

# Crystal Field Splitting Energy ( $\Delta_o$ ) and Racah Parameters (B) of Some Metal-Saccharine and Metal-Saccharine-Ethylenediamine Complexes

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## Abstract

[M(sac)<sub>2</sub>(H<sub>2</sub>O)<sub>4</sub>].2H<sub>2</sub>O [sac = saccharinato anion, M = Fe(II), Co(II), Ni(II), and Cu(II)], and [M(sac)<sub>2</sub>(en)<sub>2</sub>].2H<sub>2</sub>O [sac = saccharinato anion, en = ethylenediamine, M = Fe(II), Co(II), Ni(II) and Cu(II)] were prepared in an aqueous medium. The compounds are crystalline of different colors and are ambiently stable. By examining their physico-chemical properties and relevant literature, the metal(II) ions in both [M(sac)<sub>2</sub>(H<sub>2</sub>O)<sub>4</sub>].2H<sub>2</sub>O and [M(sac)<sub>2</sub>(en)<sub>2</sub>].2H<sub>2</sub>O complexes are octahedrally coordinated. In the former by four neutral H<sub>2</sub>O molecules and two monoanionic sac ligands while in later, the octahedral sites fulfilled by two neutral bidentate ethylenediamine molecules and two monoanionic sac ligands. Splitting of the crystal field ( $\Delta_o$ ) and Racah parameter (B) of two sets of complexes [M(sac)<sub>2</sub>(H<sub>2</sub>O)<sub>4</sub>].2H<sub>2</sub>O and [M(sac)<sub>2</sub>(en)<sub>2</sub>].2H<sub>2</sub>O are estimated from their electronic spectra using Tanabe-Sugano diagram of Co(II) and Ni(II) complexes while  $\Delta_o$  values of Fe(II) and Cu(II) derivatives are calculated directly from their absorption maxima. Our experimental results show that for the studied ligands and the divalent transition metal ions, the  $\Delta_o$  values vary according to the following order: Cu(II) > Fe(II) > Co(II) > Ni(II).

**Keywords:** Saccharine, Electronic spectra, Tanabe-Sugano diagram, Crystal field splitting, Racah parameter.

## I. Introduction

In crystal field theory, the only role of the ligands in transition metal complexes has been to produce the splitting of the d-orbitals. The bonding between the metal and the surrounding ligand molecules was presumed to be purely ionic in nature<sup>1-2</sup>. The crystal field theory modified to admit that there is some covalent bonding in addition to electrostatic interaction between the metal ion and its ligands is known as the ligand field theory. The effect of ligands in expanding the d electron clouds has been named the nephelauxetic effect. The magnitude of the nephelauxetic effect may be conveniently expressed as the Racah interelectronic repulsion parameter (B)<sup>3</sup>. The complexes of transition metals are usually colored, and they are capable of absorbing radiant energy in the infrared, ultraviolet, as well as visible regions. Tanabe-Sugano (T-S) diagrams are used in coordination and transition metal chemistry to predict absorptions in the UV-visible electromagnetic spectrum of complex compounds<sup>4-5</sup>. A Tanabe-Sugano diagram's x-axis is scaled by the B Racah Parameter and is expressed in terms of the crystal field splitting parameter, 10Dq, or  $\Delta_o$ . The y-axis is scaled by B and expressed in terms of the energy of an electronic transition, E. While adjusting the strength of the octahedral ligand field, each line represents the energy of an electronic state. By using the E/B values (y-axis) and  $\Delta_o/B$  (x-axis) to solve for B, the ligand field splitting energy, 10Dq is obtained<sup>6</sup>. Regarding the two sets of complexes [M(sac)<sub>2</sub>(H<sub>2</sub>O)<sub>4</sub>].2H<sub>2</sub>O and [M(sac)<sub>2</sub>(en)<sub>2</sub>].2H<sub>2</sub>O, crystal field splitting ( $\Delta_o$ ) and the Racah parameter (B) are estimated from their electronic spectra using Tanabe-Sugano (T-S) diagram of Co(II) and Ni(II) complexes while  $\Delta_o$  values of Fe(II) and Cu(II)

derivatives are calculated directly from their absorption maxima.

## II. Experimental

### Materials

Sodium saccharinate hydrate (C<sub>7</sub>H<sub>4</sub>NO<sub>3</sub>S)Na.2/3H<sub>2</sub>O, (NH<sub>4</sub>)<sub>2</sub>Fe(SO<sub>4</sub>).6H<sub>2</sub>O, CoCl<sub>2</sub>.2H<sub>2</sub>O, NiCl<sub>2</sub>.6H<sub>2</sub>O, CuCl<sub>2</sub>.2H<sub>2</sub>O, conc. H<sub>2</sub>SO<sub>4</sub>, and ethylenediamine were of reagent grade. Deionized water was used for making solutions.

