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SYNTHESIS AND SPECTROSCOPY STUDIES OF SOME TRIVALENT METAL IONS COMPLEXES WITH A NEW MACROCYLIC TRIDENTATE LIGAND ETHYL 2-{[(1E, 2E) - 2- (HYDROXYIMINO) -1- PHENYL ETHYLIDENE] AMINO} - 4,5,6,7 TETRAHYDRO-1-BENZOTHIOPHENE-3-CARBOXYLATE AND THEIR ANTIMICROBIAL ACTIVITY AGAINST DRUG RESISTANT UROPATHOGENS

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ABSTRACT

Complexes of general formula $[M(L)Cl_2(H_2O)]$ where M= chromium(III), iron(III) and ruthenium(III), L=ethyl 2-{[(1E,2E)-2-(hydroxyimino)-1-phenyl ethylidene] amino}-4,5,6,7 tetrahydro-1-benzothiophene-3-carboxylate have been prepared. Complexes were characterized by analytical analysis and physical-chemical methods. The ligand behaves as a tridentate chelating agent and bonded to the metal ion through azomethine nitrogen, ester carbonyl and oximino oxygen atom. Electronic spectra and magnetic susceptibility measurement reveals octahedral geometry. The complexes are found to be non-electrolytic in nature on the basis of low molar conductance. The Ru (III) metal complex exhibited antibacterial activity against drug resistant gram negative uropathogens and antifungal activity.

KEYWORDS: Polydentate ligand, octahedral geometry, antibacterial activity, antifungal activity, uropathogens

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INTRODUCTION

The research field dealing with transition metal complexes with macrocylic Schiff base has expanded enormously and embraced wide and diversified subjects comprising vast areas of organometallic compounds[1]. In the area of bioinorganic chemistry the interest in the Schiff base complexes lies in that they provide synthetic models for the metal-containing sites in metalloproteins/enzymes and also contributed to the development of medicinal chemistry. Most of the metal complexes reported to have anticancer property[2], cytotoxic[3], immunosuppressant[4], nitric oxide scavengers[5], antimicrobial[6,7], antifungal[8], antiviral[9], antimalarial, antileukamic[10] and antileprotic[11] properties. In addition, metal complexes containing nitrogen and oxygen donor atoms are effectives as stereo specific catalysts for oxidation[12], reduction[13], hydrolysis[14] and other transformations of organic and inorganic chemistry.

In continuation with the earlier work, substituted 2-amino thiophene namely ethyl 2-amino-4, 5, 6, 7 tetrahydro benzo (b) thiophene 3-carboxylate has been condensed with (2E)-2-(Hydroximino) 1-phenyl ethanone to form a potentially tridentate ligand viz ethyl 2-{[(1E,2E) - 2- (hydroxyimino)-1- phenyl ethylidene] amino}- 4,5,6,7 tetrahydro-1-benzothiophene-3-carboxylate have been synthesized and characterized by their elemental analysis, UV, IR and NMR studies[15]. This ligand is used to synthesized chromium (III), iron (III) and ruthenium (III) complexes. The complexes were characterized by elemental analysis, magnetic moments, Molar conductance and thermal analysis along with electronic and infrared spectral analysis. The octahedral geometry around these metal ions has been proposed on the basis of magnetic and spectral studies. The antibacterial and antifungal activities of metal complexes have been screened.

MATERIALS AND METHOD

All chemical used in the project work were of AR grade and was recrystallised while the solvent were purified and double distilled before use. Metal content was determined by the standard methods[16]. Molar conductance was measured in DMF (10^{-3} M solution) on an ELICO Digital Conductivity meter Model CM-180. The IR spectra were recorded in KBr disc on a Perkin Elmer Model 1600 FTIR Spectrophotometer where as the presence of υ(M-Cl) in complexes was recorded on Plytec 30 spectrometer using CsI disc.. The electronic spectra of the complex in DMF were recorded on UV-Systronic spectrophotometer. Magnetic Susceptibility measurements were carried out by employing the Gouy method using Hg [Co (SCN) $_4$] as a calibrant. Thermo gravimetric studies of the complex were done on Netzch-429 Thermoanalyser recording at a rate of 10 ^oC min^{-1}.

