

## **SYNTHESIS, CHARACTERIZATION AND THERMO- CHROMIC BEHAVIOUR OF AMODIAQUINE HYDROCHLORIDE COMPLEXES**

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### **ABSTRACT**

*Complexes of amodiaquine hydrochloride with Co<sup>II</sup>, Ni<sup>II</sup>, Cu<sup>II</sup>, Zn<sup>II</sup>, Sn<sup>IV</sup>, Ti<sup>IV</sup> and Zr<sup>IV</sup> have been prepared. The mode of bonding as well as the structure of complexes have been investigated by means of elemental analyses, molar conductance, magnetic moment and spectral methods (IR, EPR and Electronic spectra). The light has also been thrown on the thermochromic behaviour and thermal stabilities of the complexes using DTA, T.G., IR and electronic spectra. The reversible and irreversible colour changes have been attributed to dimerization, desolvation or geometry change.*

### **INTRODUCTION**

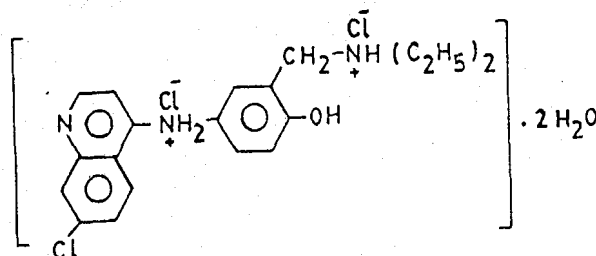
Quinoline derivatives are used as potential antimalarial and/or antiparasitic agents<sup>1-3</sup>. On the other hand, the metal complexes

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of aminoquinolines have been tested for neoplasm inhibitors<sup>4</sup>. Amodiaquine hydrochloride [4-(7-chloro 4-quinolylamino)-2 (diethylamino-methyl) phenol dihydrochloride dihydrate, (I) is one of the antimalarial family. Hassan et al. reported the determination of that drug through the formation of stable ternary complex with cobalt<sup>5</sup>. Nowadays, the thermochromic materials have a great attention due to their numerous applications for assay of various drugs, imaging systems, optoelectronic temperature probes, investigations of microheterogeneous reaction media and the storage of energy<sup>6</sup>. Recently, we have studied the thermochromic behaviour of some metal complexes of 8-aminoquinoline and its Schiff bases<sup>7,8</sup>. In the present paper a number of metal complexes with amodiaquine hydrochloride (I) were prepared and characterized to throw more light on the nature of bonding. The thermochromic behaviour as well as the thermal stabilities of the complexes have also been discussed.



## EXPERIMENTAL

### *Preparation of the complexes*

Complexes (1-7) were prepared by the addition of stoichiometric amounts of the metal chloride in EtOH to a hot alcoholic solution of the ligand (1:1) molar ratio. The reaction mixtures were gently heated with stirring in air. A precipitate was formed after 2h for (1), (3) and (4), whereas the precipitates of (2) and (5-7) were obtained by the addition of small portions of petroleum ether (60 / 80). The precipitates were collected by filtration, washed several times with EtOH and dried over  $\text{CaCl}_2 / \text{P}_4\text{O}_{10}$ .

The apparatus and working procedures were as reported earlier<sup>7,8</sup>. The metal content was estimated using a Perkin Elmer Atomic Absorption (for Co, Ni, Cu, Zn) and gravimetrically as  $\text{MO}_2$  (for Ti, Zr, Sn)..

## RESULTS AND DISCUSSION

The complexes are thermally stable in air up to 240–355°C, except nickel and copper complexes, that melt at 190 and 195°C, respectively. They soluble in water and some organic solvents like EtOH, MeOH and DMF. The complexes display changes in colour upon being heated at different temperature in the solid state. The molar conductivity values of the complexes in EtOH (Table 1) are considerably lower than those of univalent electrolytes in this

solvent<sup>9</sup>. This indicates that the complexes are predominantly covalent in character. The observed values of conductance may be attributed to the presence of HCl molecules (solvent of crystallization) in the solutions.

