

## Transition Metal Complexes of Some Biologically Active Ligands; Synthesis Characterization and Bioactivities

SAEED-UR-REHMAN\*, NAUMAN ALI AND MUHAMMAD NISAR  
*Chemistry Department, Peshawar University, Peshawar, Pakistan.*

(Received 2<sup>nd</sup> July 2008, accepted in revised form 18<sup>th</sup> September 2008)

**Summary:** Transition/representative transition metals complexes of biologically active chelating agent 1,2-dipyrrolidinoethane were synthesized and characterized through spectral and analytical data. The complexes are of the formula  $[M(L)X_2]$ . Where (M = Co (II), Ni (II), Cu (II), Zn (II), Hg (II) and Cd (II) and X = Cl, Br, NO<sub>3</sub>). Tetrahedral geometry has been proposed to these metal complexes with the help of magnetic measurements, elemental analysis, chemical stoichiometry and spectroscopic data. Antibacterial activity of the ligand and its metal complexes were screened against *Eschereschi coli*, *Klebsiella pneumonia*, *Proteus mirabilis*, *Proteus vulhari*, *Streptococcus pneumonia*, *Salmonella typhi*, *Bacillus anthrax*, *Streptococcus fecalis* and *Staphylococcus aureus*. Metal complexes were found to be active against *Eschereschi coli*, *Klebsiella pneumonia*, *Proteus mirabilis* and *Proteus vulharis*.

### Introduction

In recent years the role of the inorganic compounds, possessing powerful enzyme inhibitory activity as compared to non-complexed biological active chelating agents, have increased tremendously and has open a new field for the development of biologically active coordination compounds [1-3]. It has also been demonstrated that chelation/complexation tends to make non-biologically active compounds into biological active ones and less biological active compounds to be more active [4, 5]. The ligands 1,2-dipyrrolidinoethane (DPYE), a modified form of diamine, contains biologically active unit pyrrolidine. The present work is concerned with the synthesis of ligands 1,2-dipyrrolidinoethane (DPYE) and its coordination behaviour with some transition and representative elements as shown in Fig. 1. The above mentioned ligand contains pyrrolidine moiety, which was widely found in natures, occurs in small quantities in carrots green (*Daucus carota*) [6-8], tobacco smoke [9] and in *Schizanthus integerifolius* [10]. Polyhydroxy fatty acids, a substituted pyrrolidine derivative were found active against antitumor activity [11] while some products of pyrrolidine were sedative and also having antitumor activity [12], Pyrrolidine and their derivatives have been used as ligands for the synthesis of number of complexes. The preparation of amine adducts of these mixed ligand complexes of Co (III) with morpholine, pyrrolidine, piperidine, monothiocarbamates and acetylaceton were

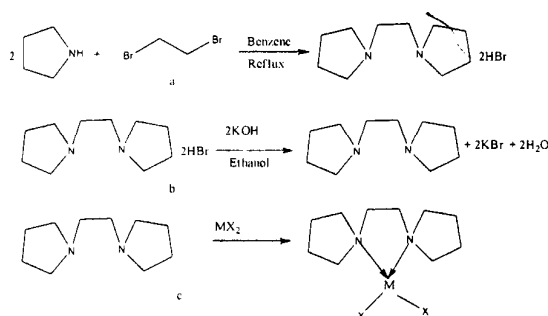


Fig. 1: (a) Scheme for the preparation of 1,2-dipyrrolidinoethane (DPYE). (b) Preparation of ligand solution for complex preparation. (c) Proposed structure of Metal-Complex, Where (M = Co (II), Ni (II), Cu (II), Zn (II), Hg (II) and Cd (II) and X = Cl<sup>-</sup>, Br<sup>-</sup>, NO<sub>3</sub><sup>-</sup>).

reported previously [13, 14]. The ligands under study (DPYE) could be viewed as N,N-di substituted ethylene diamine. The coordination chemistry of compounds containing  $N(CH_2)_nN$ , having acyclic and cyclic structures have been studied previously [15-17]. In the present study we have introduced some biological active sites to diamines  $N(CH_2)_nN$ , having acyclic structures and to see their antibacterial activities [18-20]. A molecule (DPYE) was synthesized, to study its coordination ability towards transition elements and

\*To whom all correspondence should be addressed.

also biological activities of the ligand and its metal complexes have been tested against various bacteria.

### Results and Discussion

$^1\text{H-NMR}$  of DPYE in  $\text{D}_2\text{O}$  (Fig. 2) with TMS as internal standard showed three signals indicating the presence of three environmentally different hydrogen atoms. A broad multiplet (pentett) observed at 1.91-1.96 ppm for eight hydrogens to ring carbon atom, another triplet observed at 3.27 ppm for eight hydrogens linked to carbon atom adjacent to nitrogen atom. A very sharp singlet at 3.84 ppm is of four methylene hydrogens of ethyl chain (Fig. 2).

A mass peak of moderate intensity at  $m/e$  167.7 corresponding to molecular ion  $(\text{C}_{10}\text{H}_{20}\text{N}_2)^+$  was observed in the spectrum of DPYE. The base peak at  $m/e$  84 is probably due to the formation of

$N$ -methylenepyrrolidine  $(\text{C}_5\text{H}_{10}\text{N})^+$  radical, while another signal at  $m/e$  97 was observed due to  $N$ -ethylenepyrrolidine.