### Methods and Equipments

The melting points of the complexes were recorded in a Stuart Melting Point Apparatus, Model SMP 11, VWR International Ltd. UK with a capacity of recording the temperature up to 250°C. FTIR spectra were recorded between 4000-400 cm<sup>-1</sup> by a conventional KBr pellet method on a Perkin-Elmer FTIR spectrometer, 1760X. Each Pellet was prepared by mixing the sample with an appropriate amount of KBr using an absorbance spectroscopy accessory. The UV/Vis spectra were recorded using Ultraviolet and visible Recording Spectrometer, in the wavelength range, 200-1100 nm using ethanol as solvent. Magnetic susceptibility measurements were done using a Sherwood Scientific magnetic moment balance, Cambridge, England, Model Magway MSB Mk1.

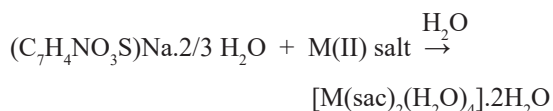
### Preparative procedure

The method of synthesis is simple and straight-forward. Since saccharin is insoluble in water, the reactions are carried out using water soluble Na-saccharin as the starting material in an aqueous medium.

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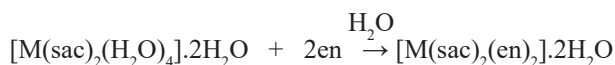
**Tetraaquadisaccharinatometal(II).dihydrate,  
[M(sac)<sub>2</sub>(H<sub>2</sub>O)<sub>4</sub>].2H<sub>2</sub>O**

Saccharinato metal(II) complexes of the type [M(sac)<sub>2</sub>(H<sub>2</sub>O)<sub>4</sub>].2H<sub>2</sub>O [sac = saccharinato, M = Fe(II), Co(II), Ni(II), and Cu(II)] were prepared and isolated as described in the literature<sup>7-10</sup>.



**Bis(ethylenediamine)bis(saccharinato) metal(II).  
dihydrate, [M(sac)<sub>2</sub>(en)<sub>2</sub>].2H<sub>2</sub>O**

Saccharinato metal(II) complexes of the type [M(sac)<sub>2</sub>(en)<sub>2</sub>].2H<sub>2</sub>O [sac = saccharinato, en = ethylenediamine, M = Fe(II), Co(II), Ni(II), and Cu(II)] were prepared and isolated as described in the literature<sup>11-12</sup>.



**Table 1. Data for the synthesis of [M(sac)<sub>2</sub>(H<sub>2</sub>O)<sub>4</sub>].2H<sub>2</sub>O.**

(C <sub>7</sub> H <sub>4</sub> NO <sub>3</sub> S)Na. 2/3H <sub>2</sub> O, g	Metal(II) salts in water		Formula of the complexes	Yield, %	Color of the Complexes
0.4212	(NH <sub>4</sub> ) <sub>2</sub> Fe(SO <sub>4</sub> ). 6H <sub>2</sub> O	0.3948 in 20 mL	[Fe(sac) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ].2H <sub>2</sub> O	94.8	Greenish yellow
0.4376	CoCl <sub>2</sub> .2H <sub>2</sub> O	0.2411 in 20 mL	[Co(sac) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ].2.2H <sub>2</sub> O	87.3	Shiny red
0.4771	NiCl <sub>2</sub> .6H <sub>2</sub> O	0.3734 in 20 mL	[Ni(sac) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ].2H <sub>2</sub> O	95.9	Green
0.4414	CuCl <sub>2</sub> .2H <sub>2</sub> O	0.1810 in 20 mL	[Cu(sac) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ].2H <sub>2</sub> O	90.0	Sky Blue

**Table 2. Data for the synthesis of [M(sac)<sub>2</sub>(en)<sub>2</sub>].2H<sub>2</sub>O.**

[M(sac) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ].2H <sub>2</sub> O. Formula	Amount, g	Ethylene- diamine, mL	Formula of the complexes	Yield, %	Color of the complexes
[Fe(sac) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ].2H <sub>2</sub> O	0.5314 in 20 mL	0.1	[Fe(sac) <sub>2</sub> (en) <sub>2</sub> ].2H <sub>2</sub> O	25.9	Dark Green
[Co(sac) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ].2H <sub>2</sub> O	0.5313 in 20 mL	0.1	[Co(sac) <sub>2</sub> (en) <sub>2</sub> ].2H <sub>2</sub> O	44.6	Dark Red
[Ni(sac) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ].2H <sub>2</sub> O	0.5311 in 20 mL	0.1	[Ni(sac) <sub>2</sub> (en) <sub>2</sub> ].2H <sub>2</sub> O	74.2	Purple
[Cu(sac) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ].2H <sub>2</sub> O	0.5324 in 20 mL	0.1	[Cu(sac) <sub>2</sub> (en) <sub>2</sub> ].2H <sub>2</sub> O	22.7	Violet

### III. Results and Discussion

Using previously published literature, complexes of saccharin-metal(II) and ethylenediamine-saccharin-metal(II) were prepared and characterized<sup>11-12</sup>. Some of the physico-chemical characteristics of the complexes, including solubility, FTIR, UV-Visible spectrum investigations, and magnetic susceptibility, were evaluated and compared with the data from the literature in order to establish their structural geometries (Fig. 1).

