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Synthesis, characterization, antimicrobial and dna interaction studies of benzophenone – ethanamine schiff base with transition metal (II) [Cu(II), Co(II), Mn(II) and Ni(II)] complexes

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ABSTRACT

The present study deals with a biologically important transition metal complexes. The complex containing Cu(II), Co(II), Mn(II) and Ni(II) ions were synthesised by using 2,2-diphenylethanamine and 2-hydroxy-4-methoxy benzophenone. The ligand and complexes were characterised separately by microanalytical, IR, NMR, UV-Visible, Cyclic voltammetry and the EPR spectroscopic techniques. The spectral data confirm the ligand acts as a neutral bidendate Schiff base, coordinating through azomethine nitrogen and oxygen atom of hydroxyl group. The interaction studies of these complexes with CT-DNA have also been performed by using spectral and electrophoresis techniques collectively indicated of the evidences for groove binding of DNA with metal complexes. In addition, the complexes showed their efficient antimicrobial activities against bacteria (Escherichia coli & Staphylococcus aureus).

Key words: Diphenylethanamine, Schiff bases, transition metal(II) chelates, DNA binding and cleavage studies, antimicrobial activity.

INTRODUCTION

Diphenyl ethanamine is a molecule that possesses various biological activities due to its neuro morphological and neuro chemical properties. Nitrogen containing heterocyclic compound has been widely used as medicinal compounds for the past few decades, which form the basis for many common drugs like morphine (analgesics). The novel structure of the certain compound makes it a desirable synthetic target, for the investigation of related heterocyclic compounds with improved levels of bioactivity. The present study could also deals with structure activity relationship study of the compounds with various bioactivities. Anticonvulsant drugs used for the treatment of epilepsy are effective for the management of certain pain such as trigeminal neuralgia (loser, 1994) and central/ post stroke pain. Benzophenone is a compound used in the manufacture of insecticides and agricultural chemicals, hypnotics, antihistamines and other pharmaceuticals; as an additive in plastics, coatings and adhesive formulations; and occasionally, as a flavour ingredient. It is significance to design and synthesize highly fluorescent organic dyes due to their fascinating functions as fluorescence sensors [1-5], and biomarkers [6-8]. Biologically important benzophenone based Schiff bases and their derivatives are used as sunscreens for humans [9]. These compounds were also known to be absorbed through skin and bio accumulated in wildlife and human [10-14]. Schiff bases are an important class of compounds widely used in medicinal and pharmaceutical field.

In this context, new Schiff base ligand and their transition metal complexes were prepared and characterised by UV-Vis, IR, NMR, Electrochemical analyser and EPR spectroscopy. Furthermore, we have investigated the DNA binding property of the complexes by using spectral and gel electrophoresis techniques.

EXPERIMENTAL SECTION

2.1. Materials and Methods

All chemicals and solvents used in this study were of AR grade. 2-hydroxy / 2,4-dihydroxy / 2-hydroxy-4-methoxy benzaldehyde (Sigma Aldrich), 2,2-diphenylethanamine (Sigma Aldrich), transition metal ions [Copper(II)chloride, Cobalt(II)chloride, Nickel(II)chloride and Manganese(II)sulphate] (Merck), Calf thymus DNA (Sigma), Tris–hydrochloride (SRL) and sodium chloride (SRL) were used as such without further purification.

Elemental analyses (C, H & N) were performed using an Elementary Vario EL elemental analyzer CHNS Mode. Metal contents were determined volumetrically by titration against standard EDTA solution after complete decomposition of their complexes with concentrated nitric acid. The chlorine content was determined by Volhard test. Molar conductivities of the metal complexes were determined in DMSO (~10^{-2}M) at room temperature using an EI Model 611E digital conductivity meter. The magnetic susceptibilities of complexes were determined on Gouy balance, and the diamagnetic corrections were made by Pascal's constant and $CuSO_4.5H_2O$ was used as a calibrant. Electrospray Ionization Mass Spectrometry (ESI-MS) analyses were recorded in LCQ Fleet (Thermo Fisher Instruments Limited, USA). Nuclear magnetic resonance spectroscopic measurements were made on a Perkin–Elmer 300 MHz spectrometer. Duetrated organic solvents along with tetramethylsilane (TMS) as the internal standard were used. UV–Vis spectral measurements for the present complexes were made in DMSO solution using JASCO double beam recording spectrophotometer in the range 190–1100 nm. The infrared spectra of all complexes as well as ligands were recorded using KBr pellets on a JASCO FT-IR 410 double beam infrared spectrophotometer in the range of 400–4000 cm^{-1}. Electron paramagnetic resonance spectra of the copper complexes were obtained on a Jeol-300MHz EPR spectrometer. The spectra were recorded for the complexes as solid forms at room temperature (RT) and solutions of complexes dissolved in acetonitrile at 77 K. 2,2-diphenyl-1-picrylhydrazyl (DPPH) was used as the field marker. Cyclic voltammetric measurements were carried out on a Bio-Analytical System (BAS) CV-50W model electrochemical analyser. The three electrodes cell comprising of a reference Ag/AgCl, counter electrode as platinum wire and working glassy carbon (GC) electrodes with surface area of 0.07 cm^2 were used. The GC was polished with 0.3 and 0.005 mm alumina before each experiment and if necessary the electrode was sonicated in distilled water for 10 min. Dissolved oxygen was removed by purging pure nitrogen gas into the solution for about 15 min before each experiment. A cyclic voltammogram has been recorded for a blank solution to check the purity of the supporting electrolyte and the solvent.

2.2. DNA interaction studies:

2.2.1. Electronic absorption spectra

The DNA binding experiments of the metal complexes with CT-DNA were carried out in Tris buffer (5mM, pH 7.1). A solution of CT-DNA in the buffer gave a ratio of UV-Vis absorbance at 260 and 280 nm of about 1.9:1, indicating that the DNA was sufficiently free from protein. The DNA concentration per nucleotide and polynucleotide concentrations were determined by absorption spectroscopy using the molar extinction coefficient (6600 M^{-1} cm^{-1}) at 260 nm. The intrinsic binding constant K_b for the interaction of these metal complexes with DNA has been calculated from the absorption spectral changes during the addition of increasing concentration of DNA by, the following equation (1)

$$[DNA]/(\varepsilon_a-\varepsilon_f) = [DNA] / (\varepsilon_b-\varepsilon_f) +1 / K_b(\varepsilon_b-\varepsilon_f) \text{ ---------- (1)}$$

Where [DNA] is the concentration of DNA in base pairs, the apparent absorption coefficient ε_a, ε_f and ε_b correspond to A_{obs} / [M], the extinction coefficient of the free and the extinction coefficient of the compound when fully bound to DNA, respectively. Plot of [DNA] / (ε_b-ε_f) vs [DNA] gave a straight line with a slope of 1/(ε_b-ε_f) and an intercept of 1/K_b(ε_b-ε_f)) and K_b was determined from the ratio of the slope to intercept.

