

RESEARCH ARTICLE

Fe (III), Ru (III) AND Rh (III) COMPLEXES OF SCHIFF BASE HYDRAZONES: PREPARATION, SPECTRAL CHARACTERIZATION AND PHARMACOLOGICAL ACTIVITIES

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ABSTRACT

This paper describes the synthesis and characterization of Schiff base ligand L¹ (IMHMBHB), and its metal complexes were synthesized by the condensation 3-(((1*H*-indol-3-yl)methylene)hydrazono)methyl)benzaldehyde with 5-bromo-3-hydrazonoindolin-2-one and Schiff base ligand L² (TIDDFO) and its metal complexes were synthesized by the condensation of 6-([1,3,4] thiadiazino[6,5-*b*]indol-3-ylimino)-2,2-dimethyl-1,3-dioxan-4-one with 5-fluoro-3-hydrazonoindolin-2-one. The chemical structures of the synthesized compounds were confirmed by means of IR, mass, ¹H NMR, molar conductance, UV-Vis, magnetic and thermal studies. Analytical data reveal that the Fe (III), Ru (III) and Rh (III) complexes exhibiting octahedral geometry. In addition biological activity of the Schiff base ligands and their metal complexes were also examined.

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INTRODUCTION

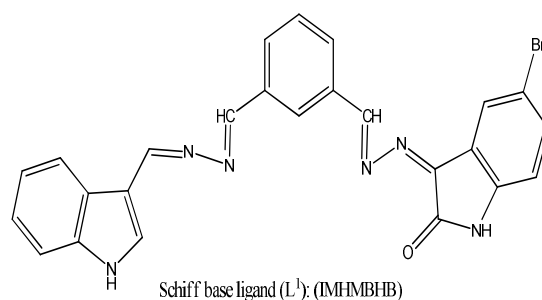
The distinguished developments in the meadow of bioinorganic chemistry have augmented curiosity in Schiff base complexes, since they have been acknowledged and designed as biologically noteworthy species. Hydrazone is a multitalented moiety that exhibits a broad assortment of activity due to the presence of N=C-S moiety in the ring. They have turned out to be an imperative class of heterocycles of great attention of researchers because of their wide types of biological activity (Lincy *et al.*, 2015). A coherent control of nuclearity of transition metal complexes is significant to blueprint systems with the desired properties, as some of these applications involve the presence of O and N donor atoms in the precise complex (Saravana *et al.*, 2015). Metal complexes of Schiff base hydrazones have wide applications in biological processes such as in the treatment of tumours, tuberculosis, leprosy and mental disorders. The biological activity has been credited to the complex forming abilities of the ligands with metal ions (Zamir *et al.*, 2015). In the present work, we have prepared and characterized the new complexes of Fe (III), Ru (III) and Rh (III) with biologically active Schiff base ligands keeping in mind the aptitude of complexation of Fe (III), Ru (III) and Rh (III) complexes and its function in biological processes.

MATERIALS AND METHODS

All the used chemicals and solvents were of analytical grade. All the reagents used for the preparation of the Schiff bases were purchased from Sigma Aldrich. The complex was formed by using metal salts: Fe (III), Ru (III) and Rh (III) were obtained from Loba chemie.

Synthesis of Schiff base ligand (L¹)
3-((3-(((1*H*-indol-3-yl) Methylene) Hydrazono) Methyl) Benzylidene) Hydrazono) -5 -Bromoindolin- 2- One (IMHMBHB)

A mixture containing 30 mL solution of 0.001 mol of 3-((E)-((E)-((1*H*-indol-3-yl) methylene) hydrazono) methyl) benzaldehyde and 0.001 mol of 5-bromo-3-hydrazonoindolin-2-one was refluxed in ethanol for about 5 h. Then it was cooled to room temperature and the product was filtered off, washed several times with hot ethanol, dried, and recrystallized from dioxane, to afford Schiff base ligand (IMHMBHB) as shown in Figure 1. The purity of the compound has been checked by TLC.


