

Thermodynamic Behaviour of Hypersensitive Transition Observed In Some Er(III) Doped Systems

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Abstract

The Er(III) doped systems with various ligands studied with respect to hypersensitive transition. The spectroscopic data for hypersensitive transition have been correlated with the thermodynamic parameters. The thermodynamic parameters include thermodynamic efficiency and partition function of the transition.

Key words: Hypersensitive transition, Erbium, N, S,&O donor ligands.

Introduction

The intensities of most of the f-f transitions of trivalent lanthanides are little affected by environment of surrounding ions. However, a few transitions are very sensitive to the environment and in the complexed lanthanide ion. They are usually more intense as compared to that of independent lanthanide ion present in the solvent medium. Such transitions are called hypersensitive transitions.

The study of hypersensitive transitions plays an important role in evaluating the effect of ligand environment on 4f orbital of lanthanide ion¹⁻³. The recent theories given by Slater-Condon, Lande, Carnall⁴ and Judd-Ofelt^{5,6} about the lanthanide f-f spectra correlate the

involvement of 4f-orbitals in terms of the various energy and intensity parameters.

The present paper describes the thermodynamic treatment of hypersensitive transitions of various ligands doped with Er (III) ion. The transition $^4I_{15/2} - ^4G_{11/2}$ and $^4I_{15/2} - ^2H_{11/2}$ are said to be hypersensitive in case of Er (III) ion. The thermodynamic treatment involves the determination of work function and thermodynamic efficiency from the spectroscopic data obtained for the present systems. The thermodynamic parameters resulting from spectroscopic data support the covalency between lanthanide ion and the surrounding ligand.

The present work includes systems of

saturated solutions in DMSO involving eight ligands. These include Urea, Thiourea, Dimethyl glyoxime, Semicarbazide, Thiosemicarbazide, Acetaldehyde-Semi-carbazone, N,N-Diphenylthiourea and Diphenyl Glyoxime.

These systems provide saturated ligand environment around Er (III) ion. The solution spectra have been recorded for the various systems in the visible region (400-850 nm). The spectroscopic data (oscillator strengths and energy of transition) have been used to compute thermodynamic parameters. These parameters represent the microscopic behavior of the hypersensitive transition.

Experimental

By employing doped model, eight systems were prepared (table 1) involving Er (III) and different ligands. Solution spectra of these systems have been recorded by a standard spectrophotometer in the range 400 to 850 nm.

(i) *Calculation of work function and thermodynamic efficiency of the transition:*

Thermodynamic parameters may also support covalency (if any in the systems), in metal-ligand interaction in addition to spectral parameters for hypersensitive transitions.

$$(a) \text{ Thermodynamic Efficiency of transition (TET)} = \frac{\text{Work Function for transition}}{\text{Energy absorbed for transition}}$$

By using thermodynamic relation-

$$A = E - TS \text{ and } S = K \ln P_{\text{obs}} \quad (1)$$

Following relation may be obtained-

$$A = E - KT \ln P_{\text{obs}}$$

Where:-

A = Work function (cm^{-1})

E = Energy absorbed for hypersensitive transition (cm^{-1})

K = Boltzmann constant = 0.6945 cm^{-1}

T = Absolute temp

P_{obs} = Oscillator strength of transition (from eq. 1)

S = Absolute energy.

Thermodynamic efficiency of transition may be expressed as-

$$\text{TET} = \frac{\text{Work function for transition (cm)}}{\text{Energy absorbed for transition (cm)}}$$

(b) Calculation of partition function (Q) and ratio of partition function

$$(Q) = g_i e^{-E/kT} \quad (3)$$

Where:

For Er - $g_i = 2J + 1 = 12$

$$(c) \text{ Ratio of Partition } (r_p) = \frac{\text{Q for lanthanide ion system (doped)}}{\text{Q for lanthanide ion (free ion in solvent)}} \quad (4)$$

Results and Discussion

The computed values of the thermodynamic parameters (for hypersensitive transition) from the spectroscopic data have been tabulated in table

- The values of work function (A) have been found to be from 19011.4068 to 19047.6190.

Table values of Thermodynamic Parameters of Er (III) SYSTEMS

S. N.	Er(III) doped systems	Energy for hypersensitive transition (${}^2H_{11/2}$) (cm^{-1})	Oscillator strength for hypersensitive transition (${}^2H_{11/2}$) ($\times 10^6$)	Work function (A) (cm^{-1})	Thermodynamic efficiency of the transition (TET)	Partition function $Q = g_i e^{-E/KT}$ ($\times 10^{26}$)	Ratio of partition function (r_p)	Peacock relation (K') = $P_{\text{obs}} / \nu T_6$
1.	Er(III) + L ₁	19047.6190	62.5216	21064.45	1.1058	23.7374	2.7186	0.9901
2.	Er(III) + L ₂	19029.4957	79.1046	20997.31	1.1034	25.8946	2.9657	1.2872
3.	Er(III) + L ₃	19047.6190	84.7954	21000.96	1.1025	23.7374	2.7186	1.3478
4.	Er(III) + L ₄	19029.4957	62.5216	21046.32	1.1059	25.8946	2.9657	0.9827
5.	Er(III) + L ₅	19011.4068	62.3875	21028.68	1.1061	28.2433	3.2347	0.9494
6.	Er(III) + L ₆	19047.6190	62.6558	21064.00	1.1058	23.7374	2.7186	1.0114
7.	Er(III)+L ₇	19011.4068	60.8656	21033.83	1.1063	28.2433	3.2347	0.9422
8.	Er(III)+L ₈	19047.6190	79.1046	21015.43	1.1033	23.7374	2.7186	1.3065

- The values of TET vary from 1.1025 to 1.1063.
- The values of partition function (Q) have been found to be from 23.7374 to 28.2433.
- The values of ratio of partition function (r_p) vary from 2.7186 to 3.2347 for Er (III) doped systems.

The significance of thermodynamic parameters are well understood but their computation from spectroscopic data proposes a microscopic behavior of the f-f transition. The present study finds that the microscopic

behavior with respect to TET for Er (III) doped systems is almost the same but there is a variation in partition function values.

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