Antimicrobial susceptibility of uropathogens

A total of 9 urine isolates were selected for the current study. They were identified as *Citrobacter diversus, Proteus mirabilis, Pseudomonas aeruginosa* strain1, *Enterobacter aerogenes*, *Citrobacter amalonaticus*, *Pseudomonas aeruginosa* strain 2, *Escherichia coli* strain1, *Klebsiella pneumonia* and *Escherichia coli* strain 2. Antibiotic sensitivity test of these pathogens was carried out using Kirby Bauer method so as to obtain Antibiogram pattern [17].

Antibacterial activity

Antibacterial activity was determined by Agar cup method. The investigated pathogenic microorganisms were *Citrobacter diversus* , *Proteus mirabilis* , *Pseudomonas aeruginosa* strain 1, *Enterobacter aerogenes*, *Citrobacter*

amalonaticus, *Pseudomonas aeruginosa* strain 2, *Escherichia coli* strain 1, *Klebsiella pneumoniae*, *Escherichia coli* strain 2. The metal complexes were dissolved in DMSO to obtain final concentration of 20,40,60,80 and 100mg/ml. A loopful of the given test strain was inoculated in 10 ml of Brain Heart infusion broth and incubated at 37°C for 24 hours in order to activate the bacterial strain activity. Sterile 20 ml of Luria Bertani agar was melted and cooled and 0.2 ml test strain (0.1 O.D. at 530nm) was seeded and poured into a 9cm diameter aneubra Petri plate. Using a sterile cork borer (8 mm in diameter), 4 wells were made in each plate after solidification of the medium. The cups were then filled with 50µl different concentration of the test sample solution. Controls were run (for each bacterial strain and solvent) where pure solvent was added into the cup. The plates were incubated at 37°C for 24 hours. The inhibitory zone formed by these compounds against the particular test bacterial strain determined the antibacterial activity of the metal complexes (zone size measured in mm). The mean value obtained for three individual replicates was used to calculate the zone growth of inhibition of each plate by subtracting the diameter of inhibition zone (zone size measured in mm) resulting with DMSO from that obtained in each case, antibacterial activity was calculated as a mean of 3 replicates [18].

Antifungal Activity

A 0.4 ml spore suspension (10^7 spore/ml) of the *Aspergillus niger* and 0.3 ml suspension (10^7cells/ml) of *Candida albicans* was added to a separate sterile 20ml Sabouraud's agar media butts just before solidification, then poured into sterile aneubra petri plates (9 cm in diameter) and left to solidify. Using a sterile cork borer (6 mm in diameter), wells were made in each plate, and then 50µl of the tested compounds, dissolved in DMSO (20,40,60,80 and 100 mg/ml), was added into these wells. Finally, the plates were incubated at 37^0C for 48 h. Then clear or inhibition zones were detected around each well. DMSO alone (50µl) was used as a control under the same condition for each organism. The inhibitory zone formed by these compounds against the particular test bacterial strain determined the antibacterial activity of the metal complexes (zone size measured in mm). The mean value obtained for three individual replicates was used to calculate the zone growth of inhibition of each plate by subtracting the diameter of inhibition zone (zone size measured in mm) resulting with DMSO from that obtained in each case, antifungal activity was calculated as a mean of 3 replicates [19,20]

Preparation of ligand ethyl 2-{[(1E,2E)-2-(hydroxyimino)-1-phenyl ethylidene] amino}-4,5,6,7 tetrahydro-1-benzothiophene-3-carboxylate[15]

Ethyl 2-amino-4, 5, 6, 7 tetrahydro benzo(b)thiophene 3-carboxylate and (2E)-2-(Hydroximino) 1-phenyl ethanone was prepared according to a reported method[21,22]. To a solution of this thiophene derivatives (0.01mol) in ethanol (20ml) was added to a solution of (2E)-2-(Hydroximino) 1-phenyl ethanone (0.01mol) dissolved in ethanol (20ml) in small portion with constant stirring. The resulting solution was refluxed on a water bath for about four hours. On cooling the solution, the Schiff base crystallized. It was then filtered, washed and sucked dry. Further purification was done by crystallization from ethanol (MP 130^oC).

