Asian Journal of Chemistry Vol. 17, No. 1 (2005), 323–328

Synthesis, Spectral and Antibacterial Studies of Some Hg(II) Chelates of Azo Dyes derived from 4-Amino-2,3-Dimethyl-1-Phenyl Pyrazol-5-one

GEORGE MATHEW †and M.L. HARI KUMARAN NAIR*
Department of Chemistry, University College, Thiruvananthapuram-695 034, India
E-mail: globalit7@hotmail.com

Eleven new complexes of three azo dyes, 2,3-dimethyl-1-phenyl-4-(2-hydroxy-5-methyl phenyl azo) pyrazol-5-one (CAAPH), 2,3-dimethyl-1-phenyl-4-(2-hydroxy-5-chlorophenylazo) pyrazol-5-one (CPAAPH) and 2,3-dimethyl-1-phenyl-4-(2-hydroxy-5-nitrophenylazo) pyrazol-5-one (NPAAPH), derived from 4-aminoantipyrine having the compositions $[Hg(LH)X_2]$, $[Hg(L'H)X_2]$ or $[Hg(L''H)X_2]$ (LH = CAAPH, L'H = CPAAPH, L''H = NPAAPH and X = Cl, Br, I or NO_3) have been synthesized and characterized by elemental analysis, magnetic moment and conductance measurement, IR and ^{1}HNMR spectral studies. The ligand NPAAPH and one of its complexes have been screened for their antibacterial activity against gram-positive and gram-negative bacteria. The ligands behave as neutral bidentate chelating agents. The complexes are found to be monomeric and neutral with a tetrahedral geometry.

Key Words: Synthesis, 4-Amino antipyrine, Mercury(II), Chelates, NMR, Antibacterial.

INTRODUCTION

Mercury was known to different people around the world for thousands of years and had played a prominent role in therapeutics, alchemy and folklore. Mercuric salts are water-soluble and nephrotoxic, while organic mercury compounds are lipid-soluble, volatile and highly neurotoxic in inverse proportion to size of ligand moiety. Mercury forms complexes[1] readily with cyanide ions, ammonia, amines, halide ions etc. In view of the importance of Hg(II) complexes, we have isolated and characterized some new complexes of three potential multidentate ligands, 2,3-dimethyl-1-phenyl-4-(2-hydroxy-5-methyl phenylazo) pyrazol-5-one (cresol-azo-antipyrine, CAAPH), 2,3-dimethyl-1-phenyl-4-(2-hydroxy-5-chlorophenyl-azo) pyrazol-5-one (chlorophenol azo-antipyrine, CPAAPH) and 2,3-dimethyl-1-phenyl-4-(2-hydroxy-5-nitrophenylazo) pyrazol-5-one (nitrophenol-azo-antipyrine, NPAAPH), derived from biologically active molecule, 4-aminoantipyrine. All these three are potential tridentate monobasic ligands[2, 3].

†Department of Chemistry, St. Gregorios College, Kottarakakara-691 531, Kollam, India.

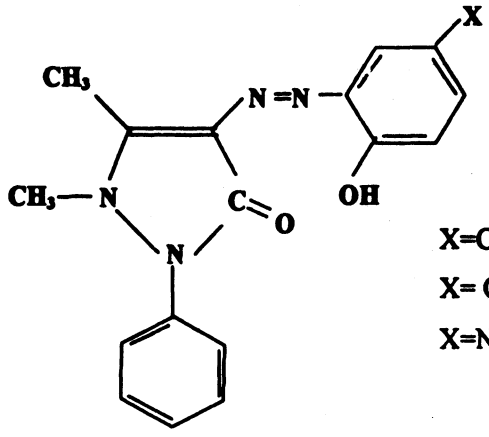

Fig. 1

EXPERIMENTAL

4-Aminoantipyrine (Fluka, Switzerland), *p*-cresol, *p*-chlorophenol and *p*-nitrophenol (Lobochemie, Mumbai) were used as supplied and other chemicals including Hg(II) salts were of BDH AR grade.

The ligands were synthesized from 4-aminoantipyrine and *p*-cresol/*p*-chlorophenol/*p*-nitrophenol, as the case may be, by diazotization and coupling as described in literature[4].

For the synthesis of complexes, the following general method was adopted. Hot methanolic solution of the metal salt (2.5 mmol) was added gradually to a hot solution of the ligand (2.5 mmol) in the same solvent with constant stirring and then refluxed for 2–3 h on a water bath. The solid complex obtained by volume reduction was then filtered, washed successively with aq. methanol, followed by benzene and finally with dry ether. It was then dried *in vacuo* over P_4O_{10}.

Mercury in the complexes was estimated gravimetically as mercuric sulphide by standard method[5]. Halides in the complexes were estimated by Volhard's method[5]. The IR spectra of the ligands and their mercury(II) complexes were run on a JASCO FTIR 430 spectrophotometer, using KBr pellets. The ^1H NMR spectra of the ligands were recorded in $CDCl_3$ on a 300 MHz (Bruker Advance dpx-300) FT NMR instrument using TMS as reference. Antibacterial activity of the ligands NPAAH and one of its complexes was tested by agar diffusion method using four bacteria such as *E. coli, S. aureus, Ps. aerugionosa* and *K. pneumoniae.* The molar conductance of the complexes in $C_6H_5NO_2$, CH_3OH and CH_3CN (*ca.* 10^{-3} M) were measured at 300 ± 2K using an Elico conductivity bridge type CM 82T with a dip type cell (ec-03), fitted with platinum electrodes (cell constant 0.94 cm^{-1}).

RESULTS AND DISCUSSION

All the complexes are coloured brown or reddish brown, non-hygroscopic, soluble in methanol and ethanol, partially soluble in water and benzene but remain insoluble in ether.

The analytical data of the complexes (Table-1) correspond to the composition $[HgLX_2]$, where L = CAAPH, CPAAPH or NPAAPH and X = Cl, Br, I or NO_3. The molar conductances show that all the complexes are non-electrolytes[6,7].

The ^1H NMR spectrum[8] of the ligand CAAPH shows three singlets which correspond to the methyl protons and are observed at δ2.2, δ2.7 and δ3.4. The signal due to five aromatic protons of the antipyrine phenyl ring appears as a multiplet between δ7.46 and δ7.58 and that due to cresol protons is observed as a multiplet between δ6.7 and δ7.3. The signal due to phenolic proton appears as a hump at δ5.2. In the ^1H NMR spectrum of CPAAPH, the signal due to two methyl protons is observed as singlets at δ2.7 and δ3.27 respectively. The latter may be due to the N-methyl group protons. The signal due to five aromatic protons of the antipyrine phenyl ring appears as a multiplet between δ7.46 and δ7.55 and that due to three protons of the phenol ring appears as a multiplet between δ6.8–7.3. The phenolic proton signal is observed as a singlet at δ5.29. The ^1H NMR spectrum of the ligand NPAAPH shows two singlets, one at δ2.21 and the other at δ3.36 which corresponds to C-CH_3 and N-CH_3 group protons. Protons of the antipyrine phenyl group appear as a multiplet between δ6.8 and δ7.3 and the signal due to nitrophenol is observed as a multiplet between δ7.96 and δ7.78. The phenolic —OH proton is observed as a hump at δ5.45.

In the IR spectra of the free ligands CAAPH, CPAAPH and NPAAPH, a broad medium intensity band observed at *ca.* 2900, 3100 and 3150 cm^{-1} respectively is assigned to hydrogen bonded —OH group[9]. A very strong band occurring at 1660 cm^{-1} in the three ligand spectra has been attributed to ν(C=O) of the pyrazolone ring. Also, another band of medium intensity observed at *ca.* 1450 cm^{-1} in the ligand spectra is attributed to the vibrational stretching of —N=N— group[10]. The bands observed at *ca.* 2900, 3100 and 3150 cm^{-1} are found to be absent in the spectra of all the complexes under the present investigation. Instead, a new broad band of medium intensity appears at *ca.* 3400 cm^{-1} in the spectra of all the complexes indicating the presence of free —OH group and its non-participation in complexation. The ν(C=O) observed at 1660 cm^{-1} in the spectra of ligands is shifted to a lower frequency *ca.* 1590 cm^{-1} in all the complexes showing evidence for the participation of this group in coordination with the metal ion. The vibrational band at 1450 cm^{-1}, assigned to ν(N=N) is also shifted by *ca.* 20 cm^{-1} in the spectra of all the complexes, confirming the coordination through one of the azo group nitrogens. Thus the ligands exhibit a neutral, bidentate behaviour in all the complexes, coordinating through the >C=O and the —N=N— groups

only. The IR spectra of nitrate complexes are suggestive of monodentately coordinated nitrate groups (ν_4 *ca.* 1500, ν_1 *ca.* 1350 and ν_2 *ca.* 1000 cm^{-1})[7].

The ligand NPAAPH and one of its complexes [Hg(NPAAPH)Cl_2] were screened for their possible antibacterial activity against gram-positive and gram-negative bacteria by agar diffusion method. The bacteria used for the present study are *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853 and *Klebsiella pneumoniae* (clinical isolate). Studies reveal that the ligand does not show antibacterial activity against these bacterial strains or found to be resistant[11-13]. But the complex is found to exhibit antibacterial activity against *E. coli, S. aureus* and *K. pneumoniae*. The zones of inhibition of growth of *E. coli, S. aureus* and *K. pneumoniae* are shown in Table-2 and it is clear that the complex inhibits the growth of *S. aureus* to a greater extent than the other two. The antibacterial activity may be due to the presence of Hg(II) in the complex. At the same time, *Ps. aerugionosa* is found to be tolerant to the complex or does not have any activity as no zone of inhibition is found against this bacteria. This may be due to the ability of this bacteria to convert toxic Hg(II) to volatile[12] Hg(0). Here the positive control used was gentamycin and the negative control was Whatmann No. 1 filter paper disc impregnated with 100 µL of absolute methanol.

On the basis of the above evidences, a tetrahedral geometry is suggested for all the complexes[14] (Fig. 2).

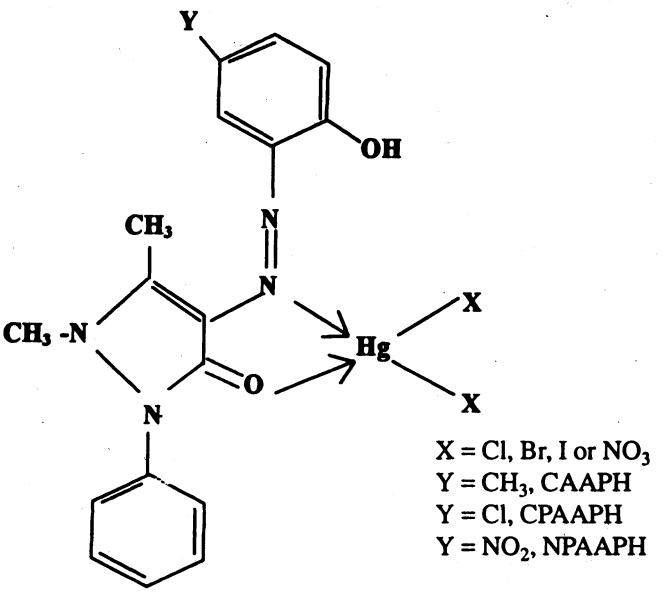

Fig. 2

TABLE-1
PHYSICAL AND ANALYTICAL DATA OF Hg(II) COMPLEXES OF CAAPH, CPAAPH AND NPAAPH

Complex (Colour)	Found % (Calculated)		Molar conductance (ohm^{-1} cm^2 mol^{-1})*		
	Hg	Cl/Br/I	Nitrobenzene	Acetonitrile	Methanol
$[Hg(CAAPH)Cl_2]$ (Brown)	32.75 (33.72)	11.37 (11.97)	3.1	23.7	21.9
$[Hg(CAAPH)Br_2]$ (Dark Brown)	28.46 (29.32)	22.57 (23.46)	11.6	22.5	40.5
$[Hg(CAAPH)I_2]$ (Light brown)	24.82 (25.77)	31.81 (32.73)	10.3	67.3	37.4
$[Hg(CAAPH)(NO_3)_2]$ (Reddish brown)	30.16 (30.95)		9.8	63.9	44.9
$[Hg(CPAAPH)Cl_2]$ (Chocolate brown)	31.76 (32.62)	11.49 (11.58)	4.7	27.7	22.8
$[Hg(CPAAPH)Br_2]$ (Orange brown)	27.82 (28.49)		9.8	54.8	38.6
$[Hg(CPAAPH)I_2]$ (Light brown)	24.77 (25.12)		8.4	58.6	41.2
$[Hg(CPAAPH)(NO_3)_2]$ (Reddish brown)	29.61 (30.03)		7.4	61.7	41.7
$[Hg(NPAAPH)Cl_2]$ (Brown)	31.18 (32.05)	10.49 (11.37)	3.9	32.5	23.9
$[Hg(NPAAPH)Br_2]$ (Brown)	27.60 (28.05)	21.61 (22.44)	10.0	58.7	44.8
$[Hg(NPAAPH)I_2]$ (Light brown)	23.93 (24.78)	30.51 (31.47)	8.9	55.7	38.8

*$\times 10^{-3}$.

TABLE-2
TEST RESULTS OF ANTIBACTERIAL ACTIVITY OF NPAAPH AND $[Hg(NPAAPH)Cl_2]$

Concentration of NPAAPH	Zone of inhibition of bacterial growth aroundthe sample			
	E. coli	*S. aureus*	*Ps. aeruginosa*	*K. pneumoniae*
1 mg/disc	No zone of inhibition	No zone of inhibition	No zone of inhibition	No zone of inhibition
5 mg/disc	No zone of inhibition	No zone of inhibition	No zone of inhibition	No zone of inhibition
10 mg/disc	No zone of inhibition	No zone of inhibition	No zone of inhibition	No zone of inhibition
Concentration of $[Hg(NPAAPH)Cl_2]$	*E. coli*	*S. aureus*	*Ps. aeruginosa*	*K. pneumoniae*
1 mg/disc	1 mm	3 mm	1 mm	No zone of inhibition
5 mg/disc	2 mm	4 mm	2 mm	No zone of inhibition
10 mg/disc	2 mm	5 mm	3 mm	No zone of inhibition

ACKNOWLEDGMENTS

The authors gratefully acknowledge the facilities provided by RSIC, CDRI Luknow, RRL Trivandrum, IIT Chennai and Sree Chitra Thirunal Institute of Medical Sciences, Poojappura, Trivandrum (biological studies). One of the authors (GM) is thankful to UGC, New Delhi for the award of a teacher fellowship to him.

REFERENCES

1. F.A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn., Wiley Eastern, New Delhi (1999).
2. C.J. Alice and C.P. Prabhakaran, *Transition Met. Chem.*, **8**, 368 (1983); M.L. Harikumaran Nair and C.P. Prabhakaran, *Indian J. Chem.*, **39A**, 989 (2000).
3. ———, *Indian J. Chem.*, **35A**, 771 (1996).
4. A.I. Vogel, A Textbook of Practical Organic Chemistry, 3rd Edn., ELBS (1973).
5. ———, A Textbook of Practical Organic Chemistry, 3rd Edn., Wiley, New York (1963).
6. R.J.W. Le Fevr'e, M.F.O. Dwyer and R.L. Werner, Chemistry and Industry, p. 378 (1953).
7. N.F. Curtis and Y.M. Curtis, *Inorg. Chem.*, **4**, 804 (1965).
8. D. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, 4th Edn., Tata McGraw-Hill, New Delhi (1988).
9. K. Ueno and A.E. Martell, *J. Phys. Chem.*, **60**, 1270 (1956).
10. L.J. Bellamy and L. Beecher, *J. Chem. Soc.*, 3372 (1961).
11. M. Alaudeen and C.P. Prabhakaran, *Indian J. Chem.*, **35A**, 517 (1996).
12. N. Kunihiko, T. Sakata and H. Nakahara, *Bull. Environ. Contam. Toxicol.*, **41**, 651 (1088).
13. M. Alaudeen, P.G. Sushama and A.M. Dorothy, *Indian J. Chem.*, **42A**, 1617 (2003).
14. G.L. Choudhary, S.R. Prasad and A. Rahman, *J.Indian Chem. Soc.*, **73**, 683 (1997).

(*Received*: 24 March 2004; *Accepted*: 25 August 2004) AJC-3531