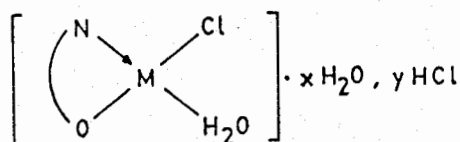
### *Vibrational spectra*

The IR spectrum of the ligand (Table 1) displays bands at 3410, 2720 – 2640 and 1610– 1560  $\text{cm}^{-1}$ . These bands are assigned to  $\nu(\text{OH})$  (phenolic),  $\nu(\text{NH})$  of amine hydrochloride moiety ( $-\text{NH}_2\text{Cl}^-$  and  $-\text{NH}^+\text{Cl}^-$ ) and  $\nu(\text{C} \equiv \text{C}) + \nu(\text{C} \equiv \text{N})$  of quinoline ring<sup>7</sup>, respectively. Both the phenolic  $\nu(\text{OH})$  and  $\nu(\text{NH})$  of amine hydrochloride disappeared in the spectra of complexes (Table 1), and the observed new band at 3320 – 3290  $\text{cm}^{-1}$  assigned to  $\nu(\text{NH})$  of free secondary amine (s-amine)<sup>10</sup>. Moreover, the  $\nu(\text{C} \equiv \text{C}) + \nu(\text{C} \equiv \text{N})$  band of quinoline ring doesn't shift from that of the ligand. This indicates that both nitrogen atoms of quinoline ring and (s-amine) do not participate in the coordination. We therefore conclude that the ligand is monobasic bidentate, chelating through phenolic oxygen and nitrogen of t-amine. Bands near 560 – 510 and 450 – 445  $\text{cm}^{-1}$  can be assigned to  $\nu(\text{M}-\text{O})$  and  $\nu(\text{M}-\text{N})$ , respectively<sup>11,12</sup>. The evidence for terminal  $\nu(\text{M}-\text{Cl})$  is taken from the appearance of bands near 290 – 280  $\text{cm}^{-1}$ <sup>13</sup>.  $\nu(\text{OH})$  of water of crystallization appears near 3400–3560  $\text{cm}^{-1}$  in the spectra of the complexes<sup>10</sup>.

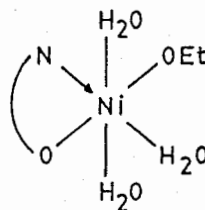
### ***Electronic spectra***

The electronic spectra of cobalt, nickel and copper complexes together with their magnetic moments were collected in Table (1). The spectrum of cobalt(II) complex in nujol mull shows a multiple absorption band centered at 665 nm. This band is assigned to  $\nu_3 [{}^4A_2 \rightarrow {}^4T_1 (P)]$  transition in a tetrahedral structure<sup>14</sup>. The anomalous moment (1.66 BM) determined for this complex may be due to lower symmetry<sup>15</sup>. The spectrum of the complex in EtOH gives the same band at (665 nm), indicating that the geometry doesn't change. The spectrum of nickel(II) complex shows a broad band within the range 530–385nm (centered at 425 nm). This band can be assigned to  $\nu_3 [{}^3A_{2g} \rightarrow {}^3T_{1g}(P)]$  transition in an octahedral structure<sup>14,16</sup>. The magnetic moment (2.8 BM) provides additional evidence for the proposed structure. The spectrum of copper(II) complex displays a broad band in the region 850 – 650 nm (centered at 780 nm). This band can be assigned to  $({}^2E_g \rightarrow {}^2T_{2g})$  transition in a square planar geometry<sup>14, 17</sup>. The value of magnetic moment (1.91 BM) lies within the permissible range that is reported for one unpaired electron. The X-band EPR spectra of the complex was also obtained in the solid state at room temperature. The spectrum (Fig. 1) exhibits an intense broad band with two lines at  $g_{||} = 1.9404$  and  $g_{\perp} = 1.9157$ . The shape of the signal and the  $g$  values are very similar to squar planar Cu(II) complexes<sup>17</sup>. On the basis of the above

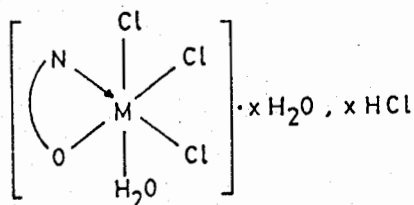
discussion, together with the elemental analyses (Table 1), we can suggest the following structures.



