



## Schiff base complexes derived from thiosemicarbazone, synthesis characterization and their biological activity

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### ABSTRACT

The Schiff bases anisaldehyde thiosemicarbazone (ATC), 3-4, dimethoxy benzaldehyde thiosemicarbazone (DMBTC), thiophene-2 aldehyde thiosemicarbazone (TATC), 2-acetyl pyridine thiosemicarbazone (APTC) and acetyl acetone thiosemicarbazone (AATC) were prepared by standard methods and characterized by M.P. & I.R. Spectra. Their complexes with palladium {(Pd ATC), (Pd DMBTC), (Pd TATC), (Pd APTC), (Pd AATC)} ruthenium {(Ru ATC), (Ru DMBTC), Ru (TATC), (Ru APTC), (Ru AATC)} and rhodium {(Rh ATC), (Rh DMBTC), (Rh TATC), (Rh APTC), (Rh AATC)} have been prepared by standard method and characterized by elemental analyses, electrical conductance, magnetic susceptibility, IR and electronic spectral studies molar conductance. Both the ligands and their complexes have been screened for their fungicidal & bactericidal activities and the results indicate that they exhibit significant antimicrobial properties.

**Key words:** Thiosemicarbazone, Schiff bases, Pd (II), Ru (III) & Rh (III), Biological Activity.

### INTRODUCTION

The coordination compounds offer variety of geometries and reactivity for use in drug design. Thiosemicarbazones and their metal complexes exhibit a great variety of biological activity<sup>1-6</sup>. The effect of Pd (II), Ru (III) & Rh (III) metal compounds on biological systems has evoked considerable interest<sup>7-9</sup>. Keeping in view the importance of compounds of Pd (II), Ru (III) & Rh (III) metals in biological system we have synthesized and characterized the complexes of these metals with ATC, DMBTC, TATC, APTC and AATC. The results of this study are reported here.

### EXPERIMENTAL SECTION

All used chemicals were of analytical grade. Materials used in the preparation of ligands (Schiff bases) were different aldehydes and ketones. The aldehydes used were anisaldehyde (BDH), 3, 4-dimethoxy benzaldehyde (Sigma), thiophene-2-aldehyde (Fluka), 2-acetyl pyridine (BDH) and ketone was acetyl acetone (BDH) and thiosemicarbazide (Aldrich).

Ruthenium, Rhodium and Palladium were used in the form of ruthenium (III) chloride (Aldrich), rhodium (III) chloride (Sigma) and Palladium (II) chloride (Aldrich).

Elemental Analyses were carried out at R.S.I.C., C.D.R.I. Lucknow. Conductivity measurements were carried out at Philips conductivity bridge model PR 9500, with a dip type conductivity cell at Dept. of Chemistry, Bareilly College, Bareilly. The conductance of the complexes were measured in DMF, DMSO and methanol at  $10^{-3}$  M dilution at 30°C. The IR studies of the complexes were made with Perkin Elmer spectrophotometer model 651 (U.S.A.) in KBr as well as nujol phase from  $4000\text{ cm}^{-1}$  to  $200\text{ cm}^{-1}$  at CDRI Lucknow. Magnetic Susceptibility of the complexes was determined by the Gouy method at the Deptt. of Chemistry, University of Roorkee, Roorkee. The

sample tube was calibrated with  $\text{CuSO}_4$ . Visible spectra were recorded with Backman DU-2 spectrophotometer in the range of 300 to 750  $\text{cm}^{-1}$  at Chemistry Deptt. Bareilly College, Bareilly.

#### **Preparation of the Ligands :**

The Schiff bases were prepared by the condensation of respective aldehyde/ketone with thiosemicarbazide. The amino compound was dissolved in ethanol and refluxed for about half an hour. The requisite amount of the respective aldehyde/ketone was then added to the flask. The mixture was then refluxed for about six hours. The reaction mixture was kept for 24 hours. The crystals of the ligand were obtained which were purified by recrystallization. The purity of the ligands was characterizing by elemental analyses and M.P. and IR spectra.