Preparation of metal complexes

To a magnetically stirred and warmed ethanolic solution (20ml) of the ligand (0.01mol) added an ethanolic solution of metal (III) chloride (0.01mol) dissolved in ethanol (20ml) in small parts. .After complete additions of the metal salt solution, the pH was adjusted to 7.5 by adding ethanolic ammonia .It was then refluxed for about six hours in a water bath and the resulting solution was reduced to half the initial volume and allow to stand overnight. The complex formed was filtered, washed successively with aqueous ethanol

and ether. Finally the complex was dried in vacuum over P_4O_{10}

RESULTS AND DISCUSSION

Elemental analysis data of the complexes of ethyl 2-{[(1E,2E)-2-(hydroxyimino)-1-phenyl ethylidene]amino}-4,5,6,7 tetrahydro-1-benzothiophene-3-carboxylate (L) with Cr(III),Fe(III)and Ru(III) can be represented by the general formula $[M(L)Cl_2(H_2O)]$ (Table1).All the complex are insoluble in water, while partly soluble in methanol, ethanol and chloroform and highly soluble in DMF and DMSO. The results of the electrical conductance measurements of the soluble complex in DMF show that they are non-electrolyte in nature.(Table-1)

Table 1
Physico-chemical characteristic of Schiff base ligand and its metal complexes

Compound	Colour	F.Wt	Elemental analysis (%) Found(calcd)					Molar Cond. ($\Omega^{-1}cm^2mol^{-1}$)
			C	N	S	Cl	M	
HL	yellow	356.44	63.2 (64.02)	6.93 (7.86)	8.5 (9.0)	-	-	------
$[Cr(L)Cl_2(H_2O)]$	Light brown	495.35	44.20 (45.98)	5.95 (5.64)	5.24 (6.46)	13.05 (14.29)	9.89 (10.48)	10.53
$[Fe(L)Cl_2(H_2O)]$	Red	500.20	43.98 (45.62)	4.59 (5.60)	7.25 (6.41)	13.34 (14.18)	10.37 (11.16)	9.68
$[Ru(L)Cl_2(H_2O)]$	Dark brown	545.42	40.22 (41.84)	4.27 (5.14)	5.02 (5.88)	12.45 (13.00)	17.24 (18.53)	11.62

The UV spectral bands characteristic of the ligand is only marginally red shifted in the spectra of the metal complexes indicating that no structural alteration of the ligand occurs on coordination with the metal ions. In the metal complexes, the υ(C=N) is displaced to lower wave number by about 20-25cm^{-1} on bond stabilization of the azomethine moiety upon coordination. The bond corresponding to the ester υ(C=O) has been shifted to lower frequency by about 30-35cm^{-1} in the metal complexes indicating coordination by ester function[23]. A medium to strong intensity band observed in the range of 997-1012cm^{-1} in all the complexes, which is assigned of oxygen – bonded υ(N-O) of coordinated deprotonated oxime group, which lead to a six- member ring structure around metal ions[24,]. All the metal complexes also show a broad band around 3340-3440cm^{-1}, which has significantly different characteristic from the band due to hydrogen bonded υ(N-OH)observed in ligand. This band is therefore attributed to stretching modes of water molecules, the centre of gravity near 3400cm^{-1} implies coordination of water molecules to the metal ions. A strong band around 2930 cm^{-1} due to υ(C-H) of cyclohexane did not show any appreciable change in metal complexes. Infra spectra of the complexes also showed non-ligand band in the region 419-430cm^{-1} and 510-520cm^{-1}, which could be assigned to υ(M-O) and υ(M-

N) modes respectively[25]. The medium band observed in the range 385- 395 cm^{-1} can be assigned to the presence of υ(M-Cl) in complexes[26] which was recorded on Plytec 30 spectrometer using CsI disc. Absence of υ (M-S) band in the far infrared spectra of the metal complexes gives direct evidence to non-involvement of ring sulphur in bond formation (Table-2).

Table -2
Important IR spectral bands of Schiff base and its metal complexes

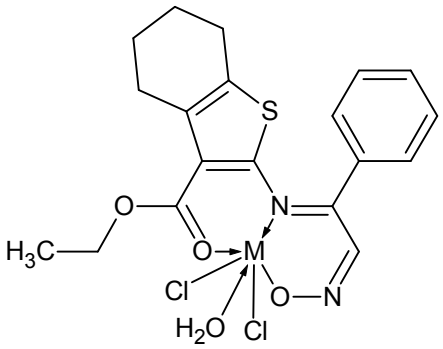
L	$[Cr(L)Cl_2(H_2O)]$	$[Fe(L)Cl_2(H_2O)]$	$[Ru(L)Cl_2(H_2O)]$	Tentative assignment
3200br	----	---	---	υ (N-O-H)
---	3340br	3395br	3440br	υ (O-H) ,H_2O
2930m	2934m	2935w	2935m	υ (C-H)
1710s	1670s	1665s	1674s	υ (C=O)
1630s	1600s	1605s	1609s	υ(C=N),azomethine
1595m	1570m	1580m	1565m	υ (C=N),oximino
987m	1005m	1015m	1012m	υ (N-O)
608s	608m	609s	608s	υ (C=S)
---	510m	515m	518m	υ (M-N)
---	420m	435m	425m	υ (M-O)
	395m	386m	392m	υ (M-Cl)

