

Synthesis, Characterization and Biological Studies of 2-[1-(2-Hydroxy-Phenyl)-Ethylidene Amino]-4-Methyl-Phenol with Ti(IV) and Zr(IV) Complexes

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Abstract: A newly synthesized Schiff base from 2-amino, 4-methyl phenol with O-hydroxy acetophenone (AMPOHA) and their Ti(IV) and Zr(IV) metal complexes. The metal chelates were characterized on the basis of infrared spectra, elemental analysis, electronic spectral data, molar conductance, ¹H NMR and X-ray diffraction studies. Molar conductivity measurements indicate that the complexes are non-electrolytic in nature. The analytical data indicates that the metal to ligand ratio in the complexes were 1:1. IR spectral data suggests that the ligand behaves as tridentate ONO donar system. X-ray diffraction studies indicate monoclinic crystal system for these complexes. The Schiff base and their metal complexes have been evaluated for their antimicrobial activity using disc diffusion methods.

Keywords: Schiff base, Metal complexes, Spectral studies and Anti-microbial activity.

INTRODUCTION

Metal complexes of Schiff bases have played a central role in the development of coordination chemistry. Schiff base and the relevant transition metal complexes are still found to be of great in inorganic chemistry although this subject has been studied extensively¹⁻³. The complexes containing O, N donar atoms are very important owing to their significant antibacterial and anticancer activity^{4,5}. Schiff bases are most widely used as chelating ligands in coordination chemistry and investigated extensively for the last several decades leading to new synthetic routes of structural, biological and industrial applications⁶⁻⁸.

Literature survey indicates that Schiff base ligand is not used as complexing agent to prepare

Ti(IV) and Zr(IV) complexes with 2-[1-(2-Hydroxy-phenyl)-ethylidene amino]-4-methyl-phenol.

EXPERIMENTAL

Materials and Methods

All the chemicals and solvents used were A.R. grade. The metals were used as their chloride salts. Elemental analysis was done on instrument Eager-300 analyzer. Infrared and UV spectra were recorded on Perkin Elmer Spectrum 100 and UV-Vis spectrophotometer 119 in the 200-1000 nm range in DMF solution (10⁻³).

Conductance of the metal chelates was determined in DMF on conductivity meter Equiptronics model No-EQ665. Melting points were

recorded by open capillary method and are uncorrected. $^1\text{H-NMR}$ spectra of Schiff base and its metal complexes recorded on Bruker 300 MHz spectrometer in DMSO-d_6 .

Powder XRD diffractograms of the complexes were obtained from CFC Shivaji University, Kolhapur on Philips Analytical XRD B.V. Spectrophotometer in the 2θ range from 10° to 90° and results are then indexed to assign the crystal system. In our present studies we have conducted some antimicrobial activity to see whether chelating agent (Schiff base) and metal complexes have any action on microbial activities. Bacteria species like *Escherichia coli*, *Bacillus subtilis*, *Aspergillus flavus* and *Aspergillus niger* were used.

Synthesis of Schiff base (AMPOHA)

Schiff base (AMPOHA) was synthesized by condensing of 2-amino, 4-methyl phenol and O-hydroxy acetophenone with 0.01M were mixed in 1:1 ratio. The reaction mixture was refluxed on water bath for 2-3 hours in presence of glacial acetic acid. The resulting reaction mixture was poured in crushed ice, dark green precipitate formed. Then it is filtered by suction and purified by distilled water and ethanol. Further it is dried in vacuum dessicator and recrystallized from ethanol, purity of the Schiff base was checked by TLC. The structure of Schiff base was confirmed by subjecting them to Infrared spectra, Elemental and NMR spectral analysis.

Synthesis of Metal Complexes

To warm ethanolic solution of AMPOHA (0.01M) and ethanolic solution of the corresponding metal chloride (0.01M) in the ratio were added drop wise with constant stirring. The pH of the solution was adjusted at 7.3 by adding alcoholic ammonia. Resulting reaction mixture refluxed for about 5 to 6 hours on water bath.

The black precipitate of complex was allowed to settle and collected by filtration. Then washed with distilled water and warm ethyl alcohol to apparent dryness. The complexes were dried in vacuum dessicator and yield was recorded.

