



RESEARCH ARTICLE

MEDICINAL CHEMISTRY

SYNTHESIS, STRUCTURAL CHARACTERIZATION AND ANTIMICROBIAL ACTIVITIES OF SOME TRANSITION METAL COMPLEXES CONTAINING 2-ACETONAPHTHONE

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ABSTRACT

New some Schiff bases and their Co(II), Ni(II) and Cu(II) complexes formed by the condensation of 2-acetonaphthone with 2-Amino-4-chlorophenol (AACP), 2-amino-4-methylbenzothiazole (AABT) and 2-aminothiazole (ACAT). These compounds have been characterized by elemental analysis, FT-IR, FAB-mass, molar conductance, electronic spectra, ESR and magnetic susceptibility. FAB-mass data show degradation pattern of the complexes. All the complexes are colored and stable towards air and moisture. The complexes exhibit coordination number to be 4 and 6. The Schiff base and metal complexes show a good activity against the bacteria; *Staphylococcus aureus*, *Escherichia coli* and *B. subtilis* and fungi *Aspergillus niger* and *Candida albicans*. The antimicrobial results also indicate that the metal complexes are better antimicrobial agents as compared to the Schiff bases.

KEYWORDS

Synthesis, FAB-mass, IR, UV-Vis, ESR, Biological activities

INTRODUCTION

Preparation of the new ligands is perhaps the most important step in the development of metal complexes, which exhibit unique desired properties and novel reactivity. The chemistry of metal complexes with tailor made Schiff base ligands and their application, have aroused considerable interest mainly because of preparative accessibility, diverse reactivity and structural variability. Metal complexes of Schiff bases have played a central role in the development of coordination chemistry and have many applications in various fields. Such ligands and their metal complexes have a variety of applications in biology and industry due to their role in catalysis and organic synthesis. The chemistry of metal complexes with tailor made Schiff base ligands and their

application, have aroused considerable interest mainly because of preparative accessibility, diverse reactivity and structural variability. Metal complexes of Schiff bases have played a central role in the development of coordination chemistry and have many applications in various fields. Such ligands and their metal complexes have a variety of applications in biology and industry due to their role in catalysis and organic synthesis¹⁻⁴. In present paper, the synthesis and characterization of the complexes of Co(II), Ni(II) and Cu(II) involving the Schiff base ligands (Fig. 1) derived from 2-acetonaphthone with 2-Amino-4-chlorophenol (AACP), 2-amino-4-methylbenzothiazole (AABT) and 2-aminothiazole (AACT) have been reported.