#### **PREPARATION OF THE COMPLEXES :**

##### ***Preparation of Palladium (II) Complexes :***

These complexes were prepared by adding palladium chloride solution to a solution of ligand (M:L in 1:2 ratio) in dil  $\text{HNO}_3$  or  $\text{H}_2\text{SO}_4$  (2N). The contents were refluxed for the hour, the precipitate filtered and dried in vacuum desiccator over  $\text{P}_2\text{O}_5$ .

##### ***Preparation of Ruthenium (III) Complexes :***

The complexes were prepared by mixing the solutions of metal salt in ethanol with the ligand dissolved in min. amount of benzene in the molar ratio of 1:2. The mixture was stirred on a hot plate for 2-4 hours. The precipitate thus obtained was filtered & washed with hot ethanol and then with hot benzene & dried over anhydrous  $\text{CaCl}_2$  in vacuum.

##### ***Preparation of Rhodium (III) Complexes :***

The complexes were prepared by refluxing the metal chloride and the ligand in ethanol for 2-3 hours. The separated solid was washed with hot water, warm ethanol and ether and dried over anhydrous  $\text{CaCl}_2$  in vacuum desiccator.

### **RESULTS AND DISCUSSION**

Elemental analyses reveal that the complexes have the compositions  $[\text{M}(\text{ligand})_2\text{Cl}_2]$  (M=Pd) and  $[\text{M}(\text{ligand})_2\text{Cl}_2]\text{Cl}$  (M=Ru & Rh) Table-1. The molar conductance of these complexes at  $10^{-3}$  M dilution were recorded in MeOH, DMF & DMSO. All complexes of palladium (II) chloride have the values of molar conductance compatible with the values suggested for 1:2 electrolytes<sup>10</sup>. The molar conductance values of the complexes of Ru (III) and Rh (III) indicate that all the complexes are 1:1 electrolytes in same three solvents i.e. methanol, dimethyl formamide and dimethyl sulphoxide<sup>11</sup>.

##### ***Palladium (II) Complexes :***

The complexes are diamagnetic as expected for square planer  $d^8$  metal ion complexes, which indicate the absence of unpaired electrons<sup>12</sup>. The electronic spectra of square planar complexes of Pd (II) are expected to show three d-d spin allowed transitions. The electronic spectra of palladium (II) complexes show bands around 17290 - 18900, 19550 - 21200 and 23450 - 22250 which may be assigned to  $^1\text{A}_{1g} \rightarrow ^1\text{A}_{2g}$ ,  $^1\text{A}_{1g} \rightarrow ^1\text{B}_{2g}$  &  $^1\text{A}_{1g} \rightarrow ^1\text{E}$  transitions respectively<sup>13</sup>. The single electron parameters  $\Delta_1$ ,  $\Delta_2$  and  $\Delta_3$  calculated using the equations suggested by Gray and Ballhausen<sup>14</sup>.

##### ***Ruthenium (III) and Rhodium (III) Complexes :***

The room temperature magnetic moments of the ruthenium (III) complexes of the ligands lie in the range of 1.89 - 1.97 B.M. which were lower than the predicted value of 2.10 B.M. The lowering in  $\mu_{\text{eff}}$  values may be due to presence of lower symmetry ligand field, metal-metal interactions or extensive electron delocalisation<sup>15</sup>. The values of magnetic moments for Rh (III) complexes indicate diamagnetic nature as expected for  $d^6$  system with octahedral inner orbital configuration. The electronic spectra of ruthenium (III) complexes exhibited that three bands lie in the range of 13500 - 13870  $\text{cm}^{-1}$ , 17350 - 17900  $\text{cm}^{-1}$  and 21850 - 22800  $\text{cm}^{-1}$  which may be assigned to  $^2\text{T}_{2g} \rightarrow ^4\text{T}_{1g}$ ,  $^2\text{T}_{2g} \rightarrow ^4\text{T}_{1g}$  &  $^2\text{T}_{2g} \rightarrow ^2\text{A}_{2g}$  transitions respectively. This indicates that the complexes of Ru (III) have an octahedral geometry with slight distortion<sup>16-17</sup>. The electronic spectra of Rh (III) complexes display bands at 17450 - 17800  $\text{cm}^{-1}$ , 20000 - 22800  $\text{cm}^{-1}$  and 23850 - 24600  $\text{cm}^{-1}$  which may be assigned to  $^1\text{A}_{1g} \rightarrow ^3\text{T}_{1g}$ ,  $^1\text{A}_{1g} \rightarrow ^1\text{T}_{1g}$  and  $^1\text{A}_{1g} \rightarrow ^1\text{T}_{2g}$  transitions respectively. The electronic spectra of  $d^6$  complexes can be used to evaluate ligand field parameters<sup>18-19</sup>.

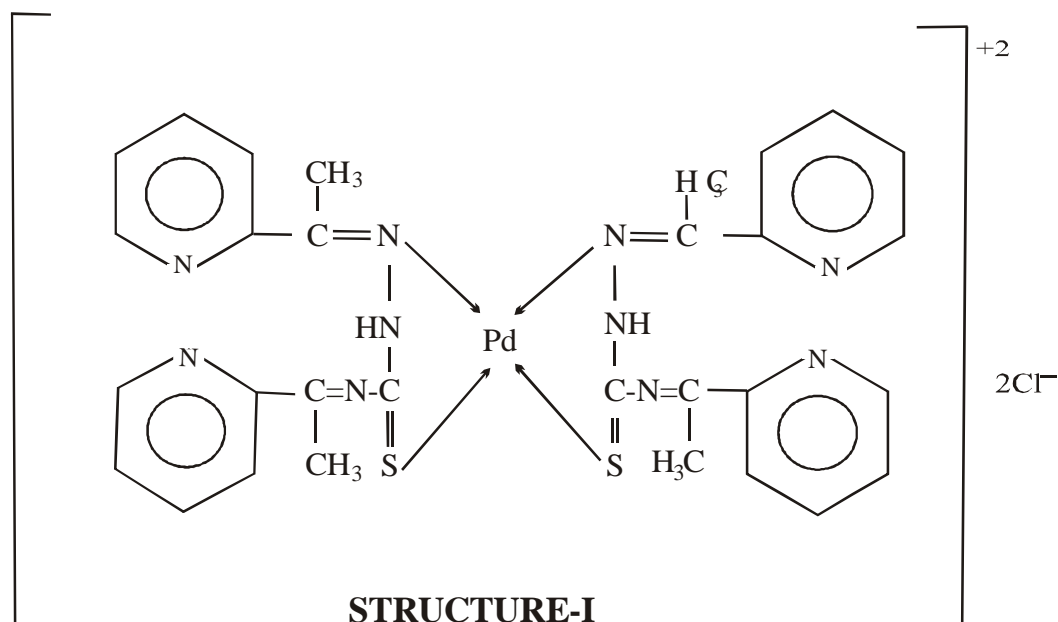
##### ***Infrared Spectra of Complexes :***

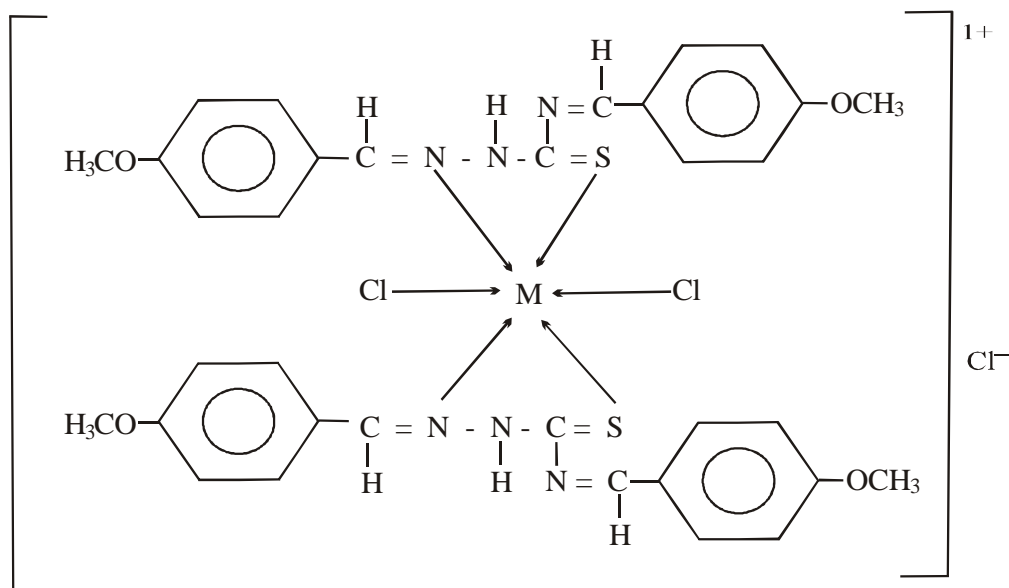
A comparative study of the IR spectra of the ligands and complexes shows that both the thiosemicarbazones behave as bidentate chelating agents coordinating to the metal ions through sulphur of the C=S group and nitrogen of the C=N group. The ligands show bands at 1620  $\text{cm}^{-1}$  and 840  $\text{cm}^{-1}$  due to C=N and C=S modes<sup>20-22</sup>. These shifts towards lower side (30-70  $\text{cm}^{-1}$ ) in the spectra of complexes, indicate that coordination takes place through nitrogen of C=N group and sulphur of C=S group. These coordination sites are further supported by the appearance of two new bands in the IR spectra of the complexes in the range of 420-460  $\text{cm}^{-1}$  and 370 - 400  $\text{cm}^{-1}$  assignable to  $\nu\text{M-N}$  and  $\nu\text{M-S}$  vibrations<sup>23</sup>. The other important band in the

IR spectra of the complex appears at 310-335  $\text{cm}^{-1}$  which has been assigned to (M-Cl) bond<sup>24</sup> (M=Ru, Rh). On the basis of above studies, structures I and II are assigned to the complexes.