 Figure 1 Structures of the Schiff-base Ligands (L¹)

Synthesis of Schiff base Ligand (L²):
3-((6-([1, 3, 4] Thiadiazino [6, 5-*b*] Indol-3-Ylimino)-2, 2-Dimethyl-1, 3-Dioxan-4ylidene) hydrazono)-5-Fluoroindolin-2-One (TIDDFO)

0.01 Mol of 6-([1, 3, 4] thiadiazino [6, 5-*b*] indol-3-ylimino)-2, 2-dimethyl-1, 3-dioxan-4-one was then refluxed with 0.001 mol of 5-Fluoro-3-Hydrazonoindolin-2-One in ethanol for 5 h. The precipitate thus formed was filtered,

dried in vacuum over CaCl₂ and recrystallised from dioxane, to afford Schiff base ligand (TIDDFO) as shown in Figure 2. The purity of the compound has been checked by TLC.

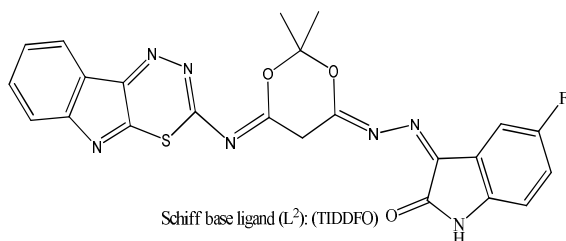


Figure 2 Structures of the Schiff-base Ligands (L²)

Table 1 Physical and analytical data of Schiff base ligands L¹ (IMHMBHB) and L² (TIDDFO) and their Fe (III), Ru (III) and Rh (III) metal complexes

Compound	Molecular formula	Yield (%)	Found (Calculated) %			$\Omega^{-1} \text{cm}^2 \text{mol}^{-1}$	μ_{eff} (BM)
			C	H	N		
L ¹ (IMHMBHB)	[C ₂₅ H ₁₇ N ₆ OBr]	62	59.87 (60.37)	3.32 (3.45)	16.71 (16.90)	-	-
Fe(III) Complex	[FeC ₂₅ H ₁₇ N ₆ OBrCl ₃]	73	44.21 (45.53)	2.51 (2.60)	12.54 (12.74)	12.91	5.73
Ru(III) Complex	[RuC ₂₅ H ₁₇ N ₆ OBrCl ₃]	87	41.38 (42.60)	2.31 (2.43)	11.74 (11.92)	16.77	1.88
Rh(III) Complex	[RhC ₂₅ H ₁₇ N ₆ OBrCl ₃]	67	41.55 (42.49)	2.34 (2.42)	11.68 (11.89)	18.83	Dia
L ² (TIDDFO)	[C ₂₅ H ₂₀ N ₇ OSF]	58	61.65 (61.84)	4.02 (4.15)	20.01 (20.19)	-	-
Fe(III) Complex	[FeC ₂₅ H ₂₀ N ₇ OSFCl ₃]	65	45.21 (46.36)	3.01 (3.11)	15.03 (15.14)	13.13	5.66
Ru(III) Complex	[RuC ₂₅ H ₂₀ N ₇ OSFCl ₃]	69	42.25 (43.33)	2.85 (2.91)	14.05 (14.15)	15.93	1.86
Rh(III) Complex	[RhC ₂₅ H ₂₀ N ₇ OSFCl ₃]	72	42.84 (43.22)	2.87 (2.90)	14.09 (14.11)	19.55	Dia

Synthesis of Metal Complexes

A solution of metal salts (Fe (III), Ru (III) and Rh (III)) in hot ethanol (0.001 mol) was refluxed with an ethanolic solution of Schiff base ligands L¹ (IMHMBHB) and L² (TIDDFO) (0.001 mol) on a water bath for 2-3 hours. Then the solution was reduced to one third of its volume on a water bath and cooled. The precipitated complex was filtered washed several times with hot ethanol and dried in vacuum (Vogel, 1962).