Divalent transition metal complexes with octahedral shape exhibit electronic transitions in the visible range that are

typically metal centered d→d transitions. These transitions are forbidden by the Laporte (orbital) selection rule, but they take place because the electronic wave functions are not entirely independent of the vibrational functions. The different electronic transitions of the complexes (Figs. 2-5) identified for the investigated metal(II) complexes are displayed in Table 3. They are relatively weak, and the T-S diagram is used for the interpretation of the electronic spectra of the complexes.

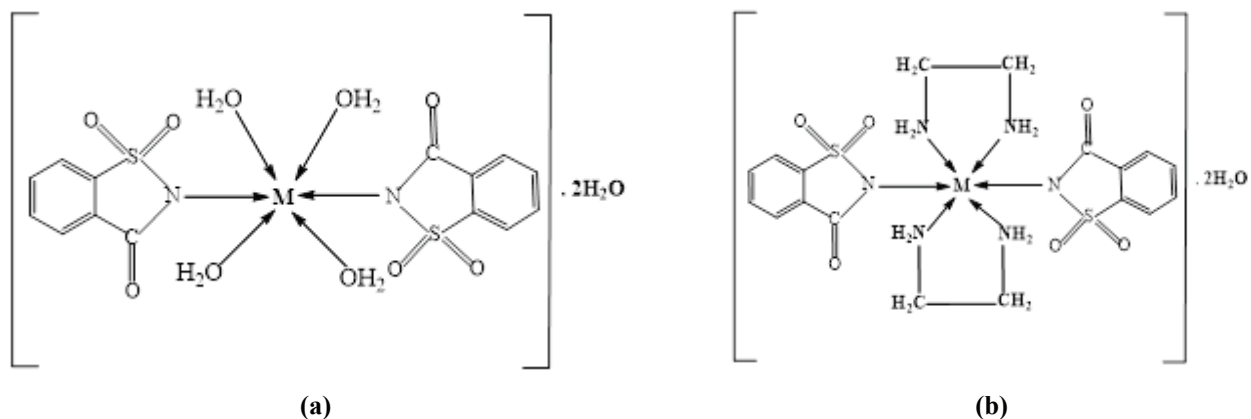
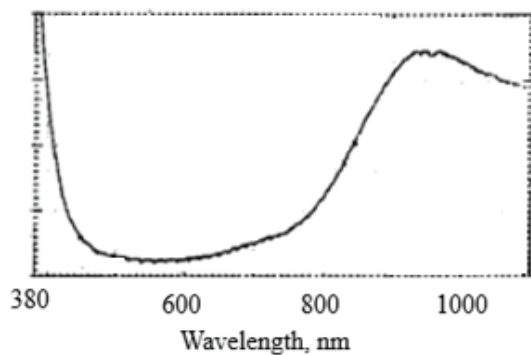


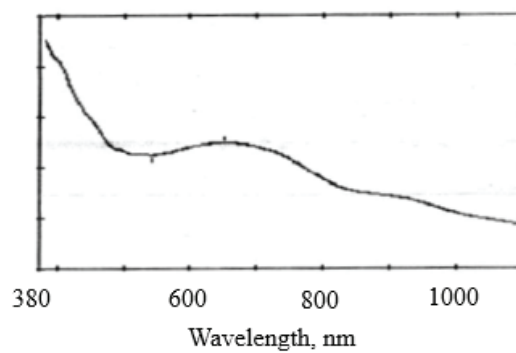
Fig. 1. Structural geometries of (a)  $[M(sac)_2(H_2O)_4].2H_2O$  and (b)  $[M(sac)_2(en)_2].2H_2O$

Table 3. Electronic spectral data of studied complexes

Complexes	Wavelength, nm	Complexes	Wavelength, nm
$[Fe(sac)_2(H_2O)_4].2H_2O$	947	$[Fe(sac)_2(en)_2].2H_2O$	651
$[Co(sac)_2(H_2O)_4].2H_2O$	507, 480	$[Co(sac)_2(en)_2].2H_2O$	501, 369
$[Ni(sac)_2(H_2O)_4].2H_2O$	721, 656, 396	$[Ni(sac)_2(en)_2].2H_2O$	885, 543
$[Cu(sac)_2(H_2O)_4].2H_2O$	805	$[Cu(sac)_2(en)_2].2H_2O$	549

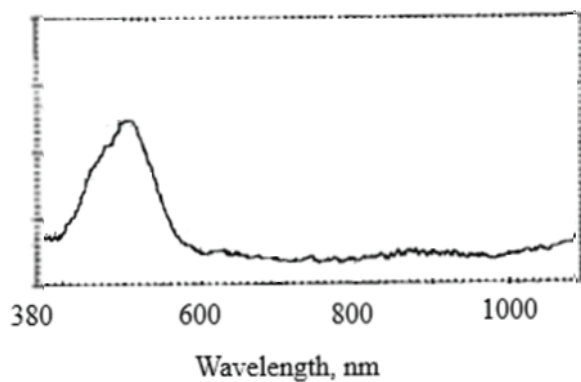


(a)

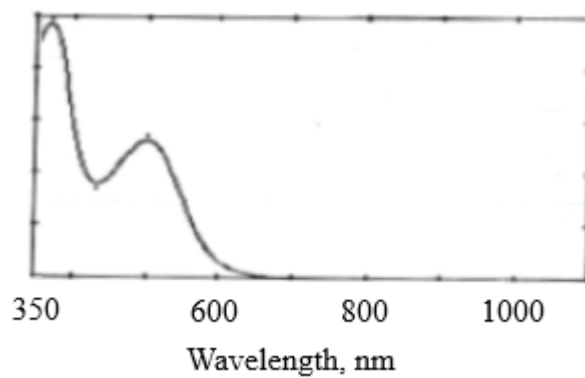


(b)

Fig. 2. Visible spectra of (a)  $[Fe(sac)_2(H_2O)_4].2H_2O$  and (b)  $[Fe(sac)_2(en)_2].2H_2O$



(a)



(b)

Fig. 3. Visible spectra of (a)  $[Co(sac)_2(H_2O)_4].2H_2O$  and (b)  $[Co(sac)_2(en)_2].2H_2O$

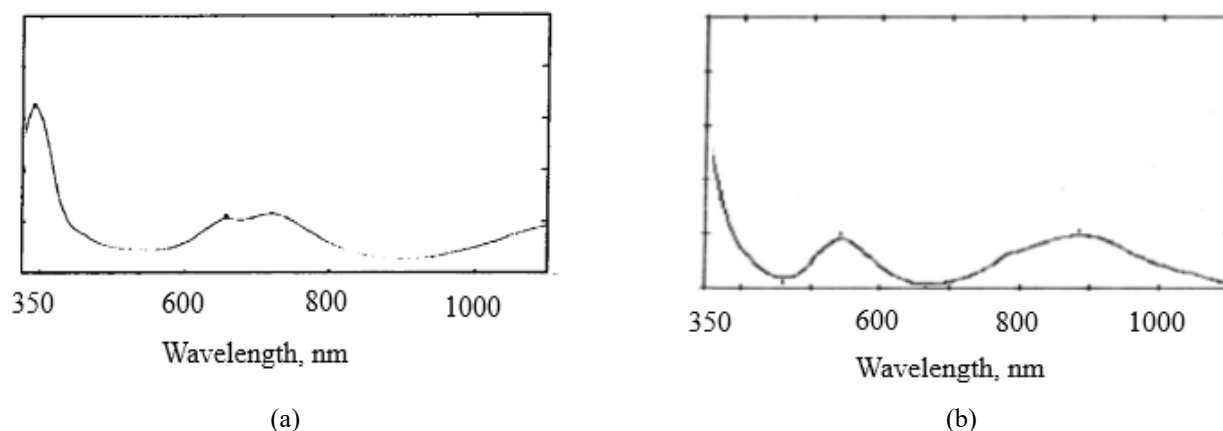


Fig. 4. Visible spectra of (a)  $[\text{Ni}(\text{sac})_2(\text{H}_2\text{O})_4] \cdot 2\text{H}_2\text{O}$  and (b)  $[\text{Ni}(\text{sac})_2(\text{en})_2] \cdot 2\text{H}_2\text{O}$

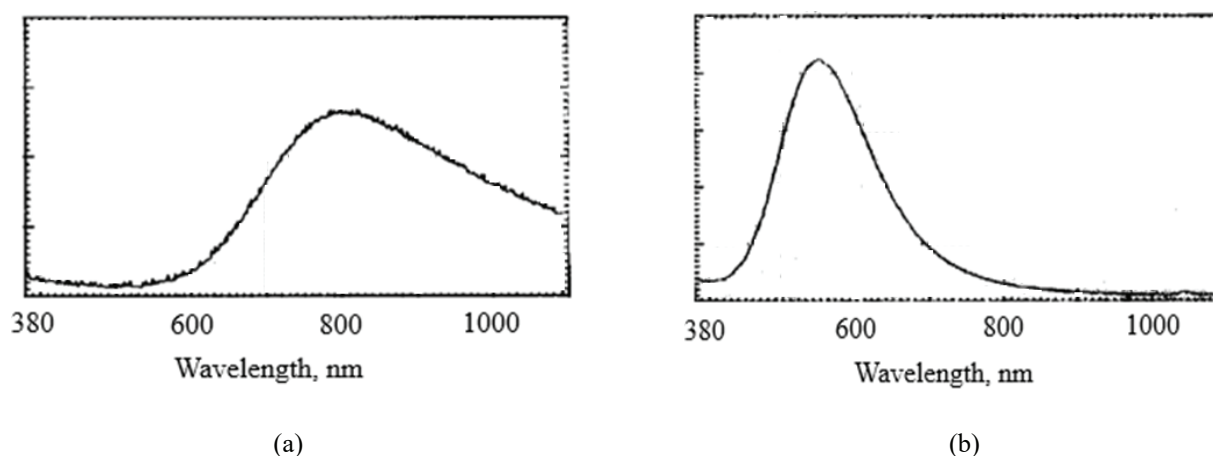


Fig. 5. Visible spectra of (a)  $[\text{Cu}(\text{sac})_2(\text{H}_2\text{O})_4] \cdot 2\text{H}_2\text{O}$  and (b)  $[\text{Cu}(\text{sac})_2(\text{en})_2] \cdot 2\text{H}_2\text{O}$

**Fe(II) ( $d^6$  ion) complexes:** The strength of the ligand field has a important impact on the nature of the electronic spectrum. For a high spin octahedral  $\text{Fe}^{2+}$  ion, there is only one spin allowed transition ( ${}^5\text{T}_{2g} \rightarrow {}^5\text{E}_g$ ), which corresponds to one absorption band, however for low spin  $\text{Fe}^{2+}$  complexes, there are two spin allowed transitions ( ${}^1\text{A}_{1g} \rightarrow {}^1\text{T}_{1g}$  and  ${}^1\text{A}_{1g} \rightarrow {}^1\text{T}_{2g}$ ) at relatively low energies. For the ligands such as  $\text{H}_2\text{O}$ , ethylenediamine and saccharinato anion used in this study are moderately strong, as indicated by their position in the spectrochemical series, their complexes with Fe(II) are high spin type because the formation of spin paired complexes requires a relatively strong field. Both  $[\text{Fe}(\text{sac})_2(\text{H}_2\text{O})_4] \cdot 2\text{H}_2\text{O}$  and  $[\text{Fe}(\text{sac})_2(\text{en})_2] \cdot 2\text{H}_2\text{O}$  are high spin complexes and exhibit a broad absorption band in their visible spectra (Fig.2) due to  ${}^5\text{T}_{2g} \rightarrow {}^5\text{E}_g$  transition. The energies associated with the single spin-allowed transition are  $10559.66$  and  $15360.98 \text{ cm}^{-1}$  for the compounds  $[\text{Fe}(\text{sac})_2(\text{H}_2\text{O})_4] \cdot 2\text{H}_2\text{O}$  and  $[\text{Fe}(\text{sac})_2(\text{en})_2] \cdot 2\text{H}_2\text{O}$  respectively. They are equal to their respective  $\Delta_o$  values. The T-S diagram cannot be used in these circumstances to derive the Racah parameters  $B^{13}$ .

**Co(II) ( $d^7$  ion) complexes:** The Co(II) in octahedral coordination has the ground state of  ${}^4\text{T}_{1g}$ . The T-S diagram

exhibits that there are three excited states:  ${}^4\text{T}_{2g}$ ,  ${}^4\text{A}_{2g}$  and  ${}^4\text{T}_{1g}$  (P). So, we can predict three spin allowed transitions. However, the absorption spectrum of high spin  $[\text{Co}(\text{sac})_2(\text{H}_2\text{O})_4] \cdot 2\text{H}_2\text{O}$  complex does not show three spin-allowed bands. Instead, the spectrum shows a broad band. From the T-S diagram, the lowest energy transition is  ${}^4\text{T}_{1g} \rightarrow {}^4\text{T}_{2g}$  that is not found in the visible spectrum due to near IR energy of this transition. The main band is the energy transition  ${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{1g}(\text{P})$  and the shoulder associated with the slightly higher energy transition  ${}^4\text{T}_{1g} \rightarrow {}^4\text{A}_{2g}$ . Overlapping of peaks due to small energy difference makes broad band in the visible spectrum.  $[\text{Co}(\text{sac})_2(\text{H}_2\text{O})_4] \cdot 2\text{H}_2\text{O}$  shows a broad band with a shoulder at  $20,833.34$  and  $19,723.86 \text{ cm}^{-1}$  and  $[\text{Co}(\text{sac})_2(\text{en})_2] \cdot 2\text{H}_2\text{O}$  shows two spin-allowed bands at  $19,960.08$ , and  $27,100.27 \text{ cm}^{-1}$  (Fig. 3) which are assigned in Table 3. The ratio of two energies for  $[\text{Co}(\text{sac})_2(\text{H}_2\text{O})_4] \cdot 2\text{H}_2\text{O}$  is given by  $v_2/v_1 = 1.05$ . From the T-S diagram for the  $d^7$  system (Fig. 6), the following data can be figured out for high spin complexes. Now, by plotting  $v_2/v_1$  vs.  $\Delta_o/B$  (Fig. 7), we find that at  $v_2/v_1 = 1.05$ , the value of  $\Delta_o/B = 12.0$ . The T-S diagram has  $\Delta_o/B = 12$ , and the value of  $E/B$  for the lowest energy transition can be read out from  $E/B = 20$ . So we can write,  $19,723.86 \text{ cm}^{-1}/B = 20$ . Therefore, Racah parameter,  $B = 19,723.86 \text{ cm}^{-1}/20$

= 986.19  $\text{cm}^{-1}$ . Now  $\Delta_o/B = 12$ , crystal field splitting energy,  $\Delta_o = 11,833.80 \text{ cm}^{-1}$ . The magnitude of  $\Delta_o = 12,831.42 \text{ cm}^{-1}$  and  $B = 1,425.72 \text{ cm}^{-1}$  for  $[\text{Co}(\text{sac})_2(\text{en})_2] \cdot 2\text{H}_2\text{O}$  is calculated by adopting the same procedure given above.

**Ni(II) ( $d^8$  ion) complexes:** The spectrum of the  $d^8$  complex  $[\text{Ni}(\text{sac})_2(\text{H}_2\text{O})] \cdot 2\text{H}_2\text{O}$  shows two bands at  $13,869.62 \text{ cm}^{-1}$  and  $25,252.52 \text{ cm}^{-1}$  (Fig. 4), which are assigned as follows (Table 6). The ratio of these two energies is given by  $\nu_2/\nu_1 =$

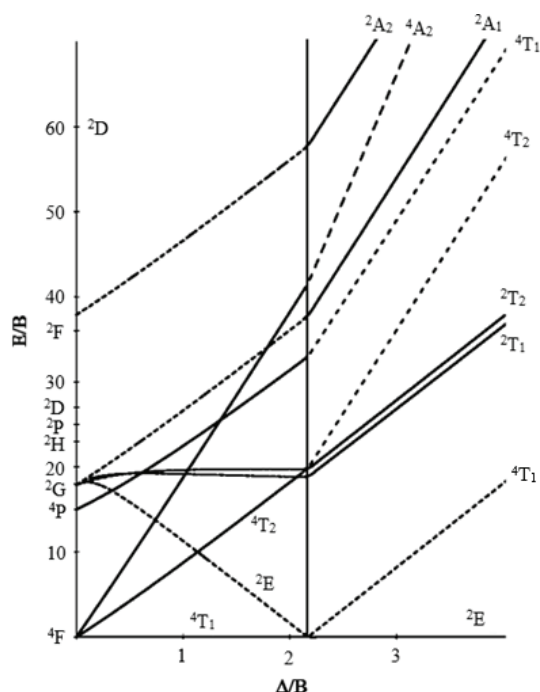
$25,252.52/13,869.62 = 1.82$ . From the T-S diagram for the  $d^8$  system (Fig. 8), the following data can be figured out (Table 7). Again, at  $\Delta_o/B = 8.25$ , the value of  $E/B$  for the lowest energy transition can be read out from the T-S diagram as  $E/B = 17.04$ . So we can write,  $13,869.62 \text{ cm}^{-1}/B = 17.04$ . Therefore,  $B = 13,869.62 \text{ cm}^{-1}/17.04 = 813.94 \text{ cm}^{-1}$ . Now  $\Delta_o/B = 8.25$ , therefore  $\Delta_o = 6715.005 \text{ cm}^{-1}$ .