2.2.2. CD spectra

CD spectra of DNA in presence and absence of all the complexes were recorded on a JASCO J-810 (163–900 nm) spectropolarimeter using a quartz cuvette of 1 mm optical path length at increasing complex/DNA ratio (r = 0.01–0.04). Each sample solution was scanned in the range of 220–320 nm. Every CD spectrum was collected after averaging over at least four accumulations using a scan speed of 100 nm min^{-1} and a 1s response time from which the buffer back ground had been subtracted [DNA] = 100 μM.

2.2.3. Gel electrophoresis

The cleavage of DNA in the presence of the activating agent H_2O_2 was monitored using agarose gel electrophoresis. In cleavage reactions, super coiled pUC19 DNA (500 ng) in 10% DMSO 5mM Tris–HCl– 50mM NaCl buffer at pH 7.2 was treated with Mn(II) complex. The samples were incubated for 1h duration at 37°C. A loading buffer containing 25% bromo phenol blue, 0.25% xylene cyanol and 30% glycerol (3 μL) was added and electrophoresis

was performed at 60V for 2h in Tris–acetate–EDTA (TAE) buffer (40 mM Tris-base; 20 mM acetic acid; 1 mM EDTA) using 1% agarose gel containing 1.0 μg mL^{-1} ethidium bromide. The cleavage products were irradiated at room temperature with a UV lamp (365 nm, 10 W) and analyzed with a Bio-Rad Model XI computer controlled electrophoresis power supply (Bio-Rad, USA).

2.3. Biological activity

2.3.1. Microbial activity of ligand and complexes

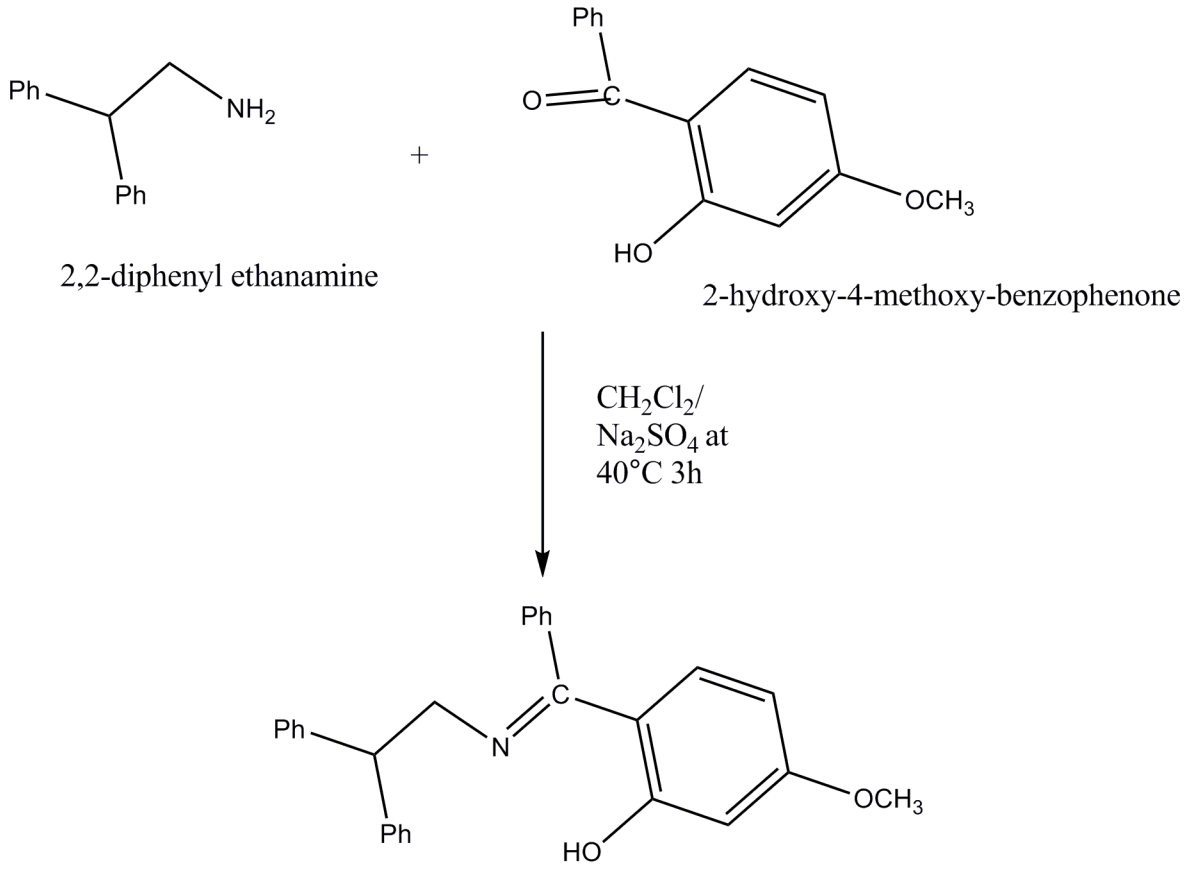
The synthesized ligand and its complexes were tested for their *in vitro* antimicrobial activity against the bacteria *Staphylococcus aureus and Escherichia coli* using agar well diffusion method Luria Bertani medium was used for testing antibacterial activity. The stock solutions (10^{-2} mol L^{-1}) of the compounds were prepared in DMSO and the zone of inhibition values of the compound were determined by serial dilution method. For determination of zone of inhibition, the respective medium was poured into the petriplates and allowed to solidify at room temperature. Wells were made on the solidified medium and the serially diluted were added on to the wells and allowed to diffuse into the wells. The indicator organisms were overlaid on to the agar medium and the plates were incubated for 37°C for 48 h. After incubation the zone of inhibition by the compound were measured and zone of inhibition was determined.

2.4. Synthesis

2.4.1. Synthesis of Schiff's base ligand

(0.98g, 0.005M) of diphenyl ethanamine and (1.14g, 0.005M) of 2-hydroxy-4-methoxy benzophenone was dissolved in dichloromethane (25ml). The reaction mixture was refluxed in water bath at 40°C for 3hours in the presence of anhydrous sodium sulfate until the yellow color homogeneous liquid solution was obtained and the completion of the reaction was monitored by TLC. The solid was washed 2 to 3 times with dichloromethane, evaporated to dryness and then recrystallised by ethanol. (65%) (Scheme.1)