L= ethyl 2-{[(1E,2E)-2-(hydroxyimino)-1-phenyl ethylidene]amino}-4,5,6,7 tetrahydro-1-benzothiophene-3-carboxylate

The electronic spectra of Cr(III) complex show bands at 580,410 and 350nm,which may be attributed to $^4A_{2g} \rightarrow {}^4T_{2g}(F)$, $^4A_{2g} \rightarrow {}^4T_{1g}(F)$, and $^4A_{2g} \rightarrow {}^4T_{1g}(P)$ transition respectively indicating an octahedral geometry around Cr(III) ion[27,28]. The high spin Fe(III) complex with d^5 configuration have the ground state $^6A_{1g}$ and all the d-d transition are spin and laporte forbidden[29]. The electronic spectra of Fe(III) complex shows band in the range of 350-500nm. It is not possible to identify the type of the d-d transition. the weak band in the range of 400-500nm, assigned to the spin and parity forbidden $^6A_{1g} \rightarrow {}^4T_{2g}$ transition of Fe(III) ion in octahedral field[30].The electronic absorption spectra of ruthenium(III) complex in DMSO solution showed only one band in the visible region at 680nm.By considering that the ligand in Ru(III) behave as strong field ligand ,one can assigned that this band maybe attributed to $^2T_{2g} \rightarrow {}^2A_{2g}$ transition[31] . The magnetic moments value observed for Cr (III) complex corresponds to three unpaired electrons. The magnetic moments of 3.80BM is slightly less than the spin only of 3.88BM as is seen in octahedral complexes due to small spin orbit coupling constant[32]. High spin complexes of Fe (III) are formed with weak or moderately strong ligands. The ground state of ^6S of Fe(III) ion is not split in the presence of ligand field. Therefore the magnetic moment of high spin complexes are found to be very close to the spin only value of 5.90BM [33]. The magnetic moment for the Ru(III) complex is 1.75BM with a configuration of S=1/2 . Ruthenium being the metal of second transition series will always give a low spin complex with magnetic moment around 1.80BM [34,35] .

The thermal analysis (TGA) were carried out on complexes in the temperature range 50-950^oC (Table -3).The results shows that there is a good agreement in the weight loss between calculated and the observed. The thermal analysis shows the complexes generally decomposes in two or three steps. In first step around 130-215^oC was assigned to the elimination of coordinated water molecules, where as in second step from 180-300^oC may

be assigned as to the elimination of chloride group in the form of HCl. In third step between 290-650°C is the complete decomposition of the complexes which ended with metal oxide formation. The elemental analysis, IR .electronic spectra, magnetic moment measurement as well as thermal analysis are compatible with the suggested structure (Fig .1)



M=Cr(III),Fe(III) and Ru(III)

Figure 1
Structural representation of the complexes.

Table -3
The Thermal analysis (TGA) of metal complexes.

No	Complexes	Temp Range(°C)	Loss in weight Found(calculated)	Assignment	Composition of the residue
1	$[Cr(L)Cl_2(H_2O)]$	130-200	3.45(3.63)	Loss of coordinated water on molecule	$[Cr(L)Cl_2]$
		235-290	15.03(14.71)	Loss of two chloride ion(2HCl)	[CrL]
		368-590	65.85(66.35)	Decomposition of complex	Cr_2O_3
2	$[Fe(L)Cl_2(H_2O)]$	155-198	3.48(3.60)	Loss of coordinated water on molecule	$[Fe(L)Cl_2]$
		220-300	14.06(14.59)	Loss of two chloride ion(2HCl)	[FeL]
		325-625	64.92(65.85)	Decomposition of complex	Fe_2O_3
3	$[Ru(L)Cl_2(H_2O)]$	145-215	3.36(3.30)	Loss of coordinated water on molecule	$[Ru(L)Cl_2]$
		245-310	13.20(13.38)	Loss of two chloride ion(2HCl)	[RuL]
		318-650	61.25(60.39)	Decomposition of complex	Ru_2O_3