The ligand DPYE behaves as a bidentate ligand and bears resemblance to 1,2-diimidazolopropane (DIP), 1,3-dipiperidinopropane (DPP) 1,2-dipiperidinoethane (DPE) in terms of chromospheric environment [21-23]. Analytical data shown in Table-1 indicates that only one DPYE molecule is found to be coordinated with metal ion and form complexes of the general formula  $[\text{M}(\text{DPYE})\text{X}_2]$ ,  $\text{M} = \text{Cu (II)}, \text{Co (II)}, \text{Zn (II)}, \text{Cd (II)}$  and  $\text{Hg (II)}$   $\text{X} = \text{Cl}^-, \text{Br}^-, \text{I}^-$  and  $\text{NO}_3^-$ .

Table-5 shows some characteristics bands in the IR spectra of the ligand and its metal complexes. The infrared spectra of the free ligand DPYE contribute the strong absorption band at  $1465 \text{ cm}^{-1}$  and  $1390 \text{ cm}^{-1}$  which are tentatively assigned to C-N ring stretching vibration [24, 25].

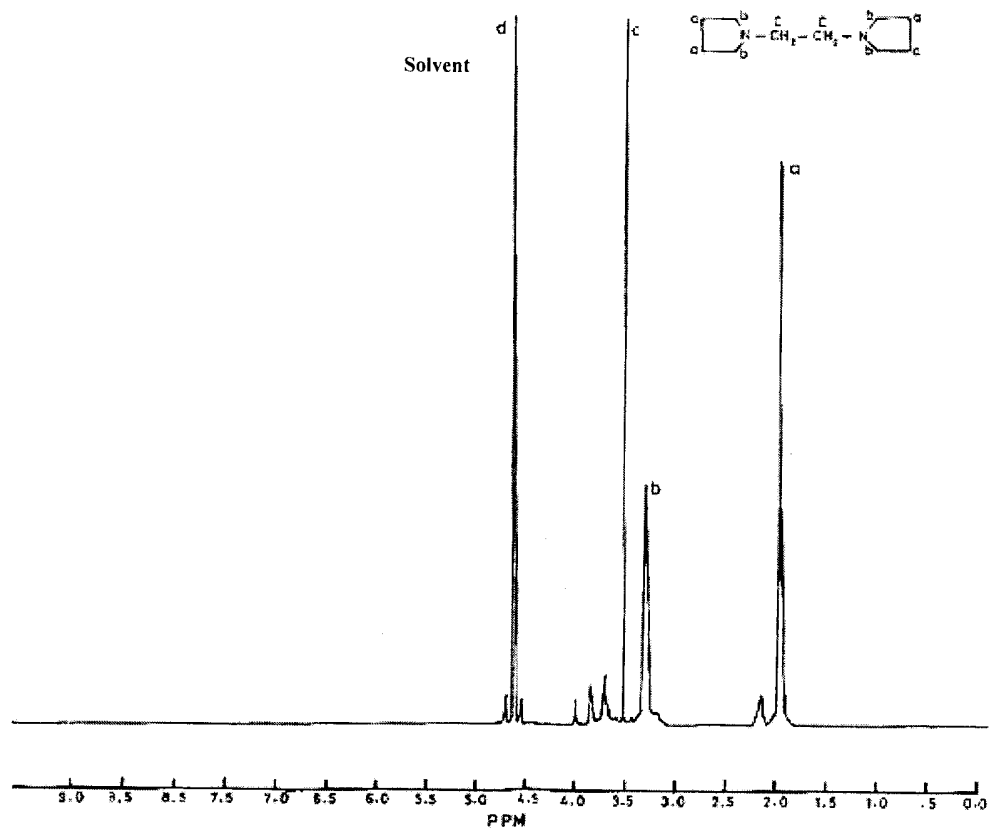


Fig. 2:  $^1\text{H-NMR}$  Spectra of 1,2-dipyrrolidinethane (DPYE).

Table-I: Analytical data of DPYE.

Compound	D point	Colour	% Metal		%Anion		C%		H%		N%	
			Found	Calc	Found	Calc	Found	Calc	Found	Calc	Found	Calc
DPYE 2HBr	300	White					35.53	36.38	6.58	6.71	7.50	8.48
Co(DPYE)Cl <sub>2</sub>	255	Green	19.24	19.64	23.33	23.63	40.02	40.03	7.30	7.39	9.39	9.33
Co(DPYE)Br <sub>2</sub>	228	Bluish green	15.01	15.14	40.75	41.07	26.89	30.87	4.59	5.70	7.28	7.20
Co(DPYE)(NO <sub>3</sub> ) <sub>2</sub>	193	Grassy green	16.38	16.68	27.16	27.44	34.99	34.00	6.33	6.27	14.73	15.86
Ni(DPYE)Cl <sub>2</sub>	230	Bluish green	19.38	19.65	23.40	23.61	40.01	40.00	7.32	7.38	9.32	9.33
Ni(DPYE)Br <sub>2</sub>	225	Blue	15.00	15.16	40.73	41.07	28.20	30.86	5.17	5.69	6.64	7.19
Ni(DPYE)(NO <sub>3</sub> ) <sub>2</sub>	218	Blue	16.80	17.00	27.50	27.43	32.89	33.99	6.26	6.27	14.99	15.85
Cu(DPYE)Cl <sub>2</sub>	190	Green	20.64	20.84	23.20	23.26	38.95	39.41	6.95	7.27	9.10	9.19
Cu(DPYE)Br <sub>2</sub>	180	Blue	16.01	16.14	40.20	40.59	30.11	30.51	5.61	6.63	7.12	7.11
Cu(DPYE)(NO <sub>3</sub> ) <sub>2</sub>	177	Blue	17.55	17.75	26.75	27.08	33.50	33.56	6.18	6.19	14.70	15.65
Zn(DPYE)Cl <sub>2</sub>	250	White	21.10	21.32	23.00	23.12	38.95	39.17	7.23	7.23	9.00	9.13
Zn(DPYE)Br <sub>2</sub>	242	White	16.30	16.53	40.12	40.40	30.30	30.37	5.60	5.60	7.12	7.08
Zn(DPYE)(NO <sub>3</sub> ) <sub>2</sub>	220	White	18.00	18.17	26.78	26.95	33.39	33.39	6.16	6.16	7.90	7.92
Cd(DPYE)Cl <sub>2</sub>	204	White	31.59	31.78	20.10	20.05	33.10	33.96	6.27	6.27	7.90	7.92
Cd(DPYE)Br <sub>2</sub>	196	White	25.13	25.40	36.15	36.11	27.00	27.14	5.00	5.01	6.30	6.33
Cd(DPYE)(NO <sub>3</sub> ) <sub>2</sub>	190	White	27.38	27.63	23.60	23.84	29.50	29.53	5.45	5.45	13.67	13.77
Hg(DPYE)Cl <sub>2</sub>	182	White	45.17	45.40	16.09	16.04	26.29	27.18	5.17	5.01	6.64	6.34
Hg(DPYE)Br <sub>2</sub>	178	White	37.63	37.79	30.15	30.11	22.53	22.63	4.16	4.17	5.30	5.27
Hg(DPYE)(NO <sub>3</sub> ) <sub>2</sub>	175	White	40.32	40.53	19.45	19.58	24.20	24.26	4.40	4.48	10.80	11.32