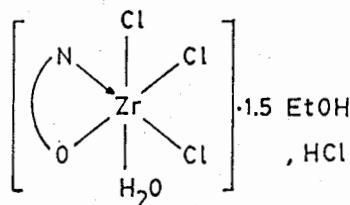
- (1) M = Co , x = 1.5 , y = 1  
 (3) M = Cu , x = 2 , y = 2  
 (4) M = Zn , x = 1 , y = 2



(2)



- (5) M = Sn , x = 2 , y = 1.5  
 (6) M = Ti , x = 2.5 , y = 2



(7)

### Thermal studies

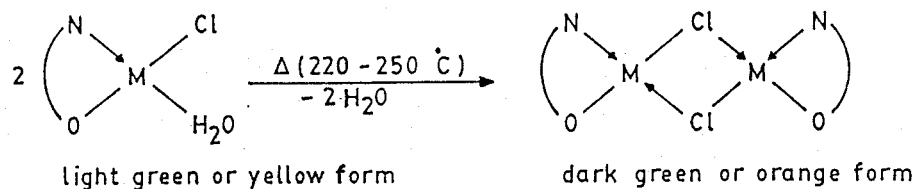
The complexes are thermochromic and show thermal stability up to 240 – 355 °C Both nickel and copper complexes melt at 190 and 195 °C, respectively together with decomposition. DTA and T.G. data, and investigation on a hot stage microscope confirm the above

### *Synthesis, Characterization and Thermochromic .....*

behaviour. The observed reversible and irreversible thermochromism can be attributed to dimerization, desolvation and geometry change as shown below. The yellow tin(IV) complex change into dark yellow and orange in the temperature ranges 60–100 and 140–240 °C respectively. The change in colour is reversible and as indicated from the T.G. data (Table 1), the change can be attributed to the loss of solvent of crystallization. The DTA curve of the complex shows two broad endothermic peaks in the same temperature ranges, confirming the desolvation process. On the other hand, the complex start its decomposition at 240 °C.

### *Cobalt and zinc-complexes*

The light green and yellow complexes of cobalt and zinc change into dark green and orange upon heating up to 250 °C, respectively. The change in colour is irreversible in air, and may be attributed to dimerization through the loss of coordinate water as shown from the T.G. weight loss in the temperature range 220–250 °C (Table 1 and Fig.2). The DTA curves of the light green and yellow forms give also an endothermic peak in that temperature range confirming the loss of water. Another evidence for dimerization was taken from the IR spectra of the dark green and orange forms. The spectra display a new splitted band in the range 260 – 205  $\text{cm}^{-1}$  assigned to bridged  $\nu(\text{M}-\text{Cl})$ <sup>8</sup>. The above behaviour can be represented as follows:



The DTA curves show also an endothermic peak in the temperature range 270–355°C which assigned to the loss of solvents of crystallization as indicated from T.G. data (Table 1). The higher temperature of desolvation (which followed by spontaneous decomposition of the complex) may be attributed to the higher interaction of the solvents in the lattice through the formation of strong hydrogen bonding between HCl or H<sub>2</sub>O and free nitrogen atoms in the ligand molecule.