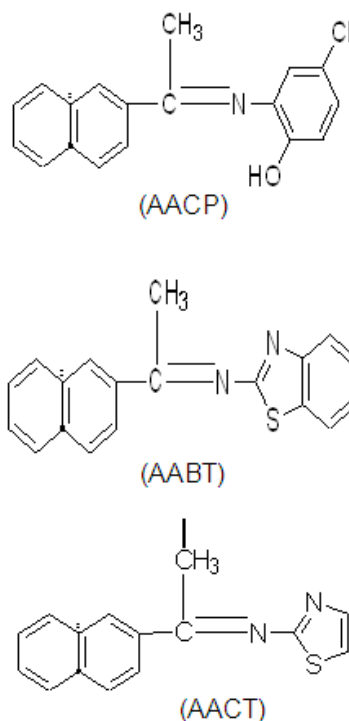


Fig. 1
Structure of ligands



EXPERIMENTAL

All the used chemicals and solvents were of Anal R grade. All the reagents used for the preparation of the Schiff bases were obtained from Sigma Aldrich. Elemental analyses were performed on an Elementar Vario EL III Carlo Erba 1108 analyzer. FAB-mass spectra were recorded on a JEOL SX 102/DA 6000 Mass Spectrometer using argon/xenon (6 kV, 10 mA) as the FAB gas. The accelerating voltage was 10 kV and the spectra were recorded at room temperature. Electronic spectra (in methanol) were recorded on Perkin Elmer Lambda-2B-spectrophotometer. Molar conductance measurements were conducted using 10^{-3} M solutions of the complexes in methanol on Elico-CM 82 Conductivity Bridge at room temperature. Magnetic susceptibility measurements were carried out on a Gouy balance at room temperature using CuSO_4 as the calibrant. FT-IR spectra were recorded in KBr medium on a Perkin Elmer RX1 spectrophotometer in wave number region $4000\text{-}400\text{ cm}^{-1}$. X-band EPR spectra were recorded on a Varian E-112 spectrometer at room temperature operating at the X-band region with 100 kHz modulation frequency, 5 mw microwave power and 1 G modulation amplitude using TCNE as the internal standard.

Biological activity

The *in vitro* biological activity of the investigated Schiff base and its metal complexes was tested against the bacteria *Escherichia coli*, *B. subtilis* and *Staphylococcus aureus* by disc diffusion method using nutrient agar as medium and streptomycin as control. The antifungal activities of the compounds were also tested by the Well diffusion method against the fungi *Aspergillus niger* and *Candida albicans*, on potato dextrose agar as the medium and miconazole as control. The stock solution was prepared by dissolving the compounds in DMSO. In a typical procedure, a well was made on agar medium inoculated with microorganism. The well was filled with the test

solution using a micropipette and the plate was incubated 24 h for bacteria at 37 °C and 72 h for fungi at 30 °C. During this period, the test solution diffused and the growth of the inoculated microorganism was affected. The inhibition zone was developed, at which the concentration was noted.

Synthesis of Schiff bases

AACP, AABT and ACAT Schiff bases were synthesized by the condensation of equimolar ratio of 2-acetonaphthone with 2-Amino-4-chlorophenol (AACP), 2-amino-4-methylbenzothiazole (AABT) and 2-aminothiazole (ACAT) dissolved in methanol. The resulting reaction mixture was stirred well, refluxed for 3-6 h and then allowed to cool overnight. The coloured solid precipitate of Schiff base obtained was filtered, washed with cold ethanol and dried in air at room temperature and finally stored under reduced pressure in a CaCl_2 desiccator. The purity of synthesized compounds was checked by TLC using silica gel G (yield: AACP = 86.7%; AABT = 85.7% and ACAT = 81.5%).

Synthesis of metal complexes

The metal complexes were prepared by the mixing of (50 ml) methanolic solution of $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ / $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ / $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ with the (50 ml) methanolic solution of Schiff bases (AACP/AABT/ACAT) in 1:2 (metal:ligand) ratio. The resulting mixture was refluxed on water bath for 5-10 h. A coloured product appeared on standing and cooling the above solution. The precipitated complex was, filtered washed with ether and recrystallized with ethanol several times and dried under the reduced pressure over anhydrous CaCl_2 in a desiccator. It was further dried in electric oven at 50-70 °C (yield: 68.8-78.3%).

RESULTS AND DISCUSSION

All the metal complexes are coloured, solid and stable towards air and moisture at room temperature. They decompose on heating at high temperature, more or less soluble in



common organic solvents. Analytical data of the compounds, together with their physical properties are consistent with proposed molecular formula are given in Table 1. All the metal chelates have 1:2 (metal:ligand)

stoichiometry. The observed molar conductance value of the complexes in methanol at room temperature is consistent with the electrolytic nature of the complexes.