While the signals appearing at 1110 cm<sup>-1</sup> and 1056 cm<sup>-1</sup> are assigned to C-N stretching vibration. Three complexes of Co (II) with DPYE, [Co(DPYE)Cl<sub>2</sub>], [Co(DPYE)Br<sub>2</sub>] and [Co(DPYE)(NO<sub>3</sub>)<sub>2</sub>] were isolated in solid state. In all the complexes the band attributed to  $\nu$  (C-N) stretching vibration at 1110 cm<sup>-1</sup> shifted towards higher frequency side to 1120 and 1122 cm<sup>-1</sup>. While peak at 1056 cm<sup>-1</sup> shift towards lower frequency 1016 and 1024 cm<sup>-1</sup>. The bands at 1465 cm<sup>-1</sup> assigned to ring stretching vibration almost remain unchanged while the band at 1390 cm<sup>-1</sup> shift towards lower frequency and appears at 1356 cm<sup>-1</sup> in chloride and at 1360 cm<sup>-1</sup> in nitrate complex and no change occurs in the bromide complex. Identical shifts in these bands are observed for Ni (II) halide and nitrate complexes of DPYE. The red shift observed in  $\nu$  C-N stretching vibration at 1056 cm<sup>-1</sup> and is of a low change as compared to Co (II) complexes. In case of Cu (II) complexes the bands attributed to  $\nu$  (C-N) stretching vibration suffers changes exactly like of Co (II) complexes. The stretching absorption band at 1065 cm<sup>-1</sup> moves towards lower frequency side. In case of Zn (II) complexes [Zn(DPYE)Cl<sub>2</sub>], [Zn(DPYE)Br<sub>2</sub>] and [Zn(DPYE)(NO<sub>3</sub>)<sub>2</sub>] the band at 1465 cm<sup>-1</sup> and 2390 cm<sup>-1</sup> which were assigned to C-N ring stretching vibration shifted to 1437, 1456 and 1390 cm<sup>-1</sup>, respectively. The bands attributed to (C-N) stretching vibration suffers red shift and changes from 1110 cm<sup>-1</sup> to 1140 cm<sup>-1</sup>, 1125 cm<sup>-1</sup> and 1122 cm<sup>-1</sup>. The stretching absorption band at 1065 cm<sup>-1</sup> moves towards lower frequency side to 1050 cm<sup>-1</sup>, 1048 cm<sup>-1</sup> and 1040 cm<sup>-1</sup>. In case Cd (II) complexes

of chloride, bromide and nitrate the bands attributed to (C-N) stretching vibrations change to 1120 cm<sup>-1</sup>, 1122 cm<sup>-1</sup> and 1125 cm<sup>-1</sup>, respectively. The stretching absorption band at 1065 cm<sup>-1</sup> shifts towards lower frequency side and was observed at 1030, 1040 cm<sup>-1</sup>, respectively. In case of Hg (II) complexes of chloride, bromide and nitrate the (C-N) stretching vibration changes to 1120 cm<sup>-1</sup>, 1125 cm<sup>-1</sup>, respectively. The stretching absorption band at 1065 cm<sup>-1</sup> shifts towards lower frequency side and was observed at 1040 and 1043 cm<sup>-1</sup>, respectively.

Molar conductance values of metal complexes are presented in Table-2 while magnetic moments for DPYE complexes are given in Table-3. The molar conductance values ranges from 5.48-53.16 ms/mole, which show the non-electrolytic nature of the metal complexes, whereas the magnetic moments of Co (II) complexes vary in the range 4.39-4.73 B.M. and show three unpaired electrons, and that of Cu (II) complexes, the magnetic moments lies in the range of 1.78-2.22 B.M. indicating single unpaired electron. Magnetic moments of Ni (II) complex are in the range of 3.50-4.06 B.M. indicating the presence of two electrons.

