

and

$$c = -4uk/3q^2, d = -4bk^2/3q^2. \quad (11d)$$

This solution can be written in the form of Patnaik metric<sup>3</sup>,

$$ds^2 = (1 + ku/q)u^{-2} [(dx^4)^2 - (d\bar{x}^1)^2] - \frac{eu^2}{4c} [(dx^2)^2 + (dx^3)^2] \quad (12)$$

if

$$\bar{x}^1 = \frac{eq}{4ck^2} [-u + ku^2/2q + (q/k) \log(1 + ku/q)] + A \quad (13)$$

where A is a constant. The case of lower signs yields the solution

$$ds^2 = - (dx^1)^2 - \frac{eu^2}{4c} [(dx^2)^2 + (dx^3)^2] + (1 - ku/q)u^{-2} (dx^4)^2 \quad (14a)$$

$$F_{14} = 4ecqu^{-3} \sqrt{1 - ku/q} \quad (14b)$$

where

$$\left. \begin{aligned} ku &= q(1 - 4\cos^2 \alpha), \\ 3\alpha &= \cos^{-1} [3k(cdx^1 - d)/q], \\ c &= -aq^2/4k^3, d = bq^2/4k^2. \end{aligned} \right\} \quad (14c)$$

This solution can also be reduced to the Patnaik form

$$ds^2 = (1 - ku/q)u^{-2} [(dx^4)^2 - (d\bar{x}^1)^2] - \frac{eu^2}{4c} [(dx^2)^2 + (dx^3)^2] \quad (15)$$

if

$$\bar{x}^1 = -\frac{eq}{4ck^2} [u + ku^2/2q + (q/k) \log(1 - ku/q)] + B \quad (16)$$

where B is a constant. The letter  $e$ , in the solution (11) and (14), is +1 or -1 according as  $c >$  or  $<$  0.

The study of geodesic motion, nature of the source of the gravitational field, the pseudo-energy-momentum tensor, etc., etc., for the new metric (4), will be published elsewhere.

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### FINE STRUCTURE OF B - X SYSTEM OF SbO MOLECULE

THE spectrum of SbO molecules has been investigated by several authors<sup>1-8</sup>. The spectrum consists of seven band systems, viz., A-X, B-X, C-X, D-X, E-X, F-X and G-X extending from infra-red to ultraviolet region. It is established that ground state of SbO molecule is a regular  ${}^2\Pi$  state with doublet separation of  $2276 \text{ cm}^{-1}$ . Analyses of D-X and C-X systems of SbO molecule by S.B. Rai *et al.*<sup>7</sup> and Rai *et al.*<sup>6</sup> reveal an appreciable  $\Lambda$ -type doubling in the ground state. Hence we expect similar results in the case of B-X system. However, analysis of B-X system by previous workers<sup>5</sup> does not reveal such  $\Lambda$ -type doubling. Hence a re-investigation of B-X system of SbO molecule has been undertaken at high dispersion and resolution. Results obtained are reported in the present note.

The spectrum of SbO molecule has been excited in a high frequency discharge (15 MHz). A pure sample of  $\text{Sb}_2\text{O}_3$  was kept in a conventional type of discharge tube. 0, 0 and 1, 0 bands of sub-systems of B-X level of SbO molecule were photographed in the 9th order at a dispersion of  $35 \text{ \AA/mm}$  on two metre plane grating spectrograph. Measurements were made on an Abbe comparator against iron arc lines as standards. The sharp lines could be measured within an error of  $0.03 \text{ cm}^{-1}$ .

The bands in B-X system are degraded to longer wavelength side and are double headed. 0, 0 and 1, 0 bands of B-X sub-system showed well resolved  $R_{12}$ ,  $R_2$ ,  $Q_2$  and  $P_2$  branches of which  $R_{12}$  and  $R_2$  are head forming,  $P_2$  branch lines are weak in intensity. The doubling of rotational lines in some branches of two component systems has been attributed to the isotopic effect of antimony. The J numbering of rotational lines and their analysis has been carried out by the method suggested by Youngner and Winans<sup>8</sup>. The analysis revealed a good amount of  $\Lambda$ -type doubling in the lower state  ${}^2\Pi_{1/2}$  and  ${}^2\Pi_{3/2}$  ( $0.06667 \text{ cm}^{-1}$  and  $0.02337 \text{ cm}^{-1}$ ) and spin splitting in the upper state  ${}^2\Sigma$  ( $0.0133 \text{ cm}^{-1}$ ). The combination differences of 0, 0 and 1, 0 bands of sub-system of B-X of SbO molecule for the common lower state were compared and found to agree within experimental errors.

$\Lambda$ -type doubling constant  $q$  and spin splitting constant  $\gamma$  have been calculated by the method of combination defect. Results obtained are given in table I. It is observed that  $B_v^4/B_v^1 = \rho^2 (0.9974)$  agrees with calculated value of  $\rho^2 = (0.9980)$ . The ground state of SbO molecule is  ${}^2\Pi_r$  state arising from the electronic configuration  $(z\sigma^2y\sigma^2\omega)\pi^4x\sigma^2v\pi$ . The excitation of an electron from  $v\pi$  orbital to  $u\tau$  orbital gives rise to  $B^2\Sigma$  state. Thus B-X system can be attributed to  $B^2\Sigma - X^2\pi_r$  transition.

TABLE I  
Molecular constants of SbO molecule obtained from the present analysis

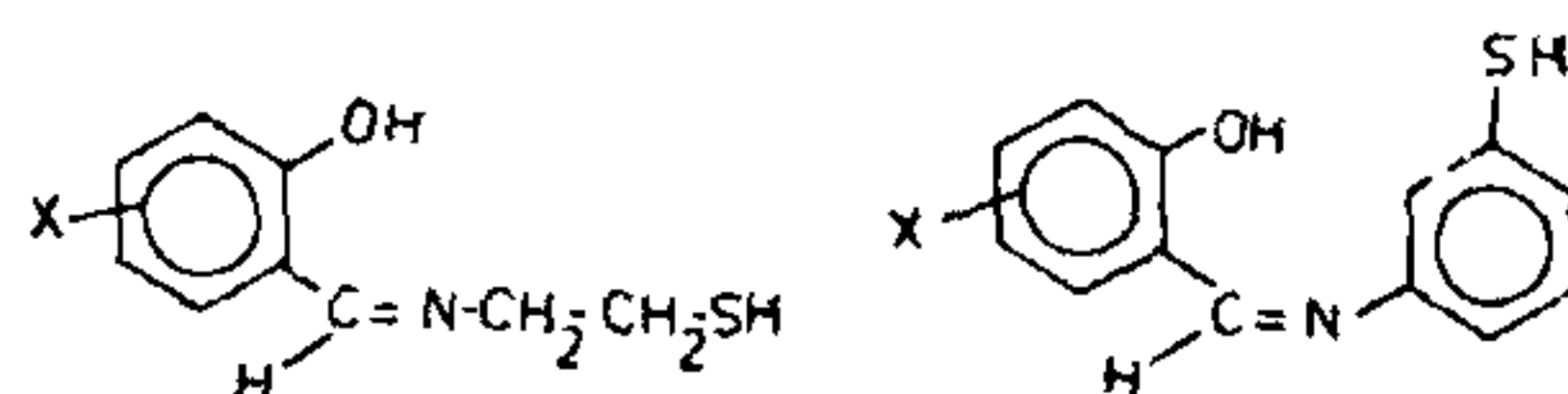
| States                     | $\Delta G_{1,2}$<br>cm <sup>-1</sup> | $B_0$<br>cm <sup>-1</sup>        | $D_0 \times 10^7$<br>cm <sup>-1</sup> | $q$<br>cm <sup>-1</sup> | $\gamma$<br>cm <sup>-1</sup> | $\alpha_0$<br>cm <sup>-1</sup> |
|----------------------------|--------------------------------------|----------------------------------|---------------------------------------|-------------------------|------------------------------|--------------------------------|
| B <sup>2</sup> $\Sigma$    | 572.50                               | $B_0 = 0.3462$<br>$B_1 = 0.3363$ | 3.5                                   |                         | 0.0133                       | 0.00913                        |
| X <sup>2</sup> $\Pi_{3,2}$ |                                      | $B_0 = 0.3585$<br>$B_1 = 0.3585$ |                                       | 0.0233                  |                              |                                |
| X <sup>2</sup> $\Pi_{1,2}$ |                                      | $B_0 = 0.2580$                   | 1.5                                   | 0.06667                 |                              |                                |

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complexes of I have been reported by Zelentsov and Suvorova<sup>6</sup>.



I. X = H, 5-chloro, 5-bromo,  
5-nitro and  
5,6-benzo.

II. X = H, 5-chloro, 5-bromo,  
5-nitro and  
5,6-benzo.

FIG. 1

#### General Method of Syntheses of the Complexes

To a methanol solution (15 ml) of 2-aminoethanethiol acetate (0.004 mole) or 3-aminothiophenol (0.004 mole) was added a methanolic solution (15-20 ml) of salicylaldehyde or substituted salicylaldehyde (0.004 mole). The mixture was stirred for 30 min. Sodium acetate (0.66 g, 0.008 mole) was added to a methanolic solution (10 ml) of oxovanadium(IV) dichloride dihydrate (0.004 mole) and the mixture was stirred and the separated sodium chloride was filtered off. To the filtrate, the ligand solution was added slowly with stirring and the mixture was refluxed for 3 h with continuous stirring. The separated compounds were filtered under reduced pressure, washed thoroughly with methanol and dried *in vacuo* at room temperature. Yield = 80-90%. The complexes gave satisfactory elemental analyses.

The analytical data (Table I) of the complexes indicate 1:2 of metal:ligand stoichiometry and hence the Schiff bases are behaving as monobasic bidentate ligands. This is supported from the IR spectral data which show a band around 3100 cm<sup>-1</sup>. The C-N stretch of the free aromatic Schiff<sup>7</sup> bases occurs at 1640 cm<sup>-1</sup>. The complexes exhibit a strong band in the region 1600-1625 cm<sup>-1</sup>. The lowering of the C-N stretch in the complexes indicates the coordination of the nitrogen atom of the Schiff bases. The  $\nu(V-O)$  frequency of the complexes occurs in the region 940-985 cm<sup>-1</sup> (Table I) which is in the normal

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#### NEW OXOVANADIUM(IV) COMPLEXES WITH SCHIFF BASES DERIVED FROM SALICYLALDEHYDE OR SUBSTITUTED SALICYLALDEHYDE AND 2-AMINOETHANETHIOL OR 3-AMINOTHIOPHENOL

THERE has been considerable interest on the syntheses, magnetic and spectroscopic properties of oxovanadium(IV) complexes of Schiff bases<sup>1-4</sup>. However, only a few Schiff bases containing sulfur donor atom have been explored for the synthesis of oxovanadium(IV) complexes<sup>2,5</sup>. In this communication the synthesis of new oxovanadium(IV) complexes with the Schiff bases I and II (Fig. 1) is reported. This is the first report of metal complexes of the ligand II and we wish to make a comprehensive study of donor properties of I and II. The nickel(II), copper(II) and cobalt(III)