Analytical Methods

Elemental analysis carbon, hydrogen and nitrogen analysis was carried out using a Heracus Carlo Erba 1108 CHN analyzer at STIC, Cochin. The IR spectra of the Schiff base ligands and their Fe (III), Ru (III) and Rh (III) complexes were recorded in the region of 4000-250 cm⁻¹ on a Perkin Elmer - Spectrum RX-IFTIR spectrophotometer. The electronic spectra of the Fe (III), Ru (III) and Rh (III) complexes were recorded on an ELICO SL-164 double beam UV-visible spectrophotometer in the range of 200-900 nm in DMF (10⁻³M) solution. Magnetic susceptibility measurements were made at room temperature on a Gouy balance using Hg [Co (NCS)₄] as the calibrant. Molar conductivity measurements were recorded on an ELICO CM-180 conductivity bridge in DMF solution (10⁻³ M) using a dip-type conductivity cell fitted with a platinum electrode. The ¹H-NMR spectra were recorded in DMSO-d₆ on a Bruker 500 MHz spectrophotometer using TMS as an internal standard. The mass spectra were recorded on a JEOL GC mate mass spectrophotometer. The ESR spectrum of the Ru (III) complex in the polycrystalline state was recorded on a Varian-E-4X band EPR spectrophotometer using TCNE as the 'g' marker (g = 2.00277) at room temperature.

Pharmacology

Antimicrobial Assay

Bacterial and fungal opposition to the antibiotic is a big waft to humanity and continual search for newer chemotherapeutic agent is the only way to strengthen against this appalling throat. All the synthesized compounds, Schiff base ligands L¹

(IMHMBHB) and L² (TIDDFO) and their Fe (III), Ru (III) and Rh (III) metal complexes were screened for *in vitro* antibacterial and antifungal activities by cup-plate method (Odds, 1989). The antibacterial activity of the compounds was evaluated against three bacterial strains (*B. subtilis*, *P. vulgaris* and *Shigella flexneri*.) the antifungal activities of the synthesized compounds were evaluated against three fungi strains (*F. solani*, *Candida krusiae* and *Candida parasilopsis*). The observed data on the antimicrobial activity of the synthesized compounds, control and standard drugs (antibacterial drug: Ciprofloxacin and antifungal drug: Amphotericin) are given in Table 1 (Prakash *et al.*, 2009).

DNA Photo Cleavage Studies

The photo induced cleavage activity of Calf-thymus DNA by the Fe(III), Ru(III) and Rh(III) metal complexes was studied by performing agarose gel electrophoresis experiment, Calf-thymus DNA was treated with the complexes in buffer 8.0 in different concentrations, and the solutions were incubated at 37°C in the incubator for 2 h. The samples were analyzed by electrophoresis for 30 min. at 50 V in TAE buffer (4.84 g Tris base, pH 8.0; 0.5 M EDTA/1 L) containing 0.8 % agarose gel. The gel was stained with 10 µg/ml of ethidium bromide for 10-15 min. and the bands observed under UV light (Peng *et al.*, 2014).

Anti Tubercular Activity

Anti-TB Activity Using Alamar Blue Dye

The anti-TB sensitivity of synthesis Schiff base ligands L¹ (IMHMBHB) and L² (TIDDFO) and their Fe (III), Ru (III) and Rh (III) metal complexes against *Mycobacterium tuberculosis* was observed by using Micro-plate Alamar Blue Assay by observing intensity of color. This method uses thermally stable reagent (Almar Blue reagent) and is non-toxic (Aditya and Preeti, 2014).

Anticancer Activity

Cytotoxicity studies were carried out using human ovarian cancer cell line (OAW 42 ovary) which was obtained from National Centre for Cell Science (NCCS), Pune, India. Cell viability was carried out using the MTT assay method. Remove the supernatant from the plate and add fresh MEM solution and treat with different concentrations of extract or compound appropriately diluted with DMSO. Control group contains only DMSO. In your study, 10, 20, 25, 30 and 50 µl of the stock solution (10mg / ml prepared in DMSO) were added to respective wells containing 100 µl of the medium. So, the final concentrations were 10, 20, 25, 30 and 50 µg / ml. After 48 hrs incubation at 37°C in a humidified atmosphere of 5% CO₂, stock solution of MTT was added to each well (20µl, 5mg per ml in sterile PBS) for further 4 hr

incubation. The supernatant carefully aspirated, the precipitated crystals of "Formazan blue" were solubilised by adding DMSO (100µl) and optical density was measured at wavelength of 570 nm by using LISA plus. The results represent the mean of five readings. The concentration at which the OD of treated cells was reduced by 50% with respect to the untreated control (Ramadoss *et al.*, 2013).

RESULTS AND DISCUSSION

The tridentate Schiff base ligands (L¹ and L²) and their complexes were synthesized and characterized by various spectral techniques. These complexes were found to be air stable, amorphous, moisture free. The physical properties of the Schiff base ligands and their complexes were summarized in Table 1. The molar conductance values of the complexes determined (Table 2) are quite low, suggesting the complexes are non electrolytic in nature (Abubakar *et al.*, 2015).

Electronic Spectral and Magnetic Susceptibility Data

The geometry of the metal complexes has been deduced from electronic spectra and magnetic data. Electronic absorption spectra of Fe (III), Ru (III) and Rh (III) metal complexes of Schiff base ligands L¹ (IMHMBHB) and L² (TIDDFO) were recorded in DMF solution (10⁻³M) at room temperature.

The electronic spectra of the Fe(III), complexes exhibits bands at 14771, 16077 and 21598 cm⁻¹ for Schiff base ligand L¹ (IMHMBHB), 14265, 18761 and 30030 cm⁻¹ for Schiff base ligand L² (TIDDFO), which have been assigned to ⁶A_{1g} → ⁴T_{1g}(G), ⁶A_{1g} → ⁴E_g(D), ⁶A_{1g} → ⁴T_{1g}(D) transitions respectively, corresponding to octahedral geometry around Fe(III) ion [3]. Whereas three bands showed at 20746, 26109 and 33033 cm⁻¹ for Ru(III) Schiff base ligand L¹ (IMHMBHB), 20576, 25575 and 32258 cm⁻¹ for Schiff base ligand L² (TIDDFO), which have been assigned to ²T_{2g} → ⁴T_{1g}, ²T_{2g} → ⁴T_{1g} and ²T_{2g} → ²A_{2g}. The observed transition bands lie well within the range of reported values. These values indicate considerable covalent character and support the octahedral geometries for the Ru (III) complexes (Taleb, 2009).

The Rh(III) complexes exhibits bands at 14684, 18416 and 24937 cm⁻¹ for Schiff base ligand L¹ (IMHMBHB), 14471, 18382 and 24875 cm⁻¹ for Schiff base ligand L² (TIDDFO), which have been assigned to ¹A_{1g} → ³T_{1g}, ¹A_{1g} → ¹T_{1g}, and ¹A_{1g} → ¹T_{2g} transitions. These transitions correspond to octahedral geometry, which is also supported by the magnetic moment values. The results of magnetic susceptibility measurements at room temperature suggests that Fe(III) and Ru(III) complexes of ligands L¹ (IMHMBHB), and L² (TIDDFO) show 5.73, 5.66, 1.88 and 1.86 B. M. which specify the paramagnetic nature and may display octahedral geometry. Rh (III) complexes of ligands L¹ and L² show diamagnetic nature and demonstrate octahedral geometry respectively (Chavan and Mehta, 2011).

IR Spectral Data

In order to study the binding mode of the Schiff base to the metal ion of the complexes, the IR spectrum of the free ligand was compared with the spectra of the complexes. In the IR spectra of ligands L¹ and L², shows their characteristic ν(C=N) and ν(C=O) band at 1588 and 1591 cm⁻¹ and 1579 and 1592 cm⁻¹, 1691cm⁻¹ and 1684 cm⁻¹, which are also shifted

to lower frequencies in the spectra of the Fe(III), Ru(III) and Rh(III) metal complexes (Hany *et al.*, 2015). The absorption due to ν(N-H) functions displayed bands at 3211 and 3208 cm⁻¹ and 3209 cm⁻¹, while absorption due to ν(C=N) functions displayed bands at 1607 and 1613 cm⁻¹ and 1604 cm⁻¹, respectively. In the spectra of all the complexes which appeared in about the same region as in the case of the respective ligands, thus conforming the noninvolvement of either ν(N-H) or ν(C=N) function in coordination with the metal ions (Mahendra and Mruthyunjayaswamy, 2013). The metal chelates show some new bands which are due to the formation of ν (M-N), ν (N-N) and ν (M-Cl) bonds respectively. These values are given in the Tables 2 and 3. Hence, it is concluded that the coordination to the metal ion occurs through the oxygen atom of ν(C=O) group and nitrogen atom of ν (HC=N) group of the Schiff bases (Rehab *et al.*, 2015).