The solution spectra of Co (II) complex in nitromethane are identical (Fig. 3). The chloride complex exhibit three bands at 18180 cm<sup>-1</sup>, 16260 cm<sup>-1</sup> and 15625 cm<sup>-1</sup>. Identical bands were observed for bromide complexes. Nitrate complex shows only two bands at 16000 cm<sup>-1</sup> and 18515 cm<sup>-1</sup>

Table-2: Conductance measurements of DPYE complexes.

Compound	Concentration $\times 10^{-3}$ M	Molar conductance (ms $\text{Mole}^{-1}$ )	Solvent
Co(DPYE)Cl <sub>2</sub>	7.42	36.77	Nitromethane
Co(DPYE)Br <sub>2</sub>	9.65	33.50	Nitromethane
Co(DPYE)(NO <sub>2</sub> ) <sub>2</sub>	8.75	44.13	Nitromethane
Ni(DPYE)Cl <sub>2</sub>	7.42	39.45	Nitromethane
Ni(DPYE)Br <sub>2</sub>	9.65	36.10	Nitromethane
Ni(DPYE)(NO <sub>2</sub> ) <sub>2</sub>	8.75	46.80	Nitromethane
Cu(DPYE)Cl <sub>2</sub>	7.5	48.81	Nitromethane
Cu(DPYE)Br <sub>2</sub>	9.77	44.93	Nitromethane
Cu(DPYE)(NO <sub>2</sub> ) <sub>2</sub>	8.87	53.16	Nitromethane
Zn(DPYE)Cl <sub>2</sub>	7.6	13.50	Nitromethane
Zn(DPYE)Br <sub>2</sub>	9.82	10.03	Nitromethane
Zn(DPYE)(NO <sub>2</sub> ) <sub>2</sub>	8.92	16.91	Nitromethane
Cd(DPYE)Cl <sub>2</sub>	8.77	11.03	Nitromethane
Cd(DPYE)Br <sub>2</sub>	0.11	8.020	Nitromethane
Cd(DPYE)(NO <sub>2</sub> ) <sub>2</sub>	0.10	2.060	Nitromethane
Hg(DPYE)Cl <sub>2</sub>	0.10	7.820	Nitromethane
Hg(DPYE)Br <sub>2</sub>	0.13	5.480	Nitromethane
Hg(DPYE)(NO <sub>2</sub> ) <sub>2</sub>	0.12	14.04	Nitromethane

shown in Table-4. These bands could be assigned to  ${}^4A_2 \rightarrow {}^4T_1$  (P) transition ( $\nu_3$ ) of Td symmetry. The low energy transition  ${}^4A_2 \rightarrow {}^4T_1$  (F)  $\nu_2$  was not

Table-3: Magnetic moments of Complexes.

Compound	Temp K	Dia.cor. $\times 10^{-6}$ g atom	Cor $\times M \times 10^{-6}$ (c.g.s)	$\mu_{\text{eff}}$ (B.M)
DPYE 2HBr	298	196.8		
Co(DPYE)Cl <sub>2</sub>	298	188.74	7811.45	4.39
Co(DPYE)Br <sub>2</sub>	298	209.74	9081	4.73
Co(DPYE)(NO <sub>2</sub> ) <sub>2</sub>	298	186.34	8145.37	4.50
Ni(DPYE)Cl <sub>2</sub>	298	188.74	4922.28	3.50
Ni(DPYE)Br <sub>2</sub>	298	209.74	6403.82	3.97
Ni(DPYE)(NO <sub>2</sub> ) <sub>2</sub>	298	186.34	5759.31	3.78
Cu(DPYE)Cl <sub>2</sub>	298	188.74	1802.64	2.08
Cu(DPYE)Br <sub>2</sub>	298	209.74	2053.62	2.22
Cu(DPYE)(NO <sub>2</sub> ) <sub>2</sub>	298	186.34	1798.38	2.07

observed. The intensity bandwidth is in accordance with Td symmetry. The spectrum of chloride, bromide and nitrate complexes of Ni (II) in nitromethane (Fig. 4) are very much similar in band position and intensities at  $16260\text{cm}^{-1}$  and is assigned to  ${}^3T_1 \rightarrow {}^3T_2$  transition ( $\nu_1$ ) in tetrahedral symmetry [23].

The spectra of Cu (II) chloride and bromide complex in nitromethane are also similar.