Table 1
Analytical and physical data of ligand and their metal complexes

Compounds (Molecular Formula)	Colour (Mol. Wt)	Yield (%)	Elemental Analysis; Found (Calcd.)%				Λ_M
			C	H	N	M	
AACP (C ₁₈ H ₁₄ NOCl)	Dark brown (295.8)	86.7	73.0 (73.2)	4.6 (4.77)	4.6 (4.7)	-	-
[Co(C ₁₈ H ₁₃ NOCl) ₂].3H ₂ O	Blakish green (702.5)	69.5	61.4 (61.5)	4.1 (4.3)	3.6 (3.9)	8.3 (8.4)	12.2
[Ni(C ₁₈ H ₁₃ NOCl) ₂].H ₂ O	Yellowish green (666.2)	68.8	64.6 (64.9)	4.10 (4.23)	4.2 (4.2)	8.5 (8.8)	10.3
[Cu(C ₁₈ H ₁₃ NOCl) ₂].H ₂ O	Black (672.1)	76.3	64.3 (64.3)	4.0 (4.1)	4.1 (4.2)	9.3 (9.4)	15.5
AABT (C ₂₀ H ₁₆ N ₂ S)	Light Yellow (316.4)	85.7	45.4 (45.5)	5.2 (5.1)	8.5 (8.8)	-	-
[Co(C ₂₀ H ₁₆ N ₂ S) ₂ Cl ₂].2H ₂ O	Dark Brown (798.7)	72.6	36.2 (36.3)	4.5 (4.5)	6.8 (7.0)	7.3 (7.4)	41.5
[Ni(C ₂₀ H ₁₆ N ₂ S) ₂ Cl ₂].2H ₂ O	Brownish Yellow (798.5)	78.2	35.6 (36.0)	4.3 (4.5)	7.1 (7.0)	7.3 (7.4)	49.6
[Cu(C ₂₀ H ₁₆ N ₂ S) ₂ Cl ₂].2H ₂ O	Yellowish Green (803.3)	75.3	35.7 (35.8)	4.5 (4.6)	7.0 (6.9)	7.7 (7.9)	36.2
ACAT (C ₁₅ H ₁₂ N ₂ S)	Orange brown (252.21)	81.5	70.8 (71.4)	4.3 (4.8)	10.5 (11.1)	-	-
[Co(C ₁₅ H ₁₂ N ₂ S) ₂ (H ₂ O) ₂].Cl ₂	Greenish black (670.34)	73.6	56.3 (56.7)	4.8 (5.1)	8.6 (8.9)	9.0 (9.2)	92.4
[Ni(C ₁₅ H ₁₂ N ₂ S) ₂ (H ₂ O) ₂].Cl ₂	Marry gold (670.11)	76.2	56.4 (56.7)	5.1 (5.1)	8.5 (8.8)	9.1 (9.2)	100.5
[Ni(C ₁₅ H ₁₂ N ₂ S) ₂ Cl ₂].2H ₂ O	Leaf brown (674.97)	78.3	53.2 (53.4)	3.6 (4.2)	8.1 (8.3)	9.2 (9.4)	41.8

$\Lambda_M = (\text{ohm}^{-1}\text{cm}^2 \text{mol}^{-1})$

FAB-mass spectra :

The FAB-mass spectra suggested that all the complexes have a monomeric nature. These complexes show molecular ion peaks in good agreement with the empirical formula suggested by elemental analyses.

The FAB mass spectrum of [Cu(AACP)₂].H₂O complex has been studied as one of the representative case. The peaks of appreciable intensity have been observed at m/z values 663, 647, 397 and 123 suggesting the

fragmentation pattern. The m/z value 663 corresponds to nearest composition [Cu(AACP)₂].H₂O, 647 to [Cu(AACP)₂], 397 to [Cu(AACP)^{1/n}]₂ and 123 to Cu (II) with chelated O and N ligand moiety.

The FAB-mass spectrum of [Co(AABT)₂Cl₂].2H₂O complex has been studied as one of the representative case. The peaks of appreciable intensity have been observed at m/z value - 800, 753, 690, 441 and 151() suggesting the fragmentation pattern.