**Table 4. Absorption maxima and band assignment of Co(II) complexes**

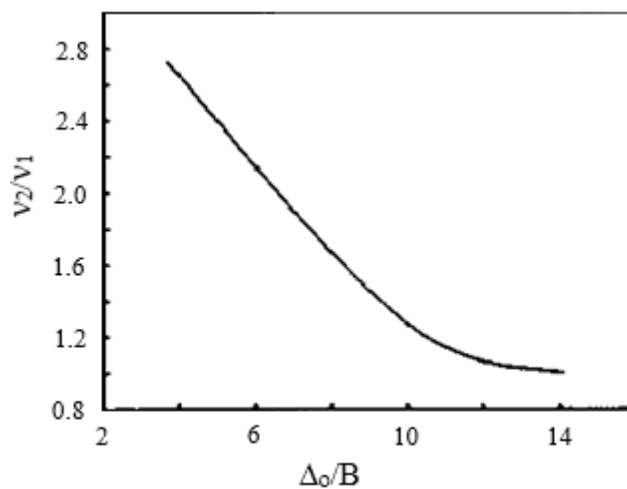
Complexes	${}^4T_{1g} \rightarrow {}^4A_{2g} (\nu_2)$ , $\text{cm}^{-1}$	${}^4T_{1g} \rightarrow {}^4T_{1g} (\text{P}) (\nu_1)$ , $\text{cm}^{-1}$
$[\text{Co}(\text{sac})_2(\text{H}_2\text{O})_4] \cdot 2\text{H}_2\text{O}$	20,833.34	19,723.86
$[\text{Co}(\text{sac})_2(\text{en})_2] \cdot 2\text{H}_2\text{O}$	27,100.27	19,960.08

**Table 5. Derived data for the determination of  $\Delta_o$  and B for  $d^7$  ion**

$\Delta_o/B$	$\nu_1$ , $\text{cm}^{-1}$	$\nu_2$ , $\text{cm}^{-1}$	$\nu_2/\nu_1$
3.70	4.40	12.0	2.72
6.70	9.60	13.6	1.42
10.0	12.00	15.2	1.26
14.07	16.80	16.8	1.00



**Fig. 6.** Tanabe-Sugano diagram for  $d^7$  ion.



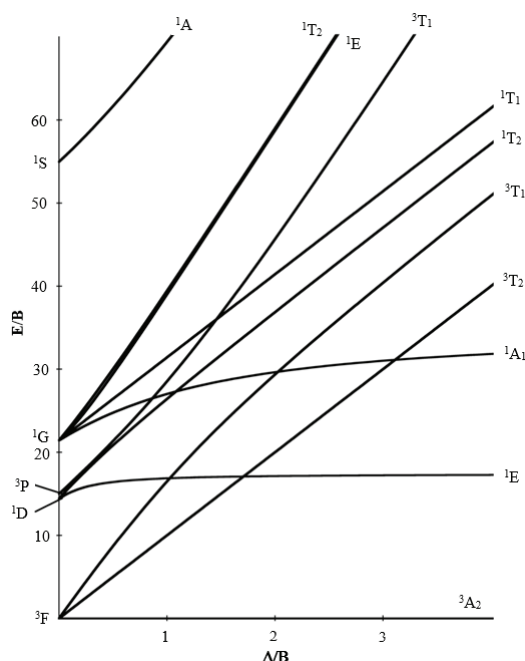
**Fig. 7.** A plot of  $\nu_2/\nu_1$  vs.  $\Delta_o/B$  for Co(II).

**Table 6. Absorption maxima and band assignment of Ni(II) complexes**

Complexes	${}^3A_{2g} \rightarrow {}^3T_{1g}(F)$ ( $\nu_1$ ) $\text{cm}^{-1}$	${}^3A_{2g} \rightarrow {}^3T_{1g}(P)$ ( $\nu_2$ ) $\text{cm}^{-1}$
$[\text{Ni}(\text{sac})_2(\text{H}_2\text{O})_4] \cdot 2\text{H}_2\text{O}$	13,869.62	25,252.52
$[\text{Ni}(\text{sac})_2(\text{en})_2] \cdot 2\text{H}_2\text{O}$	11,363.64	18,416.2

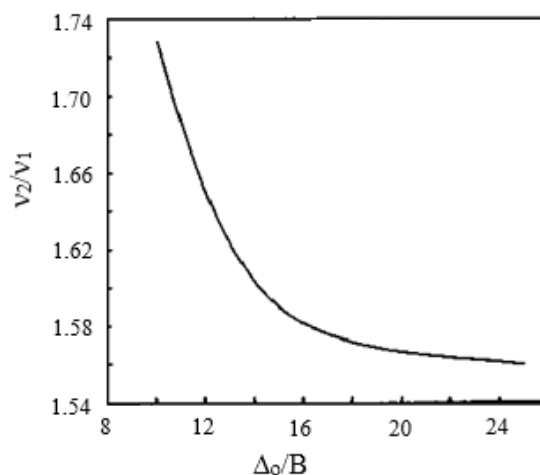
**Table 7. Derived data for the determination of  $\Delta_o$  and B for  $d^8$  ion**

$\Delta_o/B$	$\nu_1, \text{cm}^{-1}$	$\nu_2, \text{cm}^{-1}$	$\nu_2/\nu_1$
10	16.30	28.15	1.73
15	23.33	35.56	1.57
20	28.89	45.92	1.59
25	34.81	54.07	1.56
30	40.00	62.22	1.55