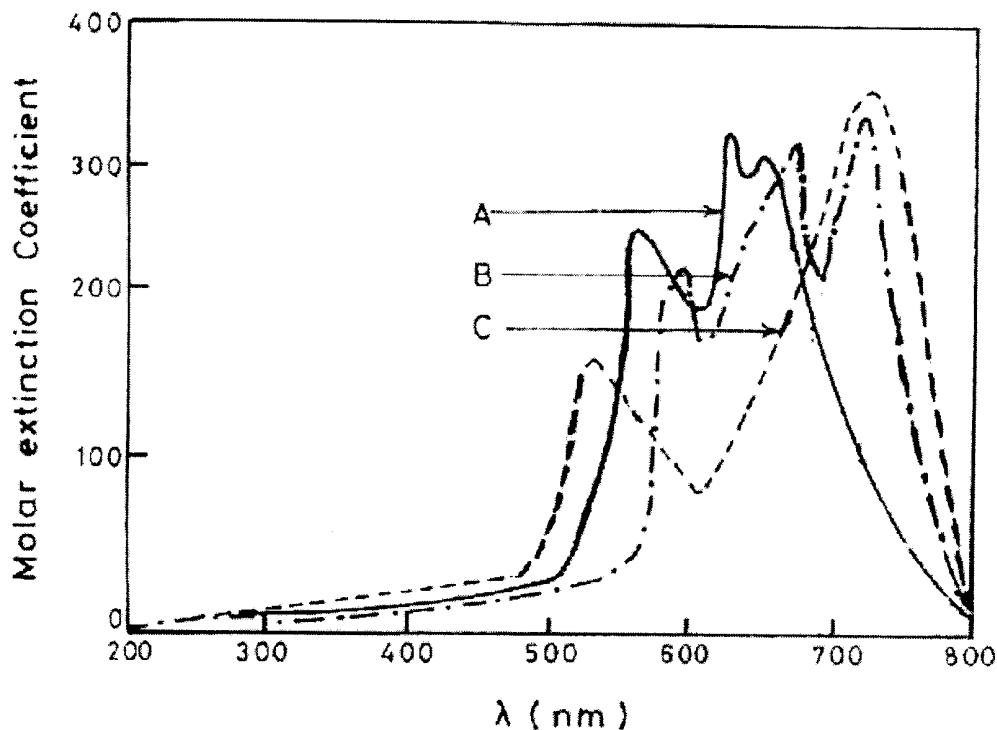


Fig. 3: UV / visible spectra of Cobalt complexes.

- A = [Co(DPYE)Cl<sub>2</sub>]  
 B = [Co(DPYE)Br<sub>2</sub>]  
 C = [Co(DPYE)(NO<sub>2</sub>)<sub>2</sub>]

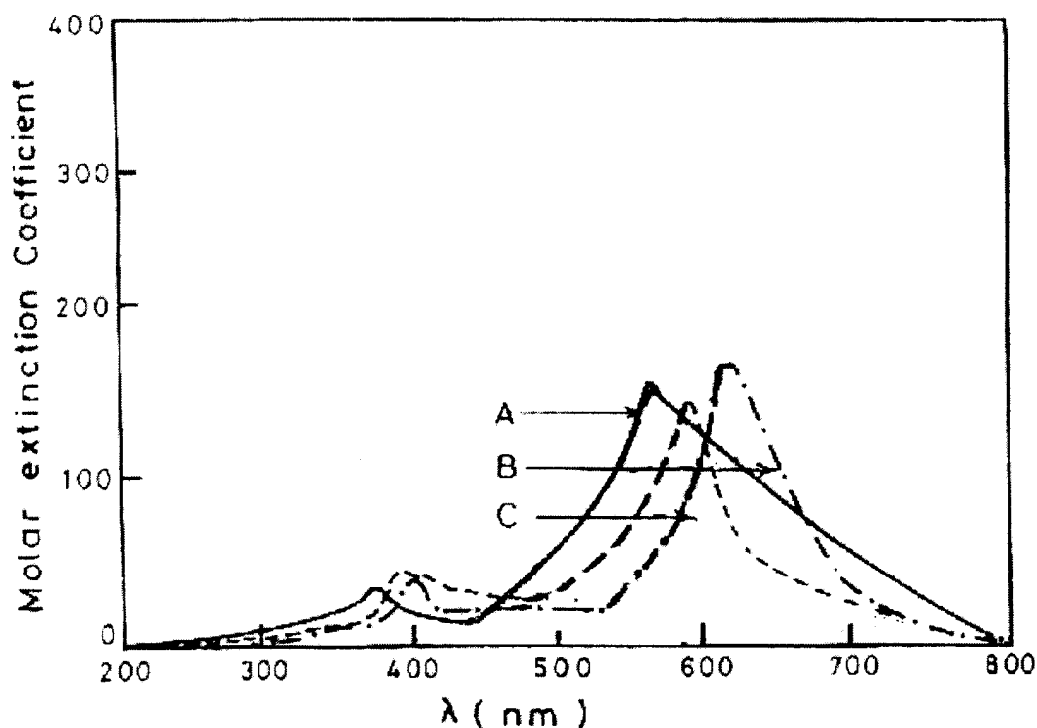


Fig. 4: UV / visible spectra of Nickel complexes.

A = Ni(DPYE)Cl<sub>2</sub>B = Ni(DPYE)Br<sub>2</sub>C = Ni(DPYE)(NO<sub>3</sub>)<sub>2</sub>

Table-4: Electronic Absorption spectral Data of DPYE complexes.

Compound	λ Max		Molar extinction Coefficient (M <sup>-1</sup> cm <sup>-1</sup> )	Solvent	Assignment
	(nm)	cm <sup>-1</sup>			
Co(DPYE)Cl <sub>2</sub>	550	18180	270	Nitromethane	<sup>4</sup> A <sub>2</sub> (F) → <sup>4</sup> T <sub>1</sub> (P)
	615	16260	348		
	640	15625	332		
Co(DPYE)Br <sub>2</sub>	565	17700	302	Nitromethane	<sup>4</sup> A <sub>2</sub> (F) → <sup>4</sup> T <sub>1</sub> (P)
	620	16130	309		
	660	15150	335		
Co(DPYE)(NO <sub>3</sub> ) <sub>2</sub>	540	18515	180	Nitromethane	<sup>4</sup> A <sub>2</sub> (F) → <sup>4</sup> T <sub>1</sub> (P)
	625	16000	362		
Ni(DPYE)Cl <sub>2</sub>	375	36665	52	Nitromethane	<sup>3</sup> T <sub>1</sub> (F) → <sup>3</sup> T <sub>1</sub> (P)
	535	15745	173		
Ni(DPYE)Br <sub>2</sub>	380	26315	48	Nitromethane	<sup>3</sup> T <sub>1</sub> (F) → <sup>3</sup> T <sub>1</sub> (P)
	645	15505	190		
Ni(DPYE)(NO <sub>3</sub> ) <sub>2</sub>	355	28165	44	Nitromethane	<sup>3</sup> T <sub>1</sub> (F) → <sup>3</sup> T <sub>1</sub> (P)
	615	16260	153		
Cu(DPYE)Cl <sub>2</sub>	505	19800	238	Nitromethane	d-d transition
	635	15745	172		
	750	13335	117		
Cu(DPYE)Br <sub>2</sub>	500	20000	251	Nitromethane	d-d transition
	665	15035	157		
	755	13245	108		
Cu(DPYE)(NO <sub>3</sub> ) <sub>2</sub>	415	14095	150	Nitromethane	d-d transition
	655	15265	60		