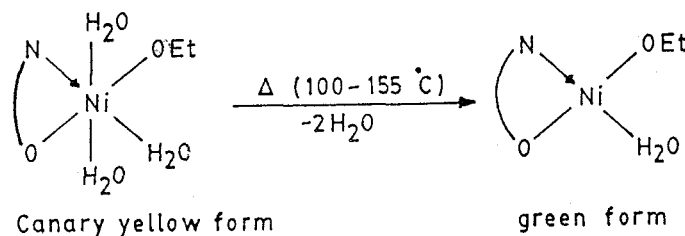
### *Nickel-complex*

The complex displays colour change from canary yellow to green upon being heated in the solid state over the temperature range 100–155 °C. The change in colour is reversible in air and can be offset if the complex heated in silicon oil. the T.G. weight loss (Table 1) corresponds to two molecules of coordinated water. The DTA curve of the canary yellow form shows an endothermic peak in the temperature range of the colour change, confirming the formation of the green



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form. The electronic spectra of the canary yellow and the green forms are significantly different, indicating a change in coordination geometry. The spectrum of the green form in nujol mull shows bands near 573 and 397 nm assigned to ( ${}^1A_{1g} \rightarrow {}^1A_{2g}$ ) and ( ${}^1A_{1g} \rightarrow {}^1B_{1g}$ ) transitions, respectively in square planar geometry<sup>14</sup>. It is noteworthy that, the isolated green square planar form is one of the few examples of green square planar nickel complexes<sup>14</sup>. As indicated from DTA and T.G. data (Table 1) the complex starts its decomposition at 250 °C.



***Titanium and zirconium-complexes***

The complexes change into light orange and deep red in the temperature range 40–160 and 170–287 °C respectively. The colour changes are irreversible in air. The T.G. data (Table 1) indicate that, the change in the colour in the first step can be attributed to desolvation (loss of solvent of crystallization), which leads to changes in the symmetry and strength of the ligand field due to structural changes<sup>18</sup>.

Whilst the change in the second step may be attributed to dimerization through the loss of HCl molecules from the inner sphere, giving titnyl or zirconyl dimeric complexes as seen below. The IR spectra of the deep red forms display a splitted band at  $278 - 201 \text{ cm}^{-1}$  assigned to bridged  $\nu(\text{M}-\text{Cl})$ . The complexes start their decomposition at  $287^\circ\text{C}$  as shown from T.G. and DTA data.

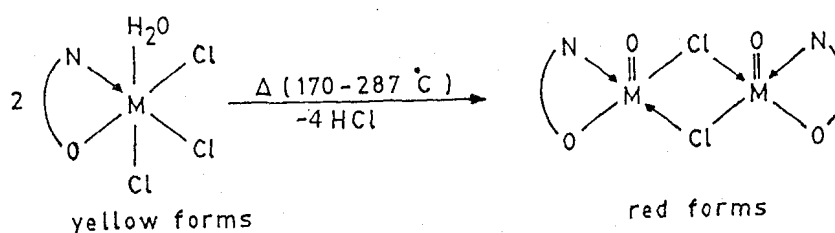


Table (1): Analytical, magnetic, spectral and thermal data for ligand and its complexes.