The m/z value 800 corresponds to nearest composition $[\text{Co}(\text{AABT})_2\text{Cl}_2] \cdot 2\text{H}_2\text{O}$; 753 to $[\text{Co}(\text{AABT})_2\text{Cl}_2]$, 690 to $[\text{Co}(\text{AABT})_2]$, 441 to $[\text{Co}(\text{AABT}^{1/n})_2]$ and 151 to Co with chelated ligand moiety.

The FAB mass spectrum of $[\text{Ni}(\text{AABT})_2\text{Cl}_2] \cdot 2\text{H}_2\text{O}$ complex has been studied as one of the representative case. The peaks of appreciable intensity have been observed at m/z values - 798, 753, 692, 441 and 149 suggesting the fragmentation pattern. The m/z value 798 corresponds to nearest composition $[\text{Ni}(\text{AABT})_2\text{Cl}_2] \cdot 2\text{H}_2\text{O}$; 753 to $[\text{Ni}(\text{AABT})_2\text{Cl}_2]$, 692 to $[\text{Ni}(\text{AABT})_2]$, 441 to $[\text{Ni}(\text{AABT}^{1/n})_2]$ and 149 to Ni with chelated ligand moiety⁵.

IR spectra:

The IR spectra of the complexes were compared with those of the free ligand in order to determine the involvement of coordination sites in chelation. Characteristic peaks in the spectra of the ligand and complexes were considered and compared.

The IR spectrum of the AACP ligand shows a strong band at 1625 cm^{-1} due to (C=N) azomethine group. This on chelation with metal ions shifts down by about $25\text{-}35 \text{ cm}^{-1}$, suggesting participation of azomethine group in complexation. The ligand spectra show bands at 3360 and 1372 cm^{-1} due to the stretching and deformation of phenolic -OH group. These do not appear in spectra of complexes. An intense ligand band at about 1270 cm^{-1} (phenolic C-O) shift to higher frequency ($1280\text{-}1290 \text{ cm}^{-1}$) in the complexes. This band also suggests deprotonation of the phenolic -OH group after its chelation with metal ion. The appearance of broad band around $3320\text{-}3394 \text{ cm}^{-1}$ in complexes may be due to $\nu(\text{OH})$ water molecules. The new bands at $538\text{-}546$ and $480\text{-}490 \text{ cm}^{-1}$ in the complexes have tentatively been assigned to $\nu(\text{M-O})$ and $\nu(\text{M-N})$ mode respectively.

In the IR spectrum of the AABT ligand, the $\nu(\text{C=N})$ (azomethine) band of the free ligand at 1614 cm^{-1} has shifted to lower wave numbers ($24\text{-}29 \text{ cm}^{-1}$) in the complexes, suggesting the

metal coordination with the azomethine nitrogen. The ligand exhibited a sharp band at 827 cm^{-1} due to C-S-C group. Its position in the spectra of complexes has been observed at $803\text{-}807 \text{ cm}^{-1}$ indicating the involvement of ring sulphur atom in coordination. An intense band at 1570 cm^{-1} in Schiff base ligand due to C=N cyclic of thiazole ring, does not alter in the spectra of complexes. This rule out the participation of (C=N cyclic) group in coordination. The ligand (Schiff base) is bidentate. A band around $3405\text{-}3409 \text{ cm}^{-1}$ in the spectra of complexes is assignable to $\nu_{\text{stre.}}$ of water. A new bands at $482\text{-}490$ and $404\text{-}407 \text{ cm}^{-1}$ have been assigned to $\nu(\text{M-N})$ and $\nu(\text{M-S})$ vibrations, respectively in the complexes.