**Fig. 8.** Tanabe-Sugano diagram for  $d^8$  ion.

**Cu(II) ( $d^9$  ion) complexes:** As like  $d^1$  metal complexes,  $d^9$  octahedral metal complexes have  ${}^2D$  term symbol. The transition is from the  $t_{2g}^6 e_g^3$  configuration ( ${}^2E_g$  state) to the  $t_{2g}^5 e_g^4$  configuration ( ${}^2T_{2g}$  state). This could be explained as a positive hole that moves from the  $e_g$  to the  $t_{2g}$  level. The sign of  $Dq$  is opposite to that of  $d^1$ , with a  ${}^2E_g$  ground state

and a  ${}^2T_{2g}$  excited state. The six coordinated  $\text{Cu}^{2+}$  complexes are mostly distorted from a regular octahedral geometry, with the axial ligands of the octahedral system further away from

**Fig. 9.** A plot of  $\nu_2/\nu_1$  vs.  $\Delta_o/B$  for Ni(II).

the metal ion than the equatorial ligands due to Jahn-Teller distortion. The absorption spectra of  $\text{Cu}^{2+}$  complexes (Fig.5) broadened by distortion from octahedral symmetry may be further broadened by spin-orbit (L-S) coupling. The energies corresponding to the  ${}^2E_g \rightarrow {}^2T_{2g}$  transition are  $12422.36 \text{ cm}^{-1}$  and  $18214.94 \text{ cm}^{-1}$  for the complexes  $[\text{Cu}(\text{sac})_2(\text{H}_2\text{O})_4] \cdot 2\text{H}_2\text{O}$  and  $[\text{Cu}(\text{sac})_2(\text{en})_2] \cdot 2\text{H}_2\text{O}$  respectively is equal to their respective  $\Delta_o$  values. In such cases, the Racah parameters B cannot be determined using the T-S diagram. The  $\nu_2/\nu_1$ ,  $\Delta_o/B$ , B, E/B,  $\Delta_o$  of studied complexes are summarized in Table 8.

**Table 8. Derived data evaluated from Tanabe-Sugano diagram for d<sup>6</sup>, d<sup>7</sup>, d<sup>8</sup>, d<sup>9</sup> ion**

Complexes	$v_2/v_1$	$\Delta_o/B$	B, cm <sup>-1</sup>	E/B	$\Delta_o$ , cm <sup>-1</sup>
[Fe(sac) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ].2H <sub>2</sub> O					10,559.66
[Fe(sac) <sub>2</sub> (en) <sub>2</sub> ].2H <sub>2</sub> O					15,360.98
[Co(sac) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ].2H <sub>2</sub> O	1.05	12.00	986.15	20.00	11,833.80
[Co(sac) <sub>2</sub> (en) <sub>2</sub> ].2H <sub>2</sub> O	1.35	9.00	1,425.72	14.00	12,831.42
[Ni(sac) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ].2H <sub>2</sub> O	1.82	8.25	813.94	17.04	6,715.01
[Ni(sac) <sub>2</sub> (en) <sub>2</sub> ].2H <sub>2</sub> O	1.62	17.50	520.08	21.85	9,101.40
[Cu(sac) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ].2H <sub>2</sub> O					12,422.36
[Cu(sac) <sub>2</sub> (en) <sub>2</sub> ].2H <sub>2</sub> O					18,214.94

#### IV. Conclusion

[M(sac)<sub>2</sub>(H<sub>2</sub>O)<sub>4</sub>].2H<sub>2</sub>O and [M(sac)<sub>2</sub>(en)<sub>2</sub>].2H<sub>2</sub>O complexes were prepared in an aqueous medium. They were crystalline, different in color and stable at ambient condition. Crystal field splitting,  $\Delta_o$ , and the Racah parameter (B) of two sets of compounds [M(sac)<sub>2</sub>(H<sub>2</sub>O)<sub>4</sub>].2H<sub>2</sub>O and [M(sac)<sub>2</sub>(en)<sub>2</sub>].2H<sub>2</sub>O [M = Fe(II), Co(II), Ni(II) and Cu(II)] were calculated from their electronic spectra. The magnitude of  $\Delta_o$  and B were estimated from their d-d transitions using the Tanabe-Sugano (T-S) diagram for Co(II) and Ni(II) compounds, while the  $\Delta_o$  values of Fe(II) and Cu(II) derivatives were calculated directly from their absorption maxima. Our experimental results demonstrate that irrespective of the ligands, the magnitudes of the crystal field splitting values,  $\Delta_o$ , vary according to the following order: Cu(II) > Fe(II) > Co(II) > Ni(II). The  $\Delta_o$  values of [M(sac)<sub>2</sub>(en)<sub>2</sub>].2H<sub>2</sub>O are systematically higher than those of [M(sac)<sub>2</sub>(H<sub>2</sub>O)<sub>4</sub>].2H<sub>2</sub>O indicates that ethylenediamine is a stronger ligand than water, which agrees well with the spectrochemical series.

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