**Table-1: Colour, Composition and Magnetic Moment Data of the Complexes**

Complex	Colour	M.P. ( $^{\circ}\text{C}$ )	Found (Calc.) %					$\mu_{\text{eff}}$ (B.M.)
			M	C	H	N	S	
[Pd (AATC) <sub>2</sub> ] Cl <sub>2</sub>	Orange Yellow	240	20.60 (21.93)	30.86 (29.50)	4.34 (3.68)	18.29 (17.21)	14.44 (13.11)	Dia magnetic
[Pd (ATC) <sub>2</sub> ] Cl <sub>2</sub>	Yellow	265	13.29 (12.86)	49.94 (49.04)	4.87 (4.08)	11.57 (10.09)	8.38 (7.69)	Dia magnetic
[Pd (DMBTC) <sub>2</sub> ] Cl <sub>2</sub>	Pale Yellow	270	12.02 (11.24)	48.18 (47.90)	4.93 (4.41)	9.27 (8.82)	7.32 (6.72)	Dia magnetic
[Pd (TATC) <sub>2</sub> ] Cl <sub>2</sub>	Orange	263	15.45 (14.54)	36.59 (35.87)	3.22 (2.44)	12.63 (11.41)	17.12 (26.08)	Dia magnetic
[Pd (APTC) <sub>2</sub> ] Cl <sub>2</sub>	Orange Red	280	14.56 (13.86)	47.39 (46.63)	4.47 (3.88)	19.05 (18.13)	9.19 (8.30)	Dia magnetic
[Ru (AATC) <sub>2</sub> Cl <sub>2</sub> ] Cl	Dark Violet	238	20.84 (19.67)	29.88 (27.77)	4.79 (3.47)	13.91 (12.34)	17.26 (16.20)	1.53
[Ru (ATC) <sub>2</sub> Cl <sub>2</sub> ] Cl	Brownish Yellow	212	12.94 (11.83)	48.29 (47.30)	4.58 (3.94)	10.63 (9.74)	8.19 (7.42)	1.57
[Ru (DMBTC) <sub>2</sub> Cl <sub>2</sub> ] Cl	Brown	255	11.87 (10.38)	47.24 (46.41)	5.73 (4.27)	9.68 (8.55)	9.79 (6.51)	1.29
[Ru (TATC) <sub>2</sub> Cl <sub>2</sub> ] Cl	Blackish Violet	273	14.83 (13.31)	35.79 (34.44)	3.29 (2.35)	11.44 (10.96)	26.54 (25.05)	1.54
[Ru (APTC) <sub>2</sub> Cl <sub>2</sub> ] Cl	Black	285	13.93 (12.71)	45.33 (44.86)	4.11 (3.74)	18.36 (17.44)	8.79 (7.97)	1.38
[Rh (AATC) <sub>2</sub> Cl <sub>2</sub> ] Cl	Pale Yellow	268	20.89 (19.83)	28.28 (27.72)	4.39 (3.46)	17.55 (16.16)	13.88 (12.32)	Dia magnetic
[Rh (ATC) <sub>2</sub> Cl <sub>2</sub> ] Cl	Yellow	245	12.24 (11.93)	48.47 (47.25)	4.12 (3.94)	10.09 (9.73)	8.67 (7.41)	Dia magnetic
[Rh (DMBTC) <sub>2</sub> Cl <sub>2</sub> ] Cl	Reddish Yellow	253	11.69 (10.47)	47.57 (46.36)	5.94 (4.27)	9.77 (8.54)	7.71 (6.51)	Dia magnetic
[Rh (TATC) <sub>2</sub> Cl <sub>2</sub> ] Cl	Buff Yellow	239	14.39 (13.42)	35.72 (34.40)	3.08 (2.34)	11.78 (10.94)	26.34 (25.01)	Dia magnetic
[Rh (APTC) <sub>2</sub> Cl <sub>2</sub> ] Cl	Orange Red	277	13.93 (12.81)	45.95 (44.80)	4.11 (3.73)	18.49 (17.42)	8.84 (7.97)	Dia magnetic



**STRUCTURE-II (Where M=Ru, Rh)****CONCLUSION**

On the basis of studies performed the Pd (II) complexes have been assigned square planar geometry whereas those of Ru (III) & Rh (III) appeared to be octahedral.

**Antimicrobial Screening :**

The antifungal activity was evaluated by the radial growth method using Czapek's agar medium having the composition, glucose 20g, starch 20g, agar-agar 20g and distilled water 10000 ml. To this medium was added requisite amount of the compound after being dissolved in DMF so as to obtain certain final concentrations (25, 50, 100 & 200 ppm). The fungicidal activity of the ligands and their metal complexes against pathogenic fungi is recorded in Table-2.

**Table-2 Fungicidal screening data for the ligands and their metal complexes**

Compound	Inhibition after 96 h(%) (conc. in ppm)					
	<i>Alternaria alternata</i>			<i>Rhizoctonia bataticola</i>		
	50	100	200	50	100	200
AATC	40	52	59	40	52	57
ATC	33	40	49	34	38	49
DMBTC	42	53	61	42	54	60
TATC	46	59	65	46	58	64
APTC	36	43	52	37	41	52
[Pd (AATC) <sub>2</sub> ] Cl <sub>2</sub>	45	55	64	45	56	61
[Pd (ATC) <sub>2</sub> ] Cl <sub>2</sub>	38	44	53	36	41	52
[Pd (DMBTC) <sub>2</sub> ] Cl <sub>2</sub>	46	55	64	45	57	62
[Pd (TATC) <sub>2</sub> ] Cl <sub>2</sub>	48	61	68	48	62	65
[Pd (APTC) <sub>2</sub> ] Cl <sub>2</sub>	39	45	54	39	44	56
[Ru (AATC) <sub>2</sub> Cl <sub>2</sub> ]Cl	43	54	62	44	55	59
[Ru (ATC) <sub>2</sub> Cl <sub>2</sub> ]Cl	35	42	51	37	40	53
[Ru (DMBTC) <sub>2</sub> Cl <sub>2</sub> ]Cl	45	56	63	44	56	64
[Ru (TATC) <sub>2</sub> Cl <sub>2</sub> ]Cl	49	62	67	48	61	66
[Ru (APTC) <sub>2</sub> Cl <sub>2</sub> ]Cl	40	46	55	41	43	53
[Rh (AATC) <sub>2</sub> Cl <sub>2</sub> ]Cl	44	56	63	43	54	60
[Rh (ATC) <sub>2</sub> Cl <sub>2</sub> ]Cl	36	43	52	35	42	51
[Rh (DMBTC) <sub>2</sub> Cl <sub>2</sub> ]Cl	44	56	65	44	55	63
[Rh (TATC) <sub>2</sub> Cl <sub>2</sub> ]Cl	47	63	68	46	60	68
[Rh (APTC) <sub>2</sub> Cl <sub>2</sub> ]Cl	38	47	56	40	45	54
Bavistin	33	94	100	85	96	100