In the IR spectrum of the ACAT ligand, the $\nu(\text{C=N})$ band of the free ligand at 1610 cm^{-1} has shifted to lower wave numbers ($1581\pm 3 \text{ cm}^{-1}$) in the complexes, suggesting the metal coordination with the azomethine nitrogen. The ligand exhibited a sharp band at 822 cm^{-1} due to C-S-C group. Its position in the spectra of complexes has been observed at $805\pm 3 \text{ cm}^{-1}$ indicating the involvement of ring sulphur atom in coordination. An intense band at 1562 cm^{-1} in Schiff base ligand due to C=N cyclic of thiazole ring, does not alter in the spectra of complexes. This rule out the participation of (C=N cyclic) group in coordination. The ligand (Schiff base) is bidentate. A band around $3395\pm 10 \text{ cm}^{-1}$ in the spectra of complexes is assignable to $\nu_{\text{stre.}}$ of water. A band of medium intensity at $785\text{-}799 \text{ cm}^{-1}$ ($\nu(\text{OH})$ rocking), present in the spectra of Co(II) and Ni(II) complexes, suggest the presence of coordinated water in these complexes. But this band is not present in the spectrum of Cu(II), indicates the absence of coordinated water molecule in Cu(II) complex. A new band appears in the complexes at $481\text{-}487$ and $403\text{-}412 \text{ cm}^{-1}$ assignable to $\nu(\text{M-N})$ and $\nu(\text{M-S})$ vibrations, respectively.

Although ligands having oxygen and nitrogen as the donor atoms are by far the most studied, the interest in sulphur donor chelating agents has grown over the years and the number of chemical studies in the area has increased



considerably. The interest in complexes of these ligand systems now covers a full gamut of areas ranging from general considerations to metal-sulphur bonding and electron delocalization in transition metal complexes. 2-Aminothiazole comprises a well known group of nitrogen and sulphur donors which have been extensively used for complex formation in the recent past⁶⁻⁹.

Electronic spectra and magnetic moments :

The electronic spectral data of the metal complexes in methanol solution are given in Table 2. The nature of the ligand field around the metal ion has been deduced from the electronic spectra.

Table 2

Electronic spectral data and ligand field parameters of schiff base and their metal complexes

complex	Transition	Band (cm ⁻¹)	μ_{eff} (B.M.)	10Dq, B, β , $\beta\%$, ν_2/ν_1 , LFSE
Co(II)-AACP	${}^4A_2 \rightarrow {}^4T_2(F)(\nu_1)$	-	4.38	-
	${}^4A_2 \rightarrow {}^4T_1(F)(\nu_2)$	14905		
	${}^4A_2 \rightarrow {}^4T_2(P)(\nu_3)$	19002		
Ni(II)-AACP	${}^1A_{1g} \rightarrow {}^1E_g(\nu_1)$	13126	Diam.	-
	${}^1A_{1g} \rightarrow {}^1B_{2g}(\nu_2)$	18670		
	${}^1A_{1g} \rightarrow {}^1B_{1g}(\nu_3)$	-		
Cu(II)-AACP	${}^2B_1 \rightarrow {}^2B_{2g}$	12220	1.88	-
	${}^2B_1 \rightarrow {}^2E_g$	18302		
Co(II)-AABT	${}^4T_{1g}(F) \rightarrow {}^4T_{2g}(F)(\nu_1)$	-	5.10	8444, 962, 0.86, 14.09, 2.25, 100.89
	${}^4T_{1g}(F) \rightarrow {}^4A_{2g}(F)(\nu_2)$	15200		
	${}^4T_{1g}(F) \rightarrow {}^4T_{1g}(P)(\nu_3)$	19500		
Ni(II)-AABT	${}^3A_{2g}(F) \rightarrow {}^3T_{2g}(F)(\nu_1)$	11350	3.12	11350, 579, 0.56, 44.41, 1.72, 162.72
	${}^3A_{2g}(F) \rightarrow {}^3T_{1g}(F)(\nu_2)$	19530		
	${}^3A_{2g}(F) \rightarrow {}^3T_{1g}(P)(\nu_3)$	23200		
Cu(II)-AABT	${}^2E_g \rightarrow {}^2T_{2g}$	13400	1.87	-
Co(II)-ACAT	${}^4T_{1g}(F) \rightarrow {}^4T_{2g}(F)(\nu_1)$	-	5.07	8617, 1025, 0.91, 8.52, 2.25, 102.95
	${}^4T_{1g}(F) \rightarrow {}^4A_{2g}(F)(\nu_2)$	15510		
	${}^4T_{1g}(F) \rightarrow {}^4T_{1g}(P)(\nu_3)$	20538		
Ni(II)-ACAT	${}^3A_{2g}(F) \rightarrow {}^3T_{2g}(F)(\nu_1)$	11352	3.04	11352, 563, 0.54, 45.94, 1.71, 162.75
	${}^3A_{2g}(F) \rightarrow {}^3T_{1g}(F)(\nu_2)$	19360		
	${}^3A_{2g}(F) \rightarrow {}^3T_{1g}(P)(\nu_3)$	-		
Cu(II)-ACAT	${}^2E_g \rightarrow {}^2T_{2g}$	23138	1.83	-