Table 2 IR spectral bands of the ligands and their metal complexes (cm⁻¹) Schiff base ligand L¹ (IMHMBHB) And its Fe (III), Ru (III) and Rh (III) metal Complexes

Tentative assignments	L ¹ (IMHMBHB)	Fe(III) Complex	Ru(III) Complex	Rh(III) Complex
ν(C=N)	1588	1578	1568	1558
ν(C=N)	1591	1551	1541	1531
ν(C=O)	1691	1682	1671	1662
Indole ring NH	3211	3211	3211	3211
-NH	3208	3208	3208	3208
ν(C=N) ring	1607	1607	1607	1607
ν(C=N)	1613	1613	1613	1613
ν(N-N)	999	1043	1038	1008
ν(N-N)	947	977	996	949
ν(M-N)	-	468	470	476
ν(M-N)	-	463	484	486
ν(M-Cl)	-	353	361	366

Tables 3 IR spectral bands of the ligands and their metal complexes (cm⁻¹) Schiff base ligand L² (TIDDFO) and It's Fe (III), Ru (III) and Rh (III) metal complexes

Tentative assignments	L ² (TIDDFO)	Fe(III) Complex	Ru(III) Complex	Rh(III) Complex
ν(N-C=N)	1579	1569	1559	1549
ν(-CH ₂ -C=N)	1592	1582	1572	1562
ν(C=O)	1684	1677	1664	1657
Indole ring NH	3209	3209	3209	3209
ν(C=N) ring	1604	1604	1604	1604
ν(M-N)	481	498	470	482
ν(M-N)	462	477	485	495
ν(N-N)	989	1022	1035	1005
ν(M-Cl)	-	351	361	371

Mass Spectral Data

For valuable structural information, the ligands and their complexes of Ru (III) are investigated by mass spectrometric measurement. Appearance of the peak at m/z 497 and m/z 485 in free ligands, which is equivalent to its molecular weights. For Ru (III) complexes peak have been observed at m/z 704 and m/z 696, which is equivalent to its molecular weight of the complexes.

¹H NMR spectral data

The ¹H NMR data of ligands L¹ and L² and their Ru (III) complexes were recorded in DMSO-d⁶. The proton peak of N-H group at δ 10.0 and δ 9.8 ppm remains at same position in ligand L¹ and in the Ru(III) complex which suggests that de-protonation do not occurred (Savita and Singh, 2015). Significant azomethine proton signal due to HC=N was

observed at δ 9.1 and δ 8.9 ppm in Schiff base ligand L^1 . On complexation the position of this signal is shifted to δ 9.6 and δ 9.4 ppm. It indicates that azomethine nitrogen involved in coordination. The multiplet of aromatic protons is seen at δ 6.3-7.3 ppm in ligand L^1 , but in Ru (III) complex multiplet is seen at δ 6.5-7.5 (Monika and Sulekh, 2012). The ^1H NMR spectra of ligand L^2 displayed singlets each at 10.50, 2.21, 2.30 and 1.3 ppm respectively, due to the 1 proton of amide NH, 4 protons of $-\text{CCH}_2\text{CCH}_2-$, 2 protons of $-\text{CCH}_2\text{C}-$, 6 methyl protons respectively. The position of this singlet remains unchanged in Ru (III) complex. The aromatic protons of ligand L^2 resonated as multiplets in the region 7.0-7.6, but in Ru (III) complex multiplet is seen at δ 7.8-8.4 (Siddappa and Nabiya sultana mayana, 2014).