Scheme-1

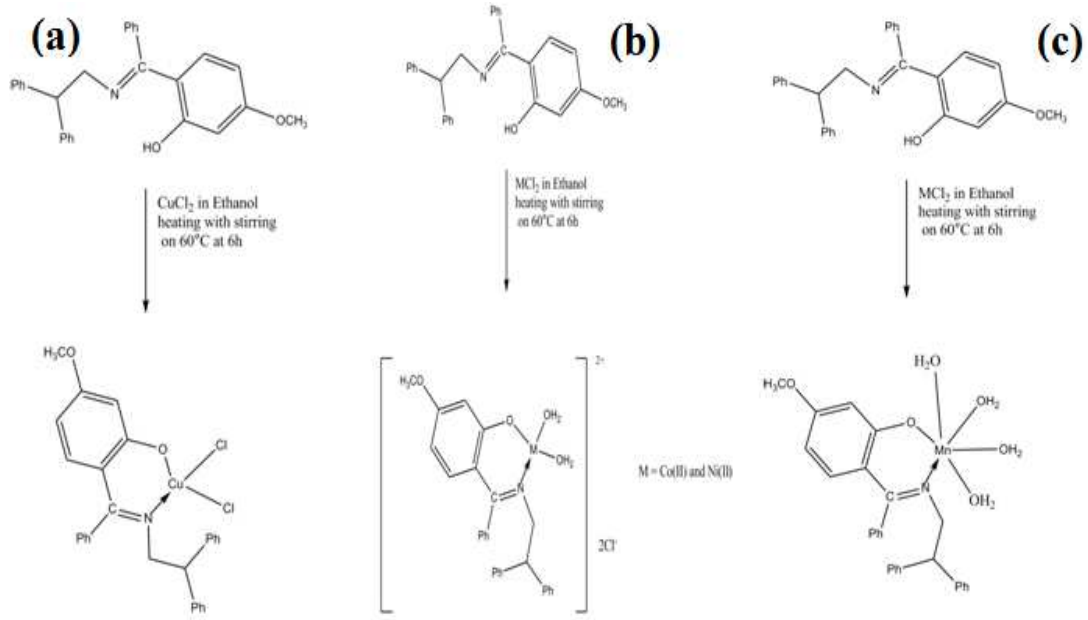


Scheme.1. Synthesis of 2-((2,2-diphenylethylimino)(phenyl)methyl-5-methoxyphenol

2.4.2. Synthesis of the transition metal complexes

The present metal complexes were prepared by mixing of 0.01M of corresponding transition metal chloride in ethanol with 0.01M of the Schiff's base. The reaction mixture was heating with stirring on 60°C at 6 h. Then it was

allowed to cool to room temperature. The solid complexes were filtered, washed with ethanol, recrystallised from ethanol and dried in a vacuum.



Scheme.2 Synthesis of metal complexes

RESULTS AND DISCUSSION

Elemental analysis data and physical characteristics of Schiff's base ligand and complexes are summarized in Table.1. The observed very high molar conductance of the Co and Ni complexes in DMSO for 10^{-2}M solution at room temperature was consistent with electrolytic nature of the complexes.

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

Schiff base compounds Ligand and complexes	Colour	Found (Cal)%					Molar conductance λ_m	Magnetic moment μ_{eff} (B.M)	M.P
		M	C	H	N	Cl	Scm^2/mole		°C
DPMMP	Yellow	-	82.29 (82.53)	6.34 (6.18)	3.30 (3.44)	-		-	135
(DPMMP):Cu	green	7.88 (8.07)	61.36 (62.17)	4.36 (4.47)	2.55 (2.59)	12.09 (13.11)	91.7	1.86	-
(DPMMP):Co	green	5.96 (6.01)	65.64 (68.64)	5.32 (5.45)	2.70 (2.86)	7.12 (7.24)	142.0	-	-
(DPMMP):Mn	Light brown	9.79 (10.02)	61.29 (63.50)	5.58 (6.43)	2.54 (2.55)	-	-	5.84	-
(DPMMP):Ni	Light Green	9.35 (10.26)	54.36 (58.78)	4.59 (4.93)	2.32 (2.45)	11.12 (12.39)	151.1	-	-

3.1. ^{1}HNMR Spectra

The ^{1}H NMR spectra of synthesised compounds showed that specific signals on characterization of DPMMP ligand [Fig.1(a)]. Signals of the aromatic protons lie in the range of 6.1 to 7.4 ppm. The presence of signal at δ 3.7 and 4.3 ppm in ethanamine is due to C-H and C-H_2 protons. The presence of signal at δ 16 ppm is due to O-H protons.

3.2. ^{13}C NMR spectra

The ^{13}C NMR [Fig.1(b)] spectrum consists of sharp signals at δ 52ppm and 55 ppm are due to the ethanamine carbon atoms of CH_2 and CH, while signals at δ 101 – 139 ppm may be attributed to the phenyl carbon atoms and the signals C=N carbon assigned at δ 142ppm and C-OH carbon assigned at δ 163 ppm.

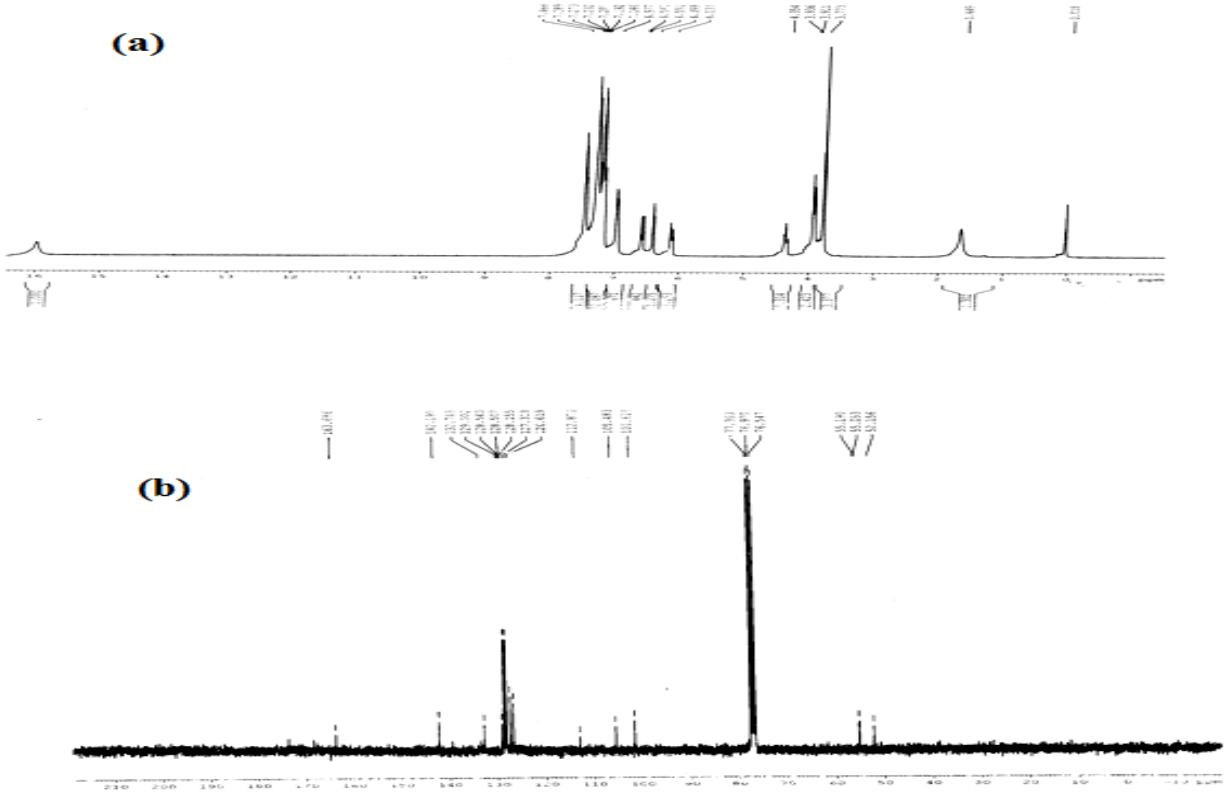


Fig.1. (a) ^{1}H NMR and (b) ^{13}C NMR spectra of DPMMP recorded in $CDCl_3$

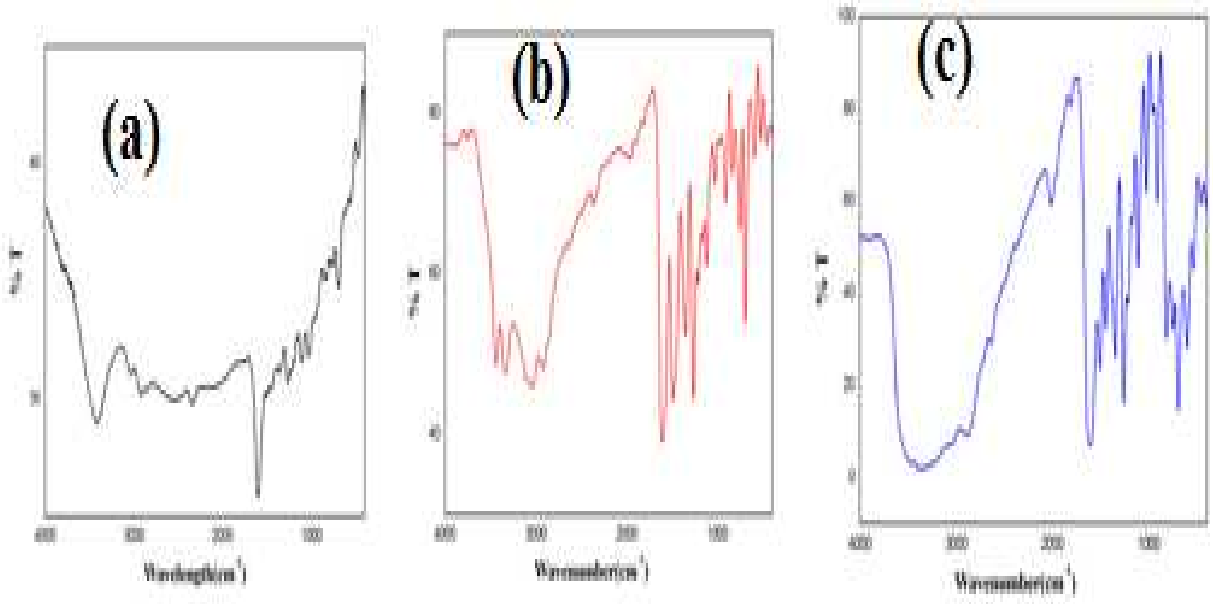
3.3. Infrared spectroscopy

The IR spectrum of the ligand L [Fig.2] showed a broad band at 3417cm^{-1} and 1598 cm^{-1} due to the stretching vibrations of hydroxyl groups and the azomethine groups, the data were tabulated in table.2. The IR spectra of complexes exhibit a broad band around 3365 cm^{-1} assigned to γ(OH) of water molecules associated with the complex except copper confirmed by elemental and thermal analyses. The IR spectra of the complexes showed a shift in the γ(C=N) band towards higher wave numbers of 1635cm^{-1} compared with the free ligand band at 1598 cm^{-1}. This shift indicates coordination of the azomethine groups with the metal ions [15]. It is expected that coordination of nitrogen to the metal atom would reduce the electron density in the azomethine absorption. New bands, which are not present in the ligand appeared around 601 - 698 cm^{-1}, corresponding to γ(M-N) [16,17] and 534-603 cm^{-1} to γ(M-O) vibrations support the involvement of N and O atoms in coordination with metal centre [18].

Table: 2. IR spectral data of Ligand and complexes

Schiff base	γOH) cm^{-1}	γ(CH=N) cm^{-1}	γ(M-N) cm^{-1}	γ (M-O) cm^{-1}
DPMMP	3417	1598	-	-
DPMMP: Cu	-	1622	698	603
DPMMP: Co	3396	1600	617	545
DPMMP: Mn	3385	1602	615	543
DPMMP: Ni	3367	1635	601	534

Fig.2. IR spectra of (a) DPMMP, (b) DPMMP:Cu and (c) DPMMP :Ni complexes



3.4. Electronic Spectrum of Ligand and transition metal complexes

The electronic spectrum of the ligand (10^{-3} M in DMSO), showed mainly three bands at 35714, 32154 and 25380 cm^{-1}due to of the presence of phenyl ring and n-π* transition within the C=N group (Table: 3) [19] and the electronic spectrum of ligand was shown in (Fig. 3). The electronic spectrum of (DPMMP):Cu complex showed the absorption band at 16,339 cm^{-1}. The geometry of the Cu(II) complex is confirmed the Square planar geometry(20,21). The electronic spectra of $(DMMP)_2Co$ complex showed two spin-allowed transitions at 14,749 cm^{-1} assignable in conformity with square planar arrangements in Fig.3 [22]. The spectral band of complex (DPMMP):Mn at 14,204 cm^{-1} is characteristic for an octahedral [23]. The nickel(II) complex of (DPMMP):Ni exhibits three d-d bands at 12,771 cm^{-1}, which arises from an square planar structure [24].

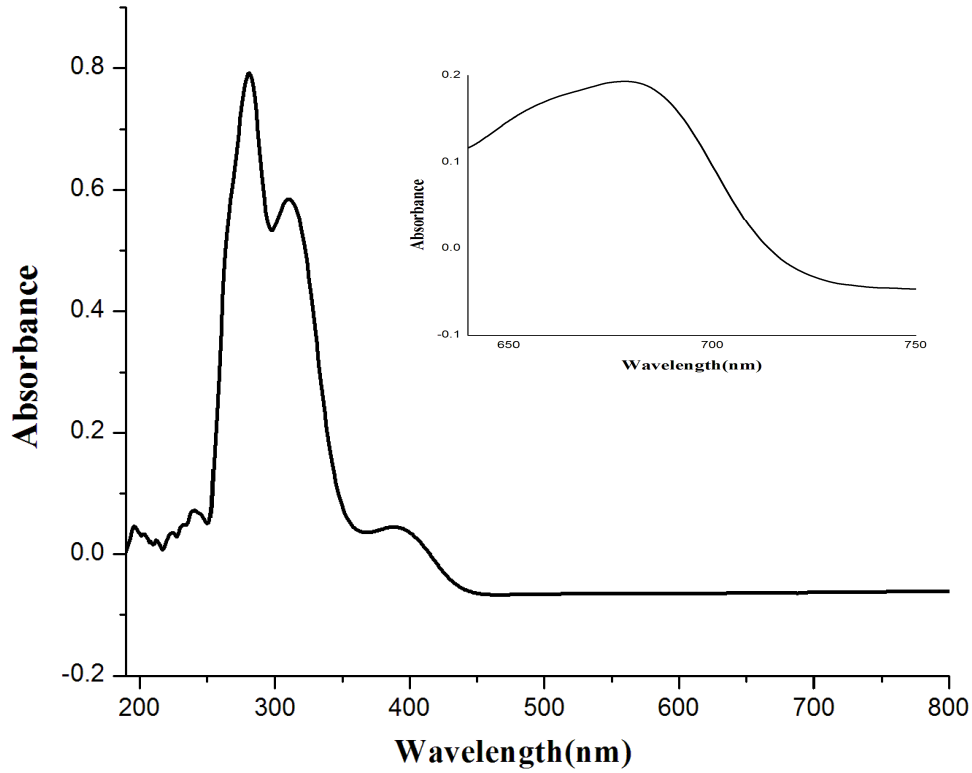


Fig.3. Electronic spectrum of DPMMP: Co

Table. 3. Electronic spectral data and assignments of ligand and their metal Complexes

Compound	$n - \pi^*$ cm^{-1}	$\pi - \pi^*$ cm^{-1}	$\pi - \pi^*$ cm^{-1}	υ_1 cm^{-1}	υ_2 cm^{-1}	υ_3 cm^{-1}
DPMMP	27,247	30,395	34,965	-	-	
DPMMP: Cu	25,252	29,585	34,129	16,339	-	
DPMMP: Co	25,575	32,154	35,587	16,260	14,705	
DPMMP:Mn	26,109	32,362	35,335	14,204	-	
DPMMP:Ni	26,041	-	34,246	19,157	14,164	12,771

3.5. Electro chemical studies

The electrochemical data of Cu(II) complex showed well defined redox couple corresponding to Cu(I)/(II). The catodic peak appearing in the 196mV and corresponding anodic peak appears in the 535mV. The measured ΔEp= -339mV (ΔEp= 312 -360mV) in (Fig.4) clearly indicate that these redox couples are a metal based irreversible reaction [25]

The cyclic voltammogram of cobalt(II) complex of (DPMMP):Co. The electrochemical data of the (DPMMP):Co complex showed one well defined redox couple corresponding to Co(II)/(III). The cathodic peak appearing in the 279mV and the corresponding anodic peak appears at 574mV of Co(III)/Co(II) redox couple. The ΔEp is -295mV. From this data it can be quasi reversible one electron process.

The electrochemical data are given in Table. 4. The (DPMMP):Mn complex showed a well defined redox couple corresponding to Mn(II/I) as expected. The catodic peak appearing in the 247mV corresponds to one electron reduction of Mn(I/II) and the corresponding anodic peak appears in the 548mV. The measured (ΔEp = -301mV) clearly indicate that these Mn(II) for the reduction to Mn(I) is limited through the formation of the Mn(II) complex.

Table:4. Electrochemical data of transition metal complexes at 25°C, v = 100mVs^{-1}

Complex	Epc	Epa	ΔEp	Ipa/Ipc
DPMMP:Cu	196	535	-339	0.53
DPMMP:Co	279	574	-295	0.81
DPMMP: Mn	247	548	-301	0.61

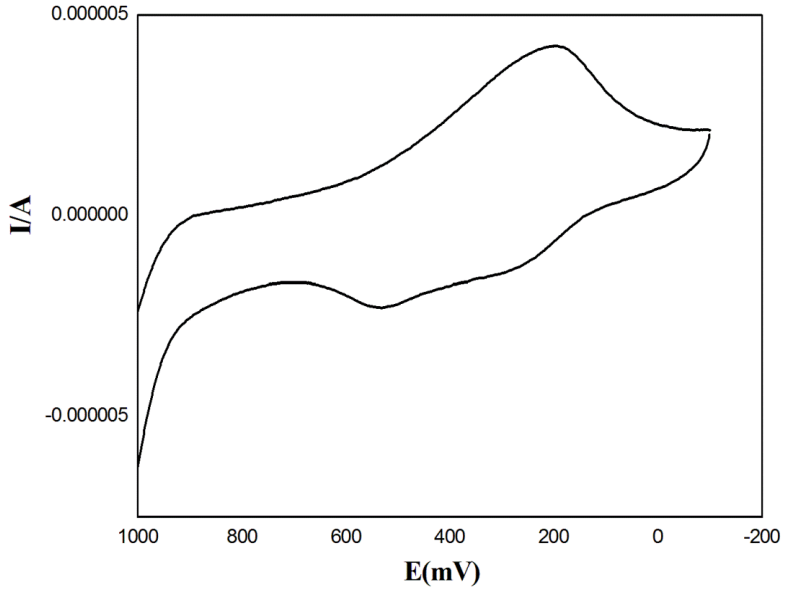


Fig. 4. Cyclic voltammogram of DPMMP:Cu

3.6. EPR Spectra

The EPR spectrum of copper(II) complex provides information, important in studying the metal ion environment. The EPR spectra recorded in DMSO at RT (room temperature) in Fig.5 . The spectrum o copper complex at RT showed that intense absorption band. The g values at $g_{\parallel} = 2.14$ and $g_{\perp} = 2.11$.

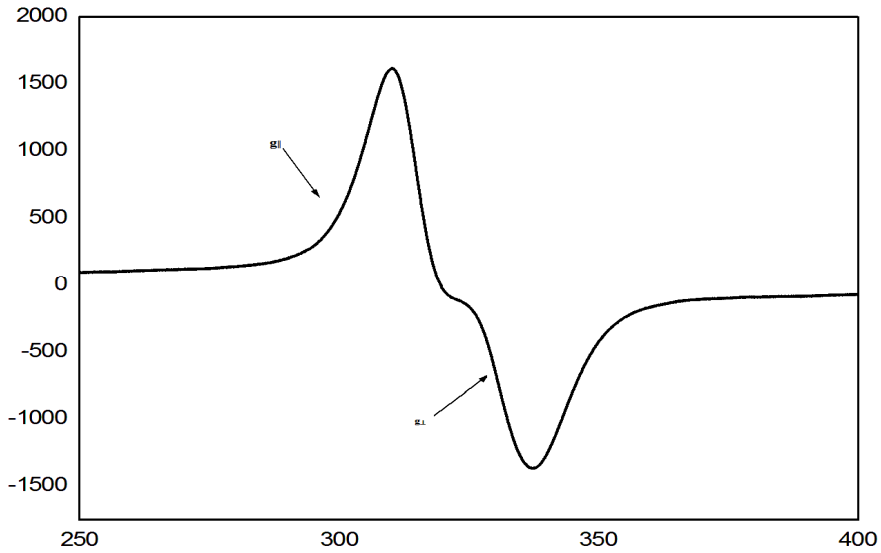


Fig.5. EPR spectra of DPMMP: Cu complex at RT

4.0. DNA Interaction studies

4.1.1. Absorption spectral experiments

This study attempted to unravel the DNA interactions with a small blue shift 8-22 nm indicating their binding with different modes to DNA. The absorption spectra showed the binding constant values listed in the table.5 and shown in figure 6 indicate a finite interaction between these complexes with CT-DNA, less than 10^7 M^{-1} facilitate the groove binding nature [26-29]. The complexes showed a good binding content which may be due to the additional oxygen atoms in this ligand skeleton which confirm a groove binding with CT-DNA [30-31].