RESULTS AND DISCUSSION

All the metal complexes were intense colour, they were sparingly soluble in DMF, DMSO. All the results of elemental analysis are given in the Table No.1. For the estimation of chloride by Volhard's

method is used⁹, metal ion percentage is determined by standard method¹⁰.

Presence of lattice water molecule present in the metal complex was recorded by keeping the known weight of the complex in previously weighed crucible in oven at 110°C for one hour. The difference in weight gives the amount of lattice water in the complex.

All compounds give satisfactory elemental analysis. Values are in close agreement with the values calculated for expected molecular formulae assigned to these complexes, suggesting 1:1 for Ti(IV) and Zr(IV) complexes. The molar conductance of Ti(IV) and Zr(IV) complexes in DMF reveals their non-electrolytic nature¹¹.

Electronic Spectra

Ligand AMPOHA exhibits strong absorption band at 30303cm^{-1} due to $n \rightarrow \pi^*$ transition. Electronic spectra of Ti(IV) and Zr(IV) complexes display absorption bands at 26178cm^{-1} and 26455cm^{-1} assigned to charge transfer band¹².

Infrared Spectra

The IR spectra of the chelating agent 2-[1-(2-Hydroxy-phenyl)-ethylidene amino]-4-methyl-phenol (AMPOHA) exhibited a bands at 3375cm^{-1} and 1373cm^{-1} due to the deformation stretching vibration of the phenolic OH group, which were absent in the spectra of the complexes^{13, 14}. A band at 1229cm^{-1} in ligand due to phenolic ν (C-O) was shifted to higher frequency in the complexes¹⁵. This suggests deprotonation of the phenolic OH group after and its chelation with metal ions. The ν (C=N) azomethine band is shifted towards higher frequency in the complexes, indicating coordination through azomethine nitrogen.

The appearance of a broadband at 3390cm^{-1} in Ti(IV) complex and 3395cm^{-1} in Zr(IV) complex suggesting the presence of coordinated water molecules^{16, 17}. Also, shows a medium intensity band at 802cm^{-1} and 820cm^{-1} in both complexes were assignable rocking mode of coordinated water molecule.

The appearance of new bands in the spectra of Ti(IV) and Zr(IV) metal ion complexes at $501\text{-}532\text{cm}^{-1}$ and $650\text{-}665\text{cm}^{-1}$ due to new bonding i.e, $\nu(\text{M-N})$ ^{18, 19} and $\nu(\text{M-O})$ ^{20, 21}.

Table No.1: Analytical data and physical properties of (AMPOHA) and their metal complexes.

Ligand / Metal Complexes Empirical Formula	Mol. Wt. Colour/ (D.P ^o C)	M:L Ratio/ Yield (%)	Molar Cond. (Ohm ⁻¹ cm ² mol ⁻¹)	Elemental analysis % Cal (Obs)				
				C	H	N	M	Cl
AMPOHA C ₁₅ H ₁₅ NO ₂	241.30 Dark green (161)	- 60	-	74.59 (74.65)	6.21 (6.35)	5.80 (5.89)	-	-
[Ti(AMPOHA) H ₂ O.Cl ₂]H ₂ O C ₁₅ H ₁₇ NO ₄ Cl ₂ Ti	393.90 Black (>300)	1:1 55	13.52	45.69 (45.56)	4.31 (4.37)	3.55 (3.26)	12.16 (12.05)	18.02 (18.08)
[Zr(AMPOHA) H ₂ O.Cl ₂]C ₁₅ H ₁₅ NO ₃ Cl ₂ Zr	419.22 Black (>300)	1:1 54	20.12	42.93 (42.99)	3.57 (3.24)	3.33 (3.18)	21.75 (21.67)	16.93 (16.69)

Table No.2: Infrared spectral data of ligand (AMPOHA) and their metal complexes.

Compound	$\nu(\text{H}_2\text{O})$	$\nu(\text{OH})$ Phenolic	$\nu(\text{OH})$ Aceto phenone moiety	$\nu(\text{C-O})$	$\nu(\text{C=N})$	$\nu(\text{M-N})$	$\nu(\text{M-O})$
AMPOHA	-	3375	1373	1229	1605	-	-
[Ti(AMPOHA)H ₂ O.Cl ₂] H ₂ O	3390	-	-	1238	1615	501	650
[Zr(AMPOHA)H ₂ O.Cl ₂]]	3395	-	-	1245	1613	532	665

¹H NMR Spectra

The ¹H-NMR spectrum of the ligand AMPOHA shows peaks at δ 2.25ppm corresponding to methyl protons of O-Hydroxy acetophenone and at δ 2.35ppm for methyl protons of (s, 3H) for Ar-CH₃. At δ 5.00ppm (s, 1H) due to Ar-OH of O-Hydroxy acetophenone group, δ 6.16-6.85ppm (m, 7H, Ar-H) and δ 13.30ppm (s, 1H, Ar-OH).

On complexation signals at δ 5.00ppm and δ 13.30ppm due to both phenolic OH attributed to involvement of bonding may be reason for

disappearance of both OH groups in Ti(IV) and Zr(IV) complexes^{22, 23}. Involvement of tertiary nitrogen in bonding, the methyl protons attached it shows peak to the deshielded region. Besides this a new peak corresponding to coordinated water molecules in Titanium (IV) and Zirconium (IV) complexes are observed at δ 2.0ppm²⁴.

Thus, AMPOHA molecule seems to be coordinated to the metal ion through both phenoxide oxygen and azomethine nitrogen.

X-ray analysis

X-ray diffraction study of Ti(IV) and Zr(IV) metal complexes were scanned in the range $2\theta=10$ to 90° . With the help of X-ray diffraction technique it is possible as certain the spatial arrangement of the structural units substance in crystalline state and employed in investigating the interior of crystal.

The major reflexes were measured and corresponding 'd' values were obtained, independent indexing, calculation of miller indices and evaluation of lattice parameters a, b, c and angle α , β , γ were done

by powder X programme. Data has been summarized in the following tables.

[Ti(AMPOHA)(H₂O)Cl₂] H₂O

Crystal system: Monoclinic Lattice Type: P

Radiation: Cu Wavelength: 1.540598 \AA

Lattice Parameter: $a=4.9168$ $b=4.9168$

$c=5.4089 \text{ \AA}$

Lattice Parameter: $\alpha=90$ $\beta=90$ $\gamma=120^\circ$

2θ Start= 10 2θ End= 89.98

Table No. 3: Powder XRD data of [Ti(AMPOHA)(H₂O)Cl₂] H₂O Complex

h	k	l	2 θ (Exp.)	2 θ (Calc.)	d (Exp.)	d (Calc.)	Intensity (Exp.)
-2	1	0	36.474	36.520	2.46140	2.45840	89.68
0	2	0	42.467	42.422	2.12692	2.12904	93.15
-2	0	1	45.754	45.763	1.98146	1.98109	95.35
0	0	3	50.495	50.585	1.80597	1.80297	91.01
0	2	2	54.813	54.835	1.67348	1.67286	91.83
-2	3	0	57.238	57.191	1.60819	1.60940	89.04
1	2	1	59.829	59.916	1.54460	1.54256	92.37
-2	1	3	64.024	63.987	1.45313	1.45388	90.29
0	0	4	69.546	69.452	1.35063	1.35222	90.84
-1	0	4	73.346	73.409	1.28975	1.28880	90.48

The cell data and crystal parameters of Ti(IV) complex is given in the table indicates that the complex have monoclinic crystal system²⁵.

[Zr(AMPOHA)(H₂O)Cl₂]

Crystal system: Monoclinic Lattice Type: P

Radiation: Cu Wavelength: 1.540598 \AA

Lattice Parameter: $a=4.9168$ $b=4.9168$ $c=5.4089 \text{ \AA}$

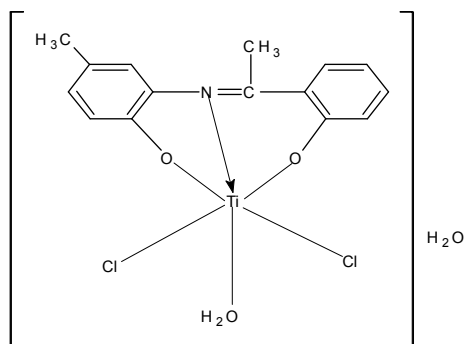
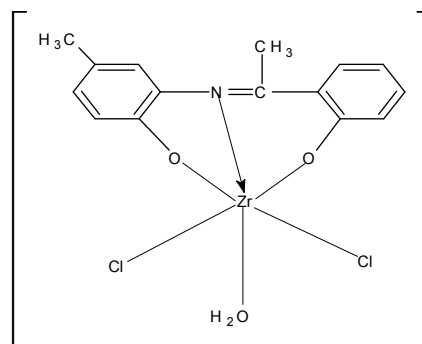
Lattice Parameter: $\alpha=90$ $\beta=90$ $\gamma=120^\circ$

2θ Start= 10 2θ End= 89.98

Table No. 4: Powder XRD data of [Zr(AMPOHA)(H₂O)Cl₂] Complex

h	k	l	2 θ (Exp.)	2 θ (Calc.)	d (Exp.)	d (Calc.)	Intensity (Exp.)
0	0	1	16.253	16.375	5.44932	5.40890	51.91
0	0	1	16.486	16.375	5.37283	5.40890	51.32
-1	1	0	20.651	20.845	4.29760	4.25807	37.31
-1	1	0	20.955	20.845	4.23600	4.25807	36.74
-1	1	1	26.605	26.622	3.34784	3.34573	46.19
-1	1	2	39.585	39.440	2.27487	2.28291	41.84
-1	2	1	40.096	40.263	2.24705	2.23807	41.60
0	2	0	42.305	42.422	2.13468	2.12904	41.83
-2	0	1	45.642	45.763	1.98607	1.98109	41.31
1	1	2	49.990	50.104	1.82301	1.81913	37.22
1	1	2	50.222	50.104	1.81515	1.81913	36.49
0	0	3	50.444	50.585	1.80767	1.80297	37.10
0	0	3	50.714	50.585	1.79869	1.80297	35.39
0	1	3	55.106	55.286	1.66527	1.66027	33.62

Cell data and crystal lattice parameters of Zr(IV) complex attributed to monoclinic crystal system²⁶.

Proposed structures for the metal complexes:**Figure 1****Figure 2**

On the basis of the above observation it is, therefore proposed that [Ti(IV) AMPOHA] and [Zr(IV) AMPOHA] complexes shows octahedral geometry in which ligand (AMPOHA) behaving as bidentate tridentate in nature.

ANTIMICROBIAL ACTIVITY

The ligand (AMPOHA) and their [Ti(IV) AMPOHA] and [Zr(IV) AMPOHA] complexes antimicrobial tests were performed by the standard disc diffusion method²⁷. The antibacterial and antifungal activity in vitro against *Escherichia coli*, *Bacillus subtilis*, *Aspergillus flavus* and *Aspergillus niger*.

2-[1-(2-Hydroxy-phenyl)-ethylidene amino]-4-methyl-phenol (AMPOHA) produces zone of inhibition i.e, 15

mm and 11 mm against growth of *Escherichia coli* and *Bacillus subtilis*. Metal complexes of [Ti(IV) AMPOHA] and [Zr(IV) AMPOHA] have negative zone of inhibition towards both bacterial species.

2-[1-(2-Hydroxy-phenyl)-ethylidene amino]-4-methyl-phenol (AMPOHA) and their metal complexes [Ti(IV) AMPOHA] and [Zr(IV) AMPOHA] shows negative zone of inhibition or they do not produce zone of inhibition towards *Aspergillus flavus* and *Aspergillus niger*.

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Table No.5: Result of antibacterial study of Ti(IV) and Zr(IV) complexes

Sr. No.	Compounds	<i>Escherichia coli</i>	<i>Bacillus subtilis</i>
1	AMPOHA	15 mm	11 mm
2	[Ti(IV)AMPOHA]	-ve	-ve
3	[Zr(IV)AMPOHA]	-ve	-ve
4	Streptomycin	24 mm	30 mm
5	Control (DMSO)	10 mm	14 mm

-ve –No antibacterial activity, zone of inhibition -----mm.

Table No.6: Result of antifungal study of Ti(IV) and Zr(IV) complexes

Sr. No.	Compounds	<i>Aspergillus flavus</i>	<i>Aspergillus niger</i>
1	AMPOHA	-ve	-ve
2	[Ti(IV) AMPOHA]	-ve	-ve
3	[Zr(IV) AMPOHA]	-ve	-ve
4	Fluconazole	15 mm	10 mm
5	Control (DMSO)	-ve	-ve

-ve –No antifungal activity, zone of inhibition -----mm.

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