Table 4 The antimicrobial activity of Schiff base ligands L^1 (IMHMBHB) and L^2 (TIDDFO) and their Fe (III), Ru (III) and Rh (III) metal complexes evaluated by (mm)

Compounds	Zone of inhibition in mm				
	Antibacterial activity			Antifungal activity	
	B. subtilis	Proteus vulgaris	Shigella flexneri	F. solani	Candida krusiae / Candida parasilopsis
L^1 (IMHMBHB)	9	8	7	11	10 / 12
Fe(III) complex	28	29	23	21	25 / 27
Ru(III) complex	37	34	32	42	41 / 44
Rh(III) complex	35	33	33	41	42 / 40
L^2 (TIDDFO)	7	9	10	8	12 / 13
Fe(III) complex	22	20	24	22	26 / 28
Ru(III) complex	37	38	31	42	43 / 43
Rh(III) complex	36	36	30	43	41 / 44
Ciprofloxacin	39	40	34	-	- / -
Amphotericin	-	-	-	44	45 / 46

ESR Spectral Data

The ESR spectra of Ru (III) complexes of ligands L^1 and L^2 provide information about the metal ion environment. The ESR spectra of the Ru (III) complexes of ligands L^1 and L^2 recorded at room temperature. Ru (III) complexes of ligands L^1 and L^2 possess g_{\parallel} value of 2.226 and 2.196 and g_{\perp} value of 2.048 and 2.032. The value of $g_{\parallel} > g_{\perp}$ and $g_{\parallel} > g_{\perp} > G$ (2.0023) suggests the presence of unpaired electron predominantly in the $d_{x^2-y^2}$ orbital. The deviation of calculated g_{av} (2.108 and 2.086) from that of the free electron (2.0023) is due to covalent character of metal – ligand bond. The g_{\parallel} value less than 2.3 indicates covalent environment. Based on these observations Ru (III) complexes of ligands L^1 and L^2 may have octahedral geometry (Anil *et al.*, 2015). The value of exchange interaction term G , for the present Ru (III) complexes of ligands L^1 and L^2 are 4.867 and 6.613, indicating exchange interaction between the ruthanium centers is negligible (Kavitha *et al.*, 2015).

Thermal Analysis Data

The thermal decomposition of Ru (III) complexes of Schiff base ligands L^1 (IMHMBHB) and L^2 (TIDDFO) were investigated. The TGA and DTA curves indicate that the decomposition is a multiple step process and that the final residual weight corresponds to the metal oxide. The Ru (III) complexes of ligand L^1 (IMHMBHB) decomposed in three steps with the temperature ranges from 293-599°C corresponding to the loss of three chloride, one bromide molecules, $\text{C}_6\text{H}_4\text{N}$ and $\text{C}_9\text{H}_7\text{N}$, respectively. The thermal decomposition of the Ru(III) complex of Schiff's base ligand L^2 (TIDDFO) proceeds with three degradation steps with the temperature ranges from 201-460°C corresponding to the loss

of Loss of three chloride and one fluoride molecules, $\text{C}_3\text{H}_6\text{O}_2$, $\text{C}_8\text{H}_4\text{N}_2$ and CNS, respectively (Usharani *et al.*, 2013).

Pharmacological Results

The Results of the Antimicrobial Screening

The Antimicrobial study for the synthesized compounds was performed on three bacterial and three fungal strains. The toxicity of the complexes was found to be enhanced than the Schiff base ligands L^1 (IMHMBHB) and L^2 (TIDDFO) due to the theory of Tweedy (Tweedy, 1964). This is almost certainly owing to the superior lipophilic nature of the complexes. Such augmented activity of the metal chelates can be explained on the basis of Overtone's notion and chelation hypothesis (Suresh and Prakash, 2011).

DNA Cleavage Efficiency

Schiff base ligand L^1 :(IMHMBHB), Fe(III), Ru(III) and Rh(III) complexes, and Schiff base ligand L^2 :(TIDDFO), Fe(III), Ru(III) and Rh(III) complexes were studied for their DNA cleavage activity by agarose gel electrophoresis against calf-thymus DNA and the gel picture showing cleavage is depicted in Figure 3. The DNA-cleavage study by electrophoresis analysis clearly revealed that the Schiff base ligands L^1 (IMHMBHB) and L^2 (TIDDFO), Fe(III) metal complexes (Lane - NA4, NA5) showed partial cleavage, whereas lane Ru(II) and Rh(II) (Lane - NA1, NA2, NA3 and NA6) complexes of L^1 and L^2 showed complete cleavage of DNA (Sangamesh *et al.*, 2014).

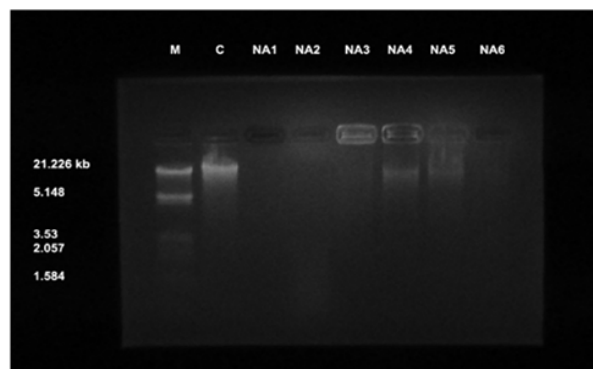
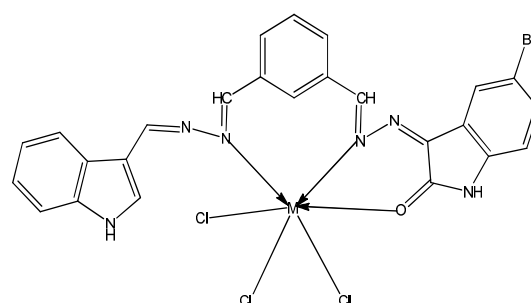
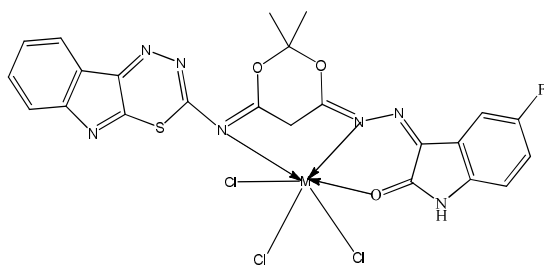


Figure 3 Gel picture showing the DNA cleavage analysis of samples



M = Fe(III), Ru(III) and Rh(III) complexes

Figures 4 Proposed structures for the metal complexes (M = Fe (III), Ru (III) and Rh (III)) of the Schiff base Ligands L^1 (IMHMBHB).



M = Fe(III), Ru(III) and Rh(III) complexes

Figure 5 Proposed structures for the metal complexes (M = Fe (III), Ru (III) and Rh (III)) of the Schiff base Ligands L² (TIDDFO).

Anti-TB Results

The Tubercular activity of synthesized Schiff base ligands L¹ (IMHMBHB) and L² (TIDDFO) and their Fe (III), Ru(III) and Rh(III) metal complexes were screened against *M. Tuberculosis* H37RV strain in the Middle Brook 7H9 (MB7H9 Broth) by using Pyrazinamide, Streptomycin and Ciprofloxacin as standard drug. Results are given in Table 5. The results of Anti tubercular activity revealed that Fe(III), Ru(III) and Rh(III) metal complexes (Anti-TB activity found from 25 to 100 µg/ml) showed significantly enhanced Anti-TB Activity against *M. Tuberculosis* in comparison to the free ligands (Anti-TB activity found from 50 to 100 µg/ml) (Rajkumar *et al.*, 2014).

Table 5 Anti Tubercular activity of Schiff base ligands L¹: (IMHMBHB) and L²: (TIDDFO) and their Fe (III), Ru (III) and Rh (III) metal complexes

Sl. No.	Samples	100 µg/ml	50 µg/ml	25 µg/ml	12.5 µg/ml	6.25 µg/ml	3.12 µg/ml	1.6 µg/ml	0.8 µg/ml
1	L ¹ (IMHMBHB)	S	S	R	R	R	R	R	R
2	Fe(III) Complex	S	S	S	R	R	R	R	R
3	Ru(III) Complex	S	S	R	R	R	R	R	R
4	Rh(III) Complex	S	S	S	R	R	R	R	R
5	L ² (TIDDFO)	S	S	R	R	R	R	R	R
6	Fe(III) Complex	S	S	S	R	R	R	R	R
7	Ru(III) Complex	S	S	S	R	R	R	R	R
8	Rh(III) Complex	S	S	S	R	R	R	R	R

S - Sensitive; R - Resistant; Strain used: *M. tuberculosis* (H37 RV strain); ATCC No- 27294. : Here are the standard values for the Anti-Tb test which was performed. : Pyrazinamide- 3.125µg/ml; Streptomycin- 6.25µg/ml; Ciprofloxacin- 3.125µg/ml

Anticancer Activity Results

To investigate the proliferation-inhibitory effect of newly synthesis compounds, human ovarian cancer cells were treated with Schiff base ligands L¹ (IMHMBHB) and L² (TIDDFO) and their Fe(III), Ru(III) and Rh(III) metal complexes were dissolved in DMSO in different concentrations followed by 3-[4,5-dimethylthiazol-2-yl]-2,5-diphenyl-tetrazolium bromide (MTT) assay. Cells treated with DMSO were used as solvent control. We found that Schiff base ligands L¹ (IMHMBHB) and L² (TIDDFO) and their Fe (III), Ru (III) and Rh (III) metal complexes (sample code: NG1, NG2, NG3, NGB1, NGB2 and NGB3) were potentially inhibited cellular proliferation. Moreover, the complexes had more significant anti-proliferative activity compared with the ligands (sample code: NG and NB) (Li *et al.*, 2015). Results are given in Table 6.

Table 6 Cytotoxicity activity of Schiff base ligands L¹: (IMHMBHB) and L²: (TIDDFO) and their Fe (III), Ru (III) and Rh (III) metal complexes

S. No.	Sample	Concentration	Absorbance (nm)	Results as observed	IC ₅₀ (µg/ml)
1.		10	0.679	No lysis	
2.		20	0.682	No lysis	
3.		30	0.686	No lysis	
4.	NG	40	0.688	No lysis	50 µg
5.		50	0.703	100% lysis	
6.		10	0.721	No lysis	
7.		20	0.728	No lysis	
8.		30	0.832	100% lysis	
9.	NG ₁	40	0.849	100% lysis	30 µg
10.		50	0.955	100% lysis	
11.		10	1.126	100% lysis	
12.		20	1.258	100% lysis	
13.		30	1.359	100% lysis	
14.	NG ₂	40	1.487	100% lysis	< 10 µg
15.		50	1.589	100% lysis	
16.		10	0.679	No lysis	
17.		20	0.882	100% lysis	
18.		30	0.926	100% lysis	
19.	NG ₃	40	0.999	100% lysis	20 µg
20.		50	1.023	100% lysis	
21.		10	0.899	No lysis	
22.		20	0.923	No lysis	
23.		30	0.925	No lysis	
24.	NB	40	0.932	No lysis	50 µg
25.		50	1.289	100% lysis	
26.		10	0.619	No lysis	
27.		20	0.622	No lysis	
28.		30	0.830	100% lysis	
29.	NGB ₁	40	0.900	100% lysis	30 µg
30.		50	1.126	100% lysis	
31.		10	1.658	100% lysis	
32.		20	1.785	100% lysis	
33.		30	1.897	100% lysis	
34.	NGB ₂	40	1.968	100% lysis	< 10 µg
35.		50	1.999	100% lysis	
36.		10	0.655	No lysis	
37.		20	1.059	100% lysis	
38.		30	1.259	100% lysis	
39.	NGB ₃	40	1.325	100% lysis	20 µg
40.		50	1.529	100% lysis	
41.	Control	-	0.428	No lysis	-

CONCLUSION

In the present paper is reported the synthesis, characterization and biological activities of the synthesized Schiff base ligands L¹ (IMHMBHB) and L² (TIDDFO) and their Fe (III), Ru (III) and Rh (III) metal complexes were reported. The analytical data show that metal: ligand ratio in all these complexes was 1:1. The spectra data of Fe (III), Ru (III) and Rh (III) metal complexes led to the assignment of octahedral geometry respectively (Figures 4 and 5). The screening of pharmacological data revealed that all the synthesized compounds show good pharmacological activities.

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