The overall the binding constant, K_b is in the order DPMMP):Mn>(DPMMP):Ni>(DPMMP):Co suggesting the higher order of oxygen groups involved in the binding phenomena.

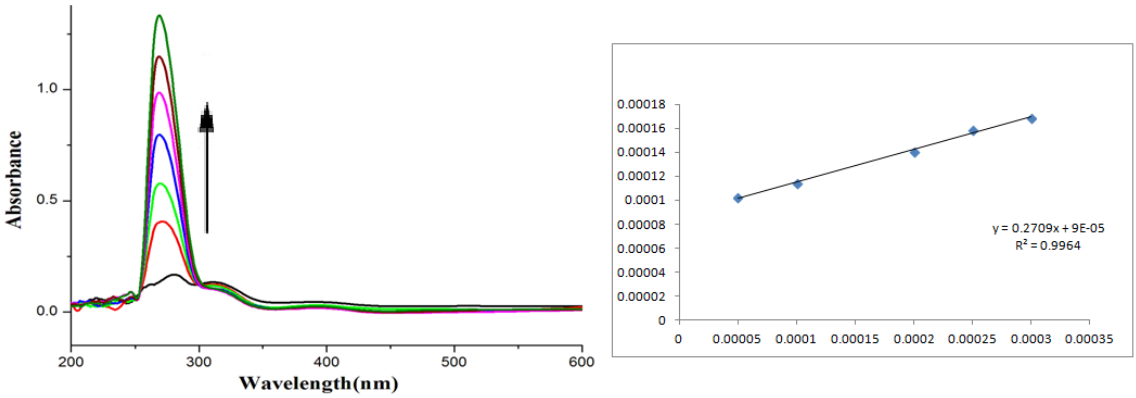


Fig.6. (a) Absorption spectra of complex 1 (1.0 x 10^{-5} M) (a), in Tris–HCl buffer pH 7.1 in the absence (R = 0) and presence (R = 0.5,1.0,1.5,2.0,2.5. . .) of increasing amounts of DNA.

R = [DNA]/[complex]. Arrow mark indicates the absorbance change upon increasing DNA concentration and binding constant plot

Table.5. Ligand-based absorption spectral properties of transition metal complexes, bound[a] to CT-DNA

Compound	λ_{max}	Blue Shift $\Delta\lambda$ (nm)	$\Delta\varepsilon$	K_b M^{-1} x 10^3
DPMMP: Co	281	8	0.78	0.438
DPMMP:Mn	280	9	0.70	0.977
DPMMP:Ni	292	22	0.78	0.974

[a]Measurements made at different R values, where R = [DNA]/[complex],concentrations of solutions of transition metal complexes in pH 7.1 in 10% DMSO–buffer solutions = (a: 0; b: 5,10,15….x10^{-5} molL^{-1}).

4.1.2. Circular dichroism

CD spectral variations of CT-DNA were recorded by the respective addition of the (DPMMP):Co complex to CT-DNA. Fig.7 shows the CD spectra of CT-DNA with the increasing addition to Co(II) complexs. In the CD spectra, the addition of (DPMMP):Co (r = 0.1–0.3) to the solution of DNA induced a increase in intensity in both positive and negative bands suggesting that the stacking mode and the orientation of base pairs in DNA were disturbed. The observed CD spectrum of calf thymus DNA consists of a positive band at 271 nm due to base stacking and a negative band at 248 nm due to helicity, the data are summarized in Table.V.6, which is characteristic of the right-handed B form DNA. This shift in positive and negative ellipticity band from 271 to 281 nm and 248 to 242 nm respectively supports this type of transformation and it is proposed that the in order to accommodate complex nature the conversion of B to A form of DNA [27] which has a groove to accommodate such molecules is effected on increasing the concentration of complex, the positive band at 278 nm and negative band at 249 nm are shifted to higher wavelength region. This effect is attributed to intra-stand linking of adjacent guanines so that the DNA conformation is modified and restacking of the adjacent bases occurs. This suggests that the DNA binding of the complexes induces certain conformational changes, such as the conversion from a more B-like to a more A-like structure with in the DNA molecule [28, 29]. Similar observations are also observed for all other complexes and indicate that the complexes interact with DNA. These changes are indicative of a non-intercalative mode of binding of these complexes and offer support to their groove binding nature [30].

Table:6. CD parameters for the interaction of CT-DNA with transition metal complexes bound[a] to CT-DNA

Compound	r	Positive band		Negative band	
		λ_{max}	CD (mdeg)	λ_{max}	CD (mdeg)
DNA	-	271	0.3994	248	-1.5992
DPMMP-Cu	0.10	276.5	0.8742	234.5	-1.1402
	0.20	272.5	0.4636	243	-1.1570
	0.30	271	0.4306	243	-1.2339
DPMMP-Co	0.10	281	0.2973	242	-1.1898
	0.20	279	0.2580	239	-1.0903
	0.30	272	1.0683	244	-0.7002
DPMMP-Mn	0.10	276.5	1.1825	240	-0.0352
	0.20	272	1.0080	242.5	-0.9892
	0.30	270	0.7215	243.5	-0.9202
DPMMP-Ni	0.10	270	1.2317	241	-0.1298
	0.20	268.5	1.2151	245.5	-0.1950
	0.30	270	0.8990	242	-0.3905

[a]*Measurements made at different r values, where r = [complex]/[DNA],[DNA] = 100 μM. Cell path length = 1 mm*