The electronic absorption spectrum of the [Co(AACP)₂].3H₂O complex shows the bands at 14905 and 19002 cm⁻¹. These transitions have tentatively been assigned to ${}^4A_2 \rightarrow {}^4T_1(F)$ (ν_2) and ${}^4A_2 \rightarrow {}^4T_1(P)$ (ν_3) transitions, respectively. The magnetic moment value of this complex is 4.38 B.M. Thus the tetrahedral

geometry has been suggested for this Co(II) complex. The electronic spectrum of [Ni(AACP)₂].H₂O complex shows two bands at 13126 and 18670 cm⁻¹. These are assignable to ${}^1A_{1g} \rightarrow {}^1E_g(\nu_1)$ and ${}^1A_{1g} \rightarrow {}^1B_{2g}(\nu_2)$, transitions, respectively. This complex is diamagnetic in nature. Therefore a square-planar geometry



has been suggested. The electronic spectrum of the $[\text{Cu}(\text{AACP})_2]\cdot\text{H}_2\text{O}$ complex exhibit bands at 12220 and 18302 cm^{-1} which have been assigned to ${}^2\text{B}_{1g}\text{-}{}^2\text{B}_{2g}$ and ${}^2\text{B}_{1g}\text{-}{}^2\text{E}_g$ transitions. The magnetic moment of the complex is 1.88 B.M. Therefore a square-planar stereochemistry has been suggested.

The electronic spectrum of $\text{Co}(\text{II})\text{-AABT}$ complex shows two bands at 15200 cm^{-1} and 19500 cm^{-1} which have tentatively been assigned to ${}^4\text{T}_{1g}(\text{F})\text{-}{}^4\text{A}_{2g}(\text{F})(\nu_2)$ and ${}^4\text{T}_{1g}(\text{F})\text{-}{}^4\text{T}_{1g}(\text{P})(\nu_3)$ respectively. The magnetic moment is 5.10 B.M. These findings are in favour of an octahedral geometry for the $\text{Co}(\text{II})\text{-complex}$. $\text{Ni}(\text{II})\text{-AABT}$ complex exhibits three bands at 11350, 19530 cm^{-1} and 23200 cm^{-1} corresponding to transitions ${}^3\text{A}_{2g}(\text{F})\text{-}{}^3\text{T}_{2g}(\text{F})(\nu_1)$, ${}^3\text{A}_{2g}(\text{F})\text{-}{}^3\text{T}_{1g}(\text{F})(\nu_2)$ and ${}^3\text{A}_{2g}(\text{F})\text{-}{}^3\text{T}_{1g}(\text{P})(\nu_3)$ respectively. The electronic spectra and magnetic moment data (3.12 B.M.) suggest the octahedral geometry for this complex. In the $\text{Cu}(\text{II})\text{-AABT}$ complex a single broad band appears at 13400 cm^{-1} corresponding to transition ${}^2\text{E}_g\text{-}{}^2\text{T}_{2g}$. The electronic spectra and magnetic moment (1.87 B.M.) data substantiate for the octahedral geometry of this complex.