Antimicrobial susceptibility testing using Kirby Bauer method of gram negative uropathogens (*Citrobacter diversus, Proteus mirabilis, Pseudomonas aeruginosa* strain1, *Enterobacter aerogenes*, *Citrobacter amalonaticus*, *Pseudomonas aeruginosa strain 2*, *Escherichia coli* strain1, *Klebsiella pneumonia* and *Escherichia coli* strain 2) isolated from this laboratory was carried out and it was found that these uropathogens were resistant to most of the antibiotics as shown in Table 4. All 9 isolates were found to be Multiple Drug Resistant (Resistant to more than 3 antibiotics) including 3rd generation Cephalosporins (Ceftazidime, Cefotaxime and Ceftriaxone). All 9 gram negative drug resistant bacterial uropathogens are sensitive to Ru(III) metal complex but are resistant to Cr(III) and Fe(III) complexes as shown in Table no 5. It was observed that as concentration of Ru(III) complex increases the inhibitory zone size also has increased. Similarly Ru(III) also exhibited antifungal activity against *Aspergillus niger* and *Candida albicans* but Cr(III) and Fe(III) failed to do so(Table 6). Chelation allows for the delocalization of π-electrons over the entire chelate ring and enhances the lipophilicity of the complexes. This increased lipophilicity facilitates the penetration of the complexes into lipid membranes, further restricting proliferation of the microorganisms. Thus, chelation enhances the penetration of the complexes into lipid membranes and the blockage of metal binding sites in the enzymes of the microorganisms [36]. This consequently increases the lipophilic character of the chelates, favouring their permeation through the lipid layers of the bacterial membrane[37].Interference with the synthesis of cellular walls, causing damage that can lead to altered cell permeability characteristics or disorganized lipoprotein arrangements, ultimately resulting in cell death. Deactivation of various cellular enzymes that play a vital role in the metabolic pathways of these microorganisms. Denaturation of one or more cellular proteins causes the normal cellular processes to be impaired [38]. The ruthenium compounds with tridentate ligand show intercalation properties with DNA and are believed to induce cytotoxicity by cross-linking DNA, causing changes to the DNA structure resulting in inhibition of replication and protein synthesis [39].

Table 4
Antibacterial susceptibility testing of gram negative uropathogens

Isolates	Antibiotics		
	Sensitive	Intermediate	Resistant
Citrobacter diversus	AS, BA, CH	-	CF, PC,RC, CI, TE, ZN, GM, AK, GF, TT, OX, RP, ZX, CB, NA, NX, AG, CU, CP, FG, PB
Proteus mirabilis	OX, AS, BA, CH, TE, GM, AK, GF, NA, ZN	-	CF, PC, RC, CI, TT, RP, ZX, CB, NX, AG, CU, CP, FG, PB
Pseudomonas aeruginosa strain 1	RC	-	AS, BA, CF, PC, CH, CI, TE, ZN, GM, AK, GF, TT, OX, RP, ZX, CB, NA, NX, AG, CU, CP, FG, PB
Enterobacter aerogenes	AS, CH	RC	BA, CF, PC, CI, TE, ZN, GM, AK, GF, TT, OX, RP, ZX, CB, NA, NX, AG, CU, CP, FG, PB
Citrobacter amalonaticus	AS, CH, GM, AK, GF	ZN	BA, CF, PC, RC, CI, TE, TT, OX, RP, ZX, CB, NA, NX, AG, CU, CP, FG, PB
Pseudomonas aeruginosa strain 2		-	AS, BA, CF, PC, CH,RC, CI, TE, ZN, GM, AK, GF, TT, OX, RP, ZX, CB, NA, NX, AG, CU, CP, FG, PB
Escherichia coli strain 1	AS, CH, AK, GF	ZN,	BA, CF, PC, RC, CI, TE, GM, TT, OX, RP, ZX, CB, NA, NX, AG, CU, CP, FG, PB
Klebsiella pneumoniae	CH	PC	AS, BA, CF, RC, CI, TE, ZN, GM, AK, GF, TT, OX, RP, ZX, CB, NA, NX, AG, CU, CP, FG, PB
Escherichia coli strain2	OX, AS, BA, CH, TE, GM, AK, GF	-	CF, PC, RC, CI, ZN, TT, RP, ZX, CB, NA, NX, AG, CU, CP, FG, PB