with some variations in band position and intensities (Fig. 5). They exhibit clearly three absorption bands in the range of 13245 to 20000 cm<sup>-1</sup> shown in Table-4, whereas only two bands were observed for nitrate complex. These

transitions observed, constitute C<sub>2v</sub> symmetry which is in accordance with the previous investigations [24, 26-29]. They resembles Cu (II) complex having CuN<sub>2</sub>X<sub>2</sub> chromosphere [30].

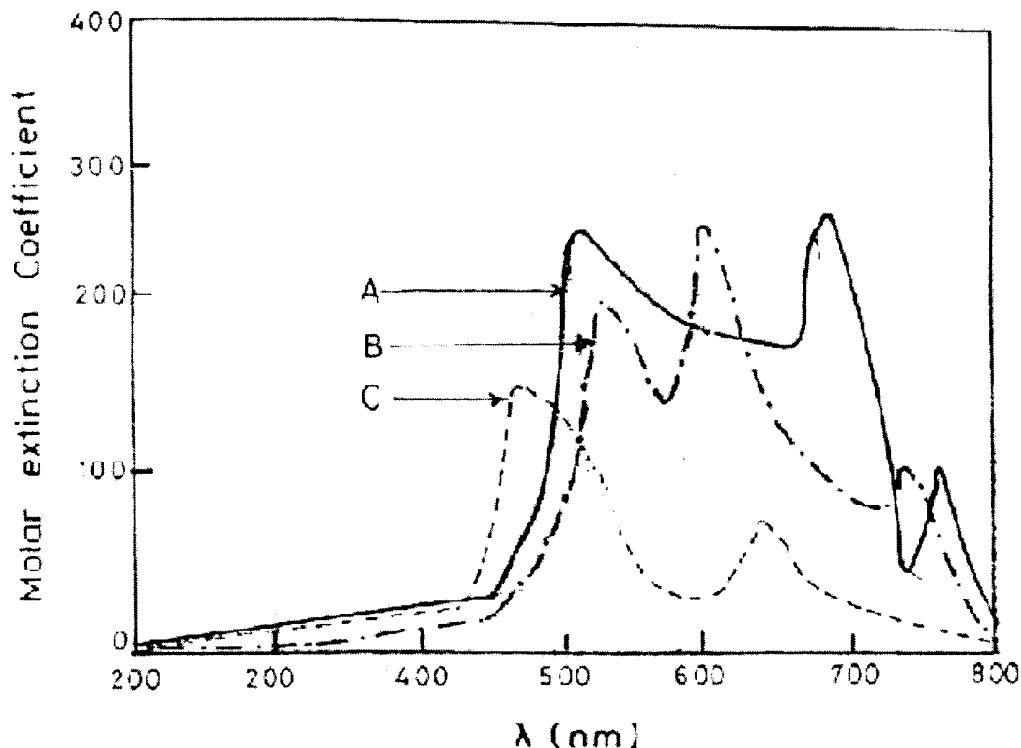


Fig. 5: UV / visible spectra of Copper complexes.

A = [Cu(DPYE)Cl<sub>2</sub>]B = [Cu(DPYE)Br<sub>2</sub>]C = [Cu(DPYE)(NO<sub>3</sub>)<sub>2</sub>]

Table-5: Infrared spectra of DPYE and their complexes.

Compound	IR spectra cm <sup>-1</sup>	
	Ring ν(H <sub>2</sub> C-N)	ν(C-N)
DPYE	1465, 1390, 1322	1110, 1056
Co(DPYE)Cl <sub>2</sub>	1465, 1356	1120, 1035
Co(DPYE)Br <sub>2</sub>	1470, 1390, 1320	1122, 1040
Co(DPYE)(NO <sub>2</sub> ) <sub>3</sub>	1465, 1360	1120, 1335
Ni(DPYE)Cl <sub>2</sub>	1440, 1396	1120, 1050
Ni(DPYE)Br <sub>2</sub>	1470, 1395, 1330	1120, 1050
Ni(DPYE)(NO <sub>2</sub> ) <sub>3</sub>	1456, 1390	1122, 1050
Cu(DPYE)Cl <sub>2</sub>	1468, 1400, 1320	1120, 1050
Cu(DPYE)Br <sub>2</sub>	- , 1390, 1320	1122, 1050
Cu(DPYE)(NO <sub>2</sub> ) <sub>3</sub>	1470, 1390	1125, 1051
Zn(DPYE)Cl <sub>2</sub>	1437, 1370, 1308	1140, 1050
Zn(DPYE)Br <sub>2</sub>	1465, 1390, 1320	1125, 1048
Zn(DPYE)(NO <sub>2</sub> ) <sub>3</sub>	1465, 1385, 1308	1122, 1040
Cd(DPYE)Cl <sub>2</sub>	1460, 1385	1120, 1030
Cd(DPYE)Br <sub>2</sub>	1450, 1370	1122, 1040
Cd(DPYE)(NO <sub>2</sub> ) <sub>3</sub>	1465, 1390, 1320	1125, 1040
Hg(DPYE)Cl <sub>2</sub>	1440, 1335	1120, 1040
Hg(DPYE)Br <sub>2</sub>	1437	1125, 1040
Hg(DPYE)(NO <sub>2</sub> ) <sub>3</sub>	1440, 1390	1120, 1043

#### Antibacterial Study

In order to perform the antibacterial activity discs of 100 μg of compounds were made

in distilled water. To 50 mL solution 50 discs of 6mm diameter in order to impregnate the samples on the discs. These discs were placed in incubator for 24 hours at 37 °C. After 24 hours sensitivity tests were performed using these discs. Medium for different types of bacteria used were Blood Agar and Nutrient Agar. The discs were placed in an incubator for about 24 hours at 37 °C. The zone inhibition was then measured (in diameter) around the discs. Metal complexes were found to be active against *Eschereschi coli*, *Klebsiella pneumonia*, *Proteus mirabilis* and *Proteus vulharis*. The results are given in Table-6

#### Experimental

##### Materials

Metal salts and other reagents were obtained from the sources mentioned at the appropriate places in this work. 1,2-dibromoethane (BDH) and pyrrolidine (Fluka) were used without

Table-6: Antibacterial activity of DPYE and their metal complexes.

Compound	Organisms											
	1	2	3	4	5	6	7	8	9	10	11	12
DPYE	++++	++++	+++	+++	++	R	R	R	R	R	R	R
Co(DPYE)Cl <sub>2</sub>	++++	+++	+++	+++	R	R	R	R	R	R	R	R
Co(DPYE)Br <sub>2</sub>	+++	++++	+++	+++	R	R	R	R	R	R	R	R
Co(DPYE)(NO <sub>2</sub> ) <sub>3</sub>	++++	++++	+++	R	R	R	R	R	R	R	R	R
Ni(DPYE)Cl <sub>2</sub>	++++	+++	+++	++++	R	R	R	R	R	R	R	R
Ni(DPYE)Br <sub>2</sub>	++++	+++	+++	+++	R	R	R	R	R	R	R	R
Ni(DPYE)(NO <sub>2</sub> ) <sub>3</sub>	+++	++++	+++	R	R	R	R	R	R	R	R	R
Cu(DPYE)Cl <sub>2</sub>	++	++++	R	+++	R	R	R	R	R	R	R	R
Cu(DPYE)Br <sub>2</sub>	++++	++++	R	++++	R	++	R	R	R	R	R	R
Cu(DPYE)(NO <sub>2</sub> ) <sub>3</sub>	++++	++++	R	++++	R	R	R	R	R	R	R	R
Zn(DPYE)Cl <sub>2</sub>	+++	++++	+++	++	R	R	R	R	R	R	R	R
Zn(DPYE)Br <sub>2</sub>	++++	++++	++++	R	R	R	R	R	R	R	R	R
Zn(DPYE)(NO <sub>2</sub> ) <sub>3</sub>	++++	++++	++++	++	R	R	R	R	R	R	R	R
Cd(DPYE)Cl <sub>2</sub>	++++	++	++++	R	R	+++	R	R	R	R	R	R
Cd(DPYE)Br <sub>2</sub>	++++	++	++	R	R	R	R	R	R	R	R	R
Cd(DPYE)(NO <sub>2</sub> ) <sub>3</sub>	+++	++	+++	++	R	+++	R	R	R	R	R	R
Hg(DPYE)Cl <sub>2</sub>	++++	++++	++++	+++	R	R	R	R	R	R	R	R
Hg(DPYE)Br <sub>2</sub>	++++	+++	+++	R	R	R	R	R	R	R	R	R
Hg(DPYE)(NO <sub>2</sub> ) <sub>3</sub>	++++	++++	++++	R	R	R	R	R	R	R	R	R

R = Resistive

1 = *Eschereschi coli*2 = *Klebsiella pneumonia*3 = *Proteus mirabilis*4 = *Proteus vulgaris*5 = *Streptococcus Pneumonia*6 = *Salmonella typhi*7 = *Bacillus Anthrax*8 = *Streptococcus Fecalis*9 = *Staphylococcus aureus*10 = *Pseudomonas Pyocyanea*11 = *Pasteurella Pseudotuberculosis*

Inhibition zone diameter mm (% inhibition)

+, 6-10 (27-45%);

++, 10-14 (45-64%);

+++, 14-18 (64-82%)

++++, 18-22 (82-100%).

purification. Partial dehydration of some salts was done by drying the hydrated salts in vacuum oven for several hours at about 105 °C. All non-aqueous solvents were freshly distilled at least once before using.

#### Preparation of Ligands

The ligand 1,2-dipyrrolidinoethane dihydrobromide [DPYE.2HBr] was prepared by mixing 1,2-dibromoethane (BDH) and pyrrolidine (Fluka) in dry benzene. The reaction mixture was refluxed for about 4 hours at 80 °C, on cooling light gray precipitate was found. The mixture was left over night, filtered through sintered glass funnel and washed three times with acetone, colour less crystals of DPYE.2HBr were obtained.

#### Preparation of Complexes

All the complexes were synthesized using the same general procedure. The calculated amount of partially dehydrated was dissolved in minimum amount of anhydrous methanol or ethanol. In some cases, metal salts were dehydrated with calculated amount of 2,2-dimethoxypropane. The solution was stirred at least for four hours to ensure complete dehydration for the metal salts. For preparation of all complexes, an excess over 1:1 ligand to metal ratio was taken, the ligand was dissolved in

absolute methanol or ethanol and added slowly to the salt solution. The complexes precipitated immediately or the solid complexes were obtained on reducing the volume of the resultant solution under vacuum. The products were filtered through sintered glass crucible washed three times with methanol or ethanol and dried under vacuum.

#### Physical Measurements

The elemental C, H and N analysis of the complexes were performed at HEJ, research institute of chemistry, University of Karachi. The infrared spectra of the ligand and solid complexes were recorded on KBr disc model 270-50 Hitachi infrared spectrometer. The <sup>1</sup>H-NMR spectra in D<sub>2</sub>O were obtained on Bruker (AM 300) using TMS as internal standard. UV and visible spectra were measured on Shimadzu UV 160 A spectrophotometer with 1 cm match quartz cells. Magnetic susceptibilities were measured by the Gouy method at room temperature using the Hg[Co(NCS)<sub>4</sub>] as the standard [31]. The mass spectra of the ligand were recorded on MAT-312 mass spectrometer.

#### References

1. Z. H. Chohan, H. Pervez, A. Rauf, K. M. Khalid and C. T. Supuran, *Journal of Enzyme Inhibition and Medicinal Chemistry*, **21**, 193 (2006).

2. I. Asif, S. Ali, S. Shahzadi and S. Mahmood, *Journal of Chinese Chemical Society*, **54**, 23 (2007).
3. G. H. Ho, T.-I. Ho, K. -H. Hsieh, Y. -C. Su, P. -Y. Lin, K. -H. Yang and S. -C. Yang, *Journal of Chinese Chemical Society*, **53**, 1363 (2006).
4. Z. H. Chohan, M. Arif, Z. Shafiq, M. Yaqub and C. T. Supuran, *Journal of Enzyme Inhibition and Medicinal Chemistry*, **21**, 95 (2006).
5. Z. H. Chohan, A. U. Shaikh, M. M. Naseer and C. T. Supuran, *Journal of Enzyme Inhibition and Medicinal Chemistry*, **21**, 771 (2006).
6. F. V. Gizycki and H. Herrmanns, *Archive der Pharmazie*, **284**, 8 (1951).
7. K. Kiyomitsu, JP Patent 2005013138, January 1 (2005).
8. K. Kiyomitsu, JP Patent 2005015684, January 1 (2005).
9. G. Neurath, M. G. Duenger, J. Gewe, W. Luettich and H. Wichern, *Beitraege Zur. Tabakforsch*, **3**, 563 (1966).
10. O. Munoz, C. Schneider and E. Breitmaier, *Liebigs Annalen der Chemie*, **5**, 521 (1994).
11. Y. Nagao and S. Sano, JP 19940329 March 29 (1994).
12. E. Ahmed, A. Abdul Khaliq and A. Shaya, *Journal of Sulfur Chemistry*, **27**, 245 (2006).
13. D. J. Bailey, D. O'hagan and M. Tavasli, *Tetrahedron: Asymmetry*, **8**, 149 (1997).
14. D. Gibson, *Coordination Chemistry Review*, **4**, 225 (1969).
15. S. F. Pavkovic and D. W. Meek, *Inorganic Chemistry*, **4**, 20 (1965).
16. D. W. Meek, *Inorganic Chemistry*, **4**, 250 (1965).
17. R. Nasanen, M. Koshinen, R. Salonen and A. Niiski, *Suomen Kemistilehti*, **38B**, 81 (1965).
18. R. Gust, H. Schoenenbergor, J. Kretzenger, K. J. Range, U. Klement and T. Burgemeister, *Inorganic Chemistry*, **32**, 5939 (1993).
19. S. Mylonas and A. Mamalis, *Journal of Hetrocyclic Chemistry*, **42**, 1273 (2005).
20. L. -L. Ya and X. -F. Wen, *Bioorganic and Medicinal Chemistry*, **12**, 5171 (2004).
21. S. U. Rehman, N. Ali, M. Shakirullah and M. Arshad, *Journal of the Chemical Society of Pakistan*, **27**, 178 (2005).
22. S. A. Khan, T. Ali, S. U. Rehman and R. Haroon, *Journal of the Chemical Society of Pakistan*, **21**, 399 (1999).
23. S. A. Khan, T. Ali, S. U. Rehman and R. Haroon, *Journal of the Chemical Society of Pakistan*, **20**, 2198 (1999).
24. G. Socrates, *Infrared and Raman Characteristics Group Frequencies*. 3<sup>rd</sup> ed. New York; John Wiley and sons (2001).
25. *The Saddler Standard Spectra. Vol. 1*, Philadelphia; Saddler (1962).
26. A. D. Liehr and C. J. Ballhausen, *Annales de Physique*, **2**, 134 (1959).
27. G. Babu, R. L. Belford and R. E. Dickerson, *Inorganic Chemistry*, **1**, 438 (1962).
28. S. N. Choi, R. D. Bereman and J. R. Wasson, *Journal of Inorganic and Nuclear Chemistry*, **37**, 2087 (1975).
29. E. Boschmann, L. Weinstock, M. Leonard and M. Germack, *Inorganic Chemistry*, **13**, 1297 (1974).
30. B. N. Figgis and J. Lewis, *Progress Inorganic Chemistry*, **6**, 37 (1964).
31. S. U. Rehman, S. Pervez, S. A. Khan, J. Shah, S. Khattak, N. Ali and M. Arshad, *Journal of the Chemical Society of Pakistan*, **25**, 147 (2003).