The electronic spectrum of $\text{Co}(\text{II})\text{-ACAT}$ complex shows two bands at 15510 cm^{-1} and 20538 cm^{-1} which have tentatively been assigned to ${}^4\text{T}_{1g}(\text{F})\text{-}{}^4\text{A}_{2g}(\text{F})(\nu_2)$ and ${}^4\text{T}_{1g}(\text{F})\text{-}{}^4\text{T}_{1g}(\text{P})(\nu_3)$ respectively. The magnetic moment is 5.07 B.M. These findings are in favour of an octahedral geometry for the $\text{Co}(\text{II})\text{-complex}$. $\text{Ni}(\text{II})\text{-ACAT}$ complex exhibits three bands at 11352 cm^{-1} , 19360 cm^{-1} and 23138 cm^{-1} corresponding to transitions ${}^3\text{A}_{2g}(\text{F})\text{-}{}^3\text{T}_{2g}(\text{F})(\nu_1)$, ${}^3\text{A}_{2g}(\text{F})\text{-}{}^3\text{T}_{1g}(\text{F})(\nu_2)$ and ${}^3\text{A}_{2g}(\text{F})\text{-}{}^3\text{T}_{1g}(\text{P})(\nu_3)$ respectively. The electronic spectra and magnetic moment data (3.04 B.M.) suggest the octahedral geometry for this complex. In the $\text{Cu}(\text{II})\text{-ACAT}$ complex a single broad band appears at 13320 cm^{-1} corresponding to transition ${}^2\text{E}_g\text{-}{}^2\text{T}_{2g}$. The electronic spectra and magnetic moment (1.83 B.M.) data substantiate for the octahedral geometry of this complex.

The different parameters such as ligand field stabilization energy (10 Dq), Racah inter-electronic repulsion parameter (B), nephelauxetic ratio (β), percent of covalent character ($\beta\%$) and ligand field stabilization energy (LFSE) have been calculated, the values of these parameters are given in Table 2. The complexes show the lower value of B than that of the free ion which indicates the orbital overlapping and delocalization of d-orbital¹⁰⁻¹³.

ESR spectra :

The ESR spectra of $\text{Cu}(\text{II})$ provide information about the extent of the delocalization of unpaired electron. The X-band ESR spectra of $\text{Cu}(\text{II})$ complexes were recorded in the solid state at room temperature and their g_{\parallel} , g_{\perp} , Δg , g_{av} and G have been calculated. The values of ESR parameters g_{\parallel} , g_{\perp} , g_{av} , Δg and G for $\text{Cu}(\text{II})$ complex of AACP are 2.1996, 2.0731, 2.0731, 0.12365 and 2.7867 respectively.

The $g_{\parallel} > 2.3$ is characteristic of an ionic environment and $g_{\parallel} < 2.3$ indicates a covalent environment in metal ligand bonding. The g_{\parallel} values for the complexes are less than 2.3 suggesting, the environment is covalent. According to Hathaway, if the value G is greater than four ($G > 4.0$), the exchange interaction is negligible; whereas when the value of G is less than four ($G < 4$) a considerable exchange coupling is present in solid complex. The G values for the $\text{Cu}(\text{II})$ complexes are less than four indicate, considerable exchange interaction in the complexes^{14,15}.