Key:
TT -Ticarcillin/clavulanic acid, OX- Oxytetracycline, RP – Ceftriaxone, ZX – Cefepime, CB – Cefuroxime, NA - Naladixic acid, NX- Norfloxacin, AG - Amoxycillin/clavulanic acid, CU – Cefadroxil,CP - Cefoperazone, FG- Ceftazidime, PB - Polymixin B, AS – Ampicillin, BA - Co-trimaxazole, CF – Cefotaxime, PC- Pipperacillin, CH – Chloramphenicol, RC – Ciprofloxacin, CI – Ceftizoxime, TE – Tetracycline, ZN – Ofloxacin, GM – Gentamicin, AK – Amikacin, GF - Gatifoxacin

Table-5
Antibacterial activity of metal-complexes against drug resistant uropathogens

Name of the culture	Metal complex	Concentration mg/ml				
		20	**40**	**60**	**80**	**100**
		Zone size in mm				
Citrobacter diversus	$[Cr(L)Cl_2(H_2O)]$	-	-	10	11	11
	$[Fe(L)Cl_2(H_2O)]$	-	-	-	-	-
	$[Ru(L)Cl_2(H_2O]$	13	14	15	16	17
Proteus mirabilis	$[Cr(L)Cl_2(H_2O)]$	-	-	-	-	-
	$[Fe(L)Cl_2(H_2O)]$	-	-	-	-	10
	$[Ru(L)Cl_2(H_2O]$	-	10	14	18	22
Pseudomonas aeruginosa strain1	$[Cr(L)Cl_2(H_2O)]$	-	-	-	-	-
	$[Fe(L)Cl_2(H_2O)]$	-	-	-	-	-
	$[Ru(L)Cl_2(H_2O]$	-	10	14	16	22
Enterobacter aerogenes	$[Cr(L)Cl_2(H_2O)]$	12	12	12	14	14
	$[Fe(L)Cl_2(H_2O)]$	10	10	10	11	12
	$[Ru(L)Cl_2(H_2O]$	12	16	20	24	25
Citrobacter amalonaticus	$[Cr(L)Cl_2(H_2O)]$	10	10	10	10	12
	$[Fe(L)Cl_2(H_2O)]$	11	11	12	12	12
	$[Ru(L)Cl_2(H_2O]$	14	16	18	20	22
Pseudomonas aeruginosa strain2	$[Cr(L)Cl_2(H_2O)]$	11	12	12	12	12
	$[Fe(L)Cl_2(H_2O)]$	11	11	11	11	12
	$[Ru(L)Cl_2(H_2O]$	16	18	20	22	23
Escherichia coli strain1	$[Cr(L)Cl_2(H_2O)]$	11	12	12	12	13
	$[Fe(L)Cl_2(H_2O)]$	10	11	12	13	14
	$[Ru(L)Cl_2(H_2O]$	15	17	18	20	22
Klebsiella pneumoniae	$[Cr(L)Cl_2(H_2O)]$	-	-	-	-	-
	$[Fe(L)Cl_2(H_2O)]$	11	12	12	12	12
	$[Ru(L)Cl_2(H_2O]$	16	18	20	22	24

= no zone of inhibition

Table-6
Antifungal activity of metal-complexes

Name of the culture	Metal complex	Concentration mg/ml				
		20	40	60	80	100
		Zone size in mm				
Aspergillus niger	$[Cr(L)Cl_2(H_2O)]$	-	-	-	-	-
	$[Fe(L)Cl_2(H_2O)]$	-	-	-	-	-
	$[Ru(L)Cl_2(H_2O)]$	12	15	18	21	22
Candida albicans	$[Cr(L)Cl_2(H_2O)]$	12	13	15	15	16
	$[Fe(L)Cl_2(H_2O)]$	-	-	-	-	10
	$[Ru(L)Cl_2(H_2O)]$	19	26	30	32	32

- ***= no zone of inhibition***

CONCLUSION

From the present investigation it has been observed that a ligand ethyl 2-{[(1E,2E)-2-(hydroxyimino)-1-phenylethylidene]amino}-4,5,6,7tetrahydro-1-benzothiophene-3-carboxylate form a complex with metal ions like Cr(III), Fe(III) and Ru(III) in 1:1 ratio. The data explain its octahedral geometry of the complexes. Ru(III) complex demonstrated antimicrobial activity against drug resisitant uropathogens and antifugal activity while Cr (III) and Fe (III) metal complexes failed to do so.

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