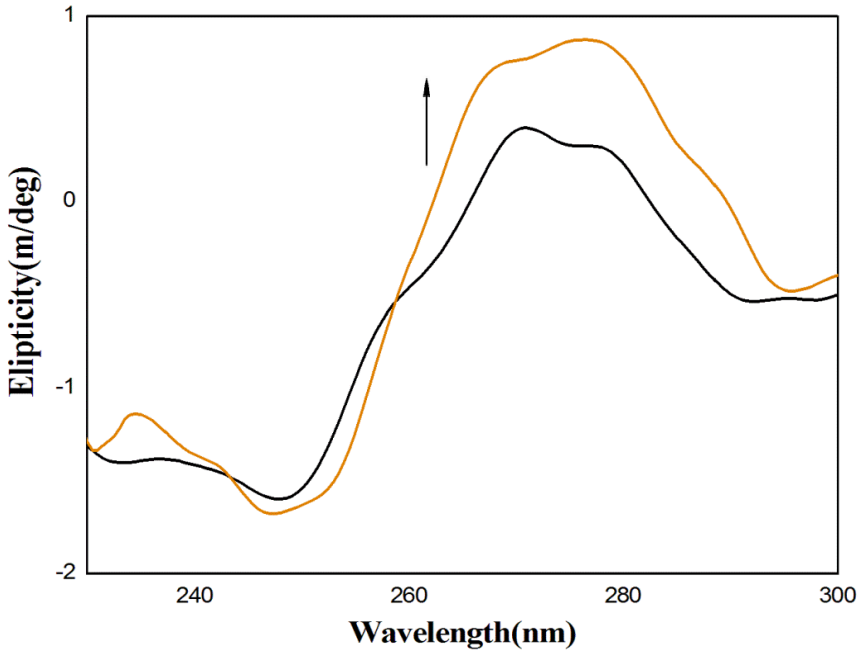


Fig.7 Circular dichroism spectra of CT-DNA in the absence (r = 0) and in presence of complexes (r = 1/R = 0 to 0.30); [CT-DNA] =100 μM. Cell path length = 1 mm.

Arrow mark indicates the molar ellipticity change upon increasing complex concentration.

4.1.3. DNA cleavage study

The DPMMP:Co, shows stronger DNA binding affinity and has the ability to change the B-form conformation, has been investigated by circular dichorism. There is a substantial and continuing interest in DNA endonucleolytic cleavage reactions that are activated by metal ions [31,33]. The interaction of Cu(II) complex with super coiled pUC19 DNA in 10% DMSO - 5mM Tris–HCl buffer pH 7.2 was studied by agarose gel electrophoresis. DNA (30 ng base pairs) was incubated with various concentrations of DPMMP:Co for 1h and then subjected to gel electrophoresis. When circular plasmid DNA is subjected to electrophoresis, relatively fast migration will be observed for the intact super coil form (Form I). Fig. 8 shows gel electrophoresis separation of pUC19 DNA after incubation with complex 1 without an oxidizing agent, H_2O_2. DNA cleavage was not observed for controls in which complex was absent, with increasing concentration (lanes 1–3), the intensity of Form I of pUC19 DNA diminishes gradually with concomitant increase of Form II.

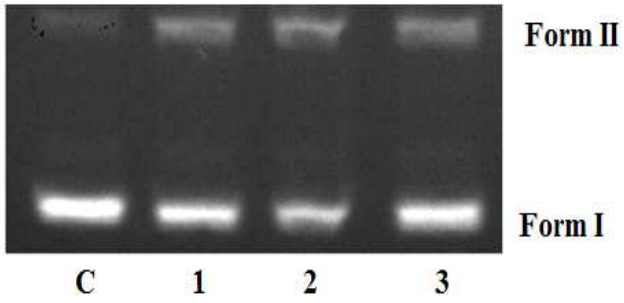


Fig.8. Agarose gel electrophoresis diagram showing the cleavage of SC pUC19 DNA (30 ng) by complex DPMMP:Co in Tris–HCl buffer 7.2.

Lane control: DNA
Lane 1: DNA+ 20μM ;
Lane 2: DNA+ 40 μM;
Lane 3: DNA+ 60μM

4.1.4. Microbial activity

Antibacterial activity of the ligand and complexes have been carried out against the gram positive bacteria like *Staphylococcus* and gram negative bacteria *E.Coli*, using disc method soluble in DMSO as solvent and an ampicillin as standard. The zone of inhibition values (Table.8 and Fig.9 &10) Incubation period of 24 h at 37°C, the metal complexes have a higher activity than that of the free ligand and the standard. The increased activity of the metal chelates can be explained on the basis of overtone's concept of cell permeability. Liposolubility is an important factor which controls the antimicrobial activity. On chelation, the polarity of the ligand orbital and partial sharing of positive charge of the metal ion with donor groups increases the delocalisation of π-electrons over the whole chelates ring and enhances the lipophilicity of the complex. This increased lipophilicity enhances the penetration of the complexes into lipid membrane and blocks the metal binding sites on enzymes of microorganisms.

Table.8. Antimicrobial activity Ligand and their complexes

Compounds	Zone of Inhibition (mm) *Staphylococcus aureus*	Zone of Inhibition (mm) *E.Coli*
DPMMP	-	12
DPMMP:Cu	18	17
DPMMP:Co	18	19
DPMMP:Mn	12	15
DPMMP:Ni	15	17
Control	8	10

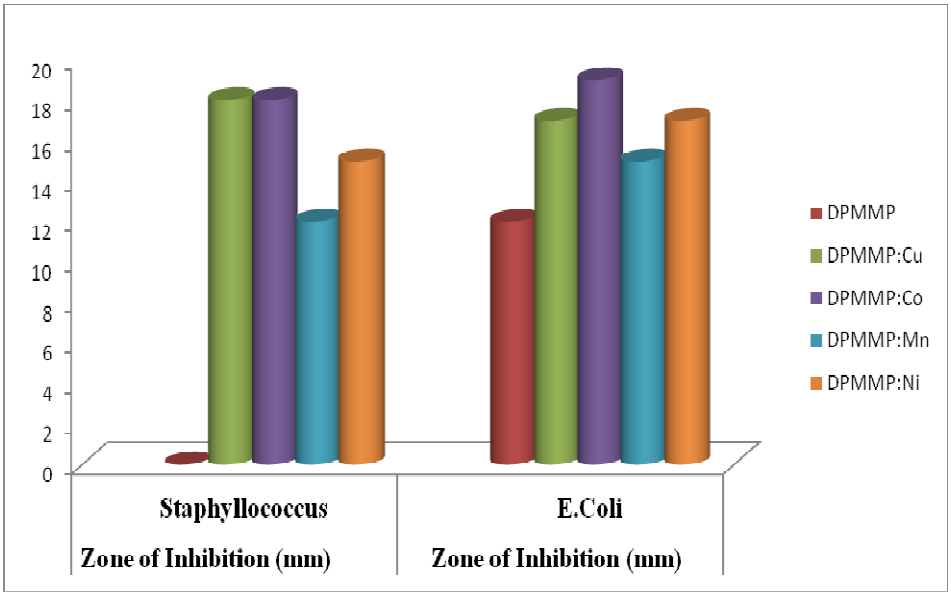


Fig.9. Antibacterial activity of ligand and complexes

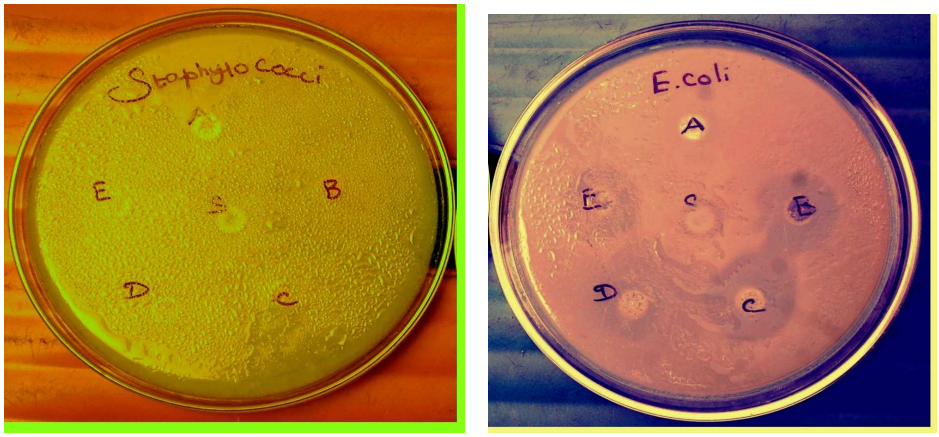


Fig.10 (a). *S.Coccus* and (b) *E.Coli* actions on ligand and complexes

CONCLUSION

♦ A new ligand and complexes using benzophenone based Schiff's base ligand has been synthesized and characterized by spectral and analytical data.

♦ The IR, electronic transition and g tensor data lead to the conclusion that the Cu(II) ion assumes a square planar geometry and the other complexes Ni(II), Co(II) and Mn(II) are octahedral in nature. In all the complexes, the ligand acts as bidendate.

♦ DNA binding properties of transition metal complexes have been exactly studied by different methods including spectral techniques. All the results suggest that the complex interaction with DNA is groove binding mode.

♦ The results of agarose gel electrophoresis indicate that the complexes exhibit cleavage capability of pUC19 DNA in the absence of oxidising agent.

♦ These studies consider significance as they further the intellectual capacity of binding of transition metal complexes to DNA and for developing the subsequently design of DNA binding.

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REFERENCES

[1] S.Yoon, AE Albers., AP.Wong, CJ. Chang, *J Am Chem Soc*, **2005**, 127(46), 16030 –16031.
[2] J.Hirano, K.Hamase, H.Miyata, K.Zaitsu, *J Fluoresc*, **2010**, 20, (2), 615 –624.
[3] KY. Pu, S. Pan, B. Liu, *J Phys Chem B*, **2008**, 112(31), 9295 –9300.
[4] L.Wang, X.Yang, M.Zhao, *J Fluoresc*, **2009**, 19(4), 593 –599.
[5] CD. Geddes, *J Fluoresc*, **2002**, 12(3), 343 –367.
[6] H. Mukundan, H. Xie, AS. Anderson, WK. Grace, JE. Shively, BI. Swanson, *Bioconj Chem*, **2009**, 20(2), 222 –230.
[7] Q. Liu, J. Liu, JC. Guo, XL. Yan, DH. Wang, L. Chen, FY. Yand, LG. Chen, *J Mater Chem*, **2009,** 19, 2018 –2025.
[8] J. Anderson, J. Nelson, C. Reynolds, D. Ringelberg, G. Tepper, D. Pestov, *J Fluoresc*, **2005**, 14(3), 269 –274.
[9] Knowland John, A. McKenzie Edward, J. McHugh Peter, A. Cridland Nigel, *FEBS Letters*, **1993**, 324(3), 309 –313.
[10] T. Felix, B.J. Hall, J.S.Brodbelt, *Anal. Chim. Acta*, **1998**, 371(2-3), 195 –203.
[11] U.Hagedorn-Leweke, B.C. Lippold, *Pharmacol. Res*, **1995**, 12(9), 1354 –1360.
[12] C.G.J.Hayden, M.S.Roberts, H.A.E.Benson, *Lancet*, **1997**, 350, 863 –864.
[13] R. Jiang, M.S. Roberts, D.M. Collins., H.A.E. Benson, *Br. J. Clin. Pharmacol*, **1999**, 48(4), 635 –637.
[14] Z.H.El-Wahab, A.Mashaly, M.Mahmoud, A.A.Salman, B.A.El-Shetary,
[15] A.A. Faheim, *Spectrochimica Acta A*, **2004**, 60(12), 2861 –2873.
[16] C.Zhang, C.Janiak, *J Chem. Cryst*, **2001**, 31, 29 –35.
[17] M. Thomas, M. K. M.Nair, P. K. Radhakrishnan, *Synth. React. Inorg. Met Org. Chem*, **1995**, 25, 471.
[18] K.Nakamoto, Infrared and Raman Spectra of inorganic and coordination comp Edition, Wile, New York, **1997.**
[19] A. Jain, R. Goyal, D.D. Agarwal, *J. Inorganic Nuclear Chem*, **198**1, 43, 2005 –2009.
[20] S. Zolezzi, E. Spodine, A. Decinti, *Polyhedron*, **2002**, 21, 55 –59.
[21] B.J. Hathaway, G. Wilkinson (Ed.), Comprehensive Coordination Chemistry, Pergamon Press, Oxford, **1987**, 5, 533–774.
[22] E.I. Solomon, W.P. Kevin, E.W. Dean, Structure and Bonding, Springer–Verlag, Berlin, **1983**, 3-21.
[23] S. Yamada, E. Ohno, Y. Kuge, A. Takeuchi, K. Yamanouchi, K. Iwasaki, *Coord. Chem. Rev*, **1968**, 3, 249.
[24] B.A. Goodman, J.B. Rayner , *Adv. Inorg. Chem. Radiochim*, **1978**, 35, 701 –712.
[25] K.F Purcell., J.C. Kotz, Inorganic Chemistry, 1st Edn., W.B. Saunders Company, London, **1977**, 596.
[26] J.P. Annaraj, K.M. Ponvel, P. Athappan, *Trans. Met. Chem*. **2004**, 29, 722 –727
[27] S. Satyanarayana, J.C. Daborusak, J.B. Chaires, *Biochemistry*, **1993,** 32, 2573–2584.
[28] C. C. Cheng, S. E. Rokita, C. J. Burrows, *Angew Chem. Int Ed. Engl*, **1993**, 32, 277–278.
[29] Y.Wang, N.Okabe, M. Odoko, *Chem. Pharm. Bull*, **2005**, 53(6), 1291–1295.
[30] P.U. Maheswari, M. Palaniandavar, *J. Inorg. Biochem*, **200**4, 98, 219–230.
[31] A.K.Patra, M.Nethaji, A.R. Chakravarthy, *J. Inorg. Biochem*, **2007**, 101, 233–244.
[32] P.X. Xi et al, *J. Inorg. Biochem*, **2009**, 103, 210–218.
[33] Z.Zhang, X.H.Qian, *Int. J. Biol. Macromol*, **2006**, 38(1), 59–64.