Antimicrobial activities

The *in vitro* Antimicrobial activity of the synthesized Schiff base ligands and their corresponding metal complexes on selected bacteria *E. coli*, *B. subtilis* and *S. aureus* and two fungi *A. niger* and *C. albicans* was carried out. All of the tested compounds showed good biological activity against microorganism. On comparing the biological activity of the Schiff base and its metal complexes with the standard bactericide and fungicide, it is show



that the metal complexes have moderate activity as compared to the standard but all the complexes are more active than their respective ligands. The higher inhibition zone of metal complexes than those of the ligands can be explained on the basis of Overtone's concept and Chelation theory. On chelation, the polarity of the metal ion will be reduced to greater extent due to the overlap of the ligand orbital and partial sharing of the positive charge of the metal ion with donor groups. Further, it increases the delocalization of π -electrons over the whole chelating ring and enhances the penetration of the complexes into lipid membranes and

blocking of the metal binding sites in the enzymes of microorganisms. There are other factors which also increase the activity are solubility, conductivity and bond length between the metal and ligand¹⁶⁻¹⁹.

Antibacterial activity

The antibacterial activity of AABT and ACAT compounds were screened against some selected bacteria and examined for the inhibition of growth of the organism. The concentrations of the compounds were given in ppm. The diameter of the inhibition zones in (mm) are given in Table 3.

Table 3
Antibacterial activity of the synthesized compounds

Compound	<i>E.coli</i>		<i>B. subtilis</i>		<i>S. aureus</i>	
	25 mg/ml	50 mg/ml	25 mg/ml	50 mg/ml	25 mg/ml	50 mg/ml
AABT	1 ⁺	1 ⁺	1 ⁺	1 ⁺	1 ⁺	1 ⁺
Co(II)-AABT	1 ⁺	2 ⁺	2 ⁺	2 ⁺	2 ⁺	2 ⁺
Ni(II)-AABT	1 ⁺	2 ⁺	1 ⁺	2 ⁺	1 ⁺	1 ⁺
Cu(II)-AABT	1 ⁺	2 ⁺	1 ⁺	2 ⁺	2 ⁺	2 ⁺
ACAT	-	-	1 ⁺	1 ⁺	1 ⁺	1 ⁺
Co(II)-ACAT	2 ⁺	3 ⁺	3 ⁺	4 ⁺	3 ⁺	4 ⁺
Ni(II)-ACAT	-	-	1 ⁺	1 ⁺	1 ⁺	2 ⁺
Cu(II)-ACAT	3 ⁺	4 ⁺	2 ⁺	3 ⁺	3 ⁺	3 ⁺
Streptomycin (Standard)	3 ⁺	4 ⁺	3 ⁺	4 ⁺	2 ⁺	3 ⁺

Zone of inhibition in (mm), 1⁺=4-8; 2⁺=8-14; 3⁺=14-22; 4⁺=22-28; =>(inactive/not measurable)

Antifungal activity

The antifungal activity of AABT and ACAT compounds were screened against selected fungi and determined their minimal inhibition zones in (mm) were presented in Table 4 and concentrations of the compounds were given in ppm.

Table 4
Antifungal activity of the synthesized compounds

Compound	<i>A. niger</i>		<i>C. albicans</i>	
	25 mg/ml	50 mg/ml	25 mg/ml	50 mg/ml
AABT	1 ⁺	1 ⁺	1 ⁺	1 ⁺
Co(II)-AABT	2 ⁺	2 ⁺	1 ⁺	2 ⁺
Ni(II)-AABT	1 ⁺	2 ⁺	1 ⁺	2 ⁺
Cu(II)-AABT	2 ⁺	2 ⁺	1 ⁺	2 ⁺
ACAT	1 ⁺	1 ⁺	1 ⁺	1 ⁺
Co(II)-ACAT	3 ⁺	4 ⁺	2 ⁺	3 ⁺
Ni(II)-ACAT	2 ⁺	2 ⁺	1 ⁺	2 ⁺
Cu(II)-ACAT	3 ⁺	3 ⁺	3 ⁺	4 ⁺
Griseofulvin (Standard)	3 ⁺	4 ⁺	3 ⁺	4 ⁺

Zone of inhibition in (mm), 1⁺=9-12; 2⁺=13-19; 3⁺=20-26; 4⁺=27-32; ==>(inactive/not measurable)



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