The activity against bacteria was evaluated by the inhibition zone technique (paper-disc plate method), 15 ml nutrient agar medium having the composition peptone 5g, beef extract 5 g, agar-agar 20 g and distilled water 1000 ml., was pipetted into the petri dish. The organisms used in the present investigations included *Staphylococcus*

aureus and *Zanthomonas compestris*. The compound were dissolved in DMF in 500 and 1000 ppm concentrations. The bactericidal activity of the ligands and their metal complexes against pathogenic bacteria is recorded in Table-3.

The free ligands and their respective metal chelates were screened against selected fungi and bacteria to assess their potential as antimicrobial agents. The results are quite promising. The antimicrobial data reveal that the complexes are superior to the free ligands. The enhanced activity of the metal chelates may be ascribed to the increased lipophilic nature of these complexes arising due to the chelation<sup>25-26</sup>. The toxicity increased as the concentration was increased.

**Table-3 Antibacterial screening data for the ligands and their metal complexes**

Compound	Diameter of Inhibition Zone (mm)			
	(conc. in ppm)			
	<i>Staphylococcus aureus</i>		<i>Xanthomonas compestris</i>	
	500	1000	500	1000
AATC	8	11	7	9
ATC	6	9	8	10
DMBTC	9	12	11	13
TATC	7	10	9	11
APTC	9	12	10	13
[Pd (AATC) <sub>2</sub> ] Cl <sub>2</sub>	10	13	9	11
[Pd (ATC) <sub>2</sub> ] Cl <sub>2</sub>	7	10	9	12
[Pd (DMBTC) <sub>2</sub> ] Cl <sub>2</sub>	10	13	12	14
[Pd (TATC) <sub>2</sub> ] Cl <sub>2</sub>	8	11	10	12
[Pd (APTC) <sub>2</sub> ] Cl <sub>2</sub>	10	13	11	14
[Ru (AATC) <sub>2</sub> Cl <sub>2</sub> ] Cl	11	12	8	10
[Ru (ATC) <sub>2</sub> Cl <sub>2</sub> ] Cl	8	11	11	13
[Ru (DMBTC) <sub>2</sub> Cl <sub>2</sub> ] Cl	11	14	13	12
[Ru (TATC) <sub>2</sub> Cl <sub>2</sub> ] Cl	9	12	11	13
[Ru (APTC) <sub>2</sub> Cl <sub>2</sub> ] Cl	11	14	12	15
[Rh (AATC) <sub>2</sub> Cl <sub>2</sub> ] Cl	10	13	9	10
[Rh (ATC) <sub>2</sub> Cl <sub>2</sub> ] Cl	9	12	10	11
[Rh (DMBTC) <sub>2</sub> Cl <sub>2</sub> ] Cl	12	13	14	11
[Rh (TATC) <sub>2</sub> Cl <sub>2</sub> ] Cl	11	14	12	14
[Rh (APTC) <sub>2</sub> Cl <sub>2</sub> ] Cl	12	13	14	13
Streptomycin	15	19	16	19

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