Compound	Colour	Found (Calcd)%			$\mu_{eff}$ B.M	$\Lambda_m$ $cm^2 \Omega mol^{-1}$ in EtOH	i.r. ( $cm^{-1}$ )				Electronic spectra (nm) in nujol mulls (d-d)	T.g. temp. (°C)	weight loss found (calcd)%	assignment	
		C	H	M			$\nu$ (OH) phenolic	$\nu$ (NH) of s-amine	$\nu$ (-NH <sub>2</sub> X) or $\nu$ (-NHX)	$\nu$ (C=C) +					$\nu$ (M-N)
amodiaquine hydrochloride (HL)	Yellow						3410(s)		2720-2640 <sup>a</sup>	1610(s), 1560(s)					
(1) [CoLCl(H <sub>2</sub> O)].1.5H <sub>2</sub> O, HCl	Light green	45.1 (45.2)	5.2 (5.1)	11.5 (11.1)	1.66	65.0		3320(w)		1610(s), 1580(s)	460(m) 560(w) 280(m)	691 - 634 <sup>b</sup> 220 - 250 305 - 355	3.3(3.4) 12.2(12.0)	H <sub>2</sub> O 1.5H <sub>2</sub> O+HCl	
(2) [NiL(EtO)(H <sub>2</sub> O) <sub>3</sub> ]	Canary yellow	51.7 (51.6)	5.3 (5.3)	11.8 (11.5)	2.80	32.8		3310(w)		1610, 1590, 1575	445(w) 510(m)	530 - 385 br 100 - 155	7.0(7.0)	2H <sub>2</sub> O	
(3) [CuLCl(H <sub>2</sub> O)].2H <sub>2</sub> O, 2HCl	Yellowish brown	41.7 (41.3)	4.1 (5.0)	10.0 (10.9)	1.91	76.0		3300(w)		1610(s), 1575(s)	510(w) 285(w)	420 (s), 780 (br) 75 - 230 230 - 255 255 - 300	6.5(6.2) 6.5(6.2) 9.3(9.4)	2H <sub>2</sub> O HCl H <sub>2</sub> O+HCl	
(4) [ZnLCl(H <sub>2</sub> O)].H <sub>2</sub> O, 2HCl	Yellow	42.5 (42.5)	4.6 (4.8)	11.8 (11.6)		54.7		3320(w)		1610(s), 1580(s)	460(m) 560(w)	225 - 250 270 - 355	3.2(3.2) 16.0(16.1)	H <sub>2</sub> O H <sub>2</sub> O+2HCl	
(5) [SnLCl <sub>3</sub> (H <sub>2</sub> O)].2H <sub>2</sub> O, 1.5HCl	Yellow	35.5 (34.9)	4.2 (4.1)	17.1 (17.2)		59.3		3290(m)		1610(s), 1585(m)	480(w) 550(m) 285(m)	60 - 100 140 - 240	5.2(5.2) 8.4(8.4)	2H <sub>2</sub> O 1.5HCl	
(6) [TiLCl <sub>3</sub> (H <sub>2</sub> O)].2.5H <sub>2</sub> O, 2HCl	Yellow	36.9 (37.2)	4.6 (4.3)	7.0 (7.4)		partially soluble		c		1600(s), 1580(s)	412(m) 540(w)	40 - 160 170 - 280	12.2(12.7) 16.9(17.0)	2.5H <sub>2</sub> O+HCl 3HCl	
(7) [ZrLCl <sub>3</sub> (H <sub>2</sub> O)].1.5 EtOH, HCl	Yellow	40.1 (40.1)	4.6 (4.9)	13.8 (13.5)		40.0		c		1600(s), 1580(m)	420(m) 510(w) 290(sh)	40 - 150 183 - 287	15.6(15.6) 10.4(10.8)	HCl+1.5EtOH 2HCl	

a : several bands      b : split,      c : covered by the broad band of water of crystallization in the same region.

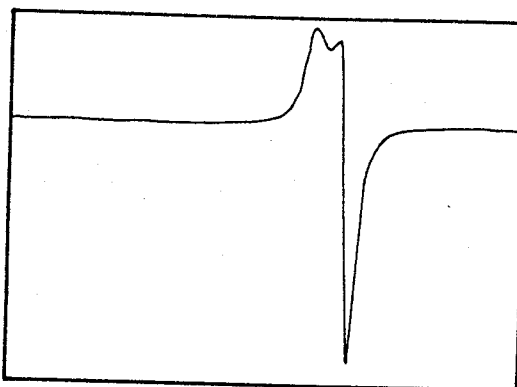


Fig. 1. X-band EPR of copper (II)-  
complex at 298 K .

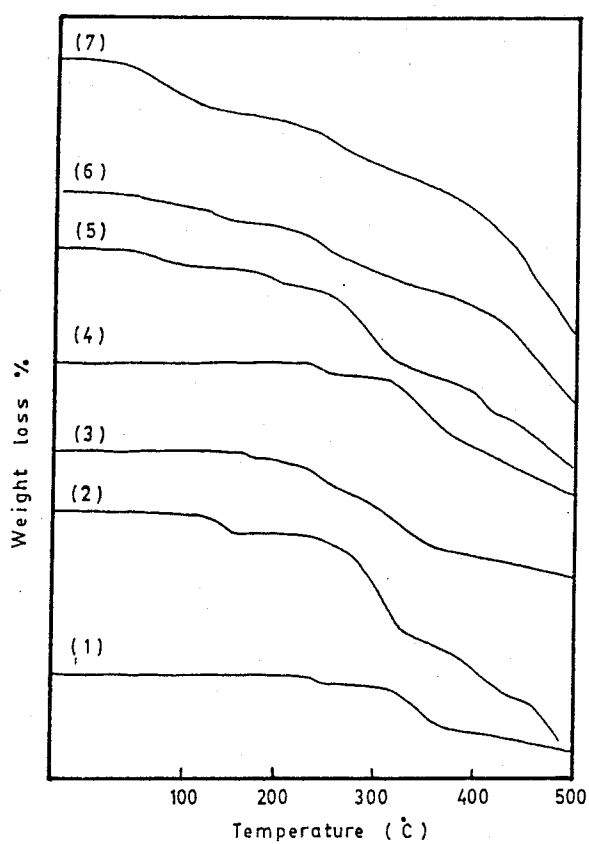


Fig. 2. T.G. Thermograms of the complexes .

## REFERENCES

1. K.K. Pandey, *J. Def. Sci.*, **30**, 191 (1980).
2. B.K. Bhat, M. Seth and A.P. Bhaduri, *Prog. Drug Res.* **28**, 197 (1984).
3. J.C. Anders, H. Chung and A.D. Theoharides, *Fundam. Appl. Toxicol.*, **10**, 270 (1988).
4. Y. Kidani, Y. Oya and K. Inagaki, *Yakugaku Zasshi*, **97**, 932 (1977).
5. S.M. Hassan, M.E.S. Metwally and A.A. Abou Ouf, *Analyst*, **107**, 1235 (1982).
6. L. Tan-Sien-Hee, D.L. Lavabre, G. Lévy and J.C. Micheau, *New J. Chem.*, **13**, 227 (1989).
7. A.M. Donia and H.A. El-Boraey, *Transition Met. Chem.*, **17**, 307 (1992).
8. A.M. Donia and H.A. ElBoraey, *Transition met. Chem.*, **18**, 315 (1993).
9. G. Devoto, M. Massacesi, R. Pinna and G. Ponticelli, *Spectrochimica Acta*, **38**, 725 (1982).
10. K. Nakanishi and P.H. Solomon "Infrared Absorption Spectroscopy" 2<sup>nd</sup> Edition, Holden-Day, Inc. , Oakland (1977).
11. I. Nakagawa and T. Shimanouchi, *Spectrochimica Acta*, **23**, 2099 (1967) .
12. B. Khera, A.K. Sharma and N.K. Kaushik, *Polyhedron*, **2**, 1177 (1983).
13. M. Izquierdo, *Transition Met Chem.*, **8**, 110 (1983).

14. A.B.P. Lever "Inorganic Electronic Spectroscopy" Elsevier, Amsterdam (1968).
15. A.A. El-Asmy, T.Y. Al-Ansi, R.R. Amin and M. Mounir, Polyhedron **9**, 17 (1990).
16. A.A. El-Asmy, T.Y. Al-Ansi and Y.M. Shaibi, Transition Met. Chem., **14**, 446 (1989).
17. S.M. Abu-El-Wafa, M.A. El-Ries and F.H. Ahmed, Inorg. Chim. Acta, **136**,127 (1987) .
18. K. Sone and Y. Fukuda " Inorganic Thermochemistry" Spinger Verlag, Berlin, 1987.

## تحضير-تشخيص - ودراسة السلوك اللوني الحرارى لمتراكبات عقار هيدروكلوريد الأموديكين

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فى هذا البحث تم تحضير متراكبات عقار هيدروكلوريد الأموديكين  
(الذى يستخدم فى علاج الملاريا) مع بعض أيونات الفلزات الثنائية والرابعة.  
وقد تم الوقوف على نظام الترابط بين أيونