACKNOWLEDGMENTS :

I would like to special thanks “Dr. Sujeet Jain Sir” for providing us research facility and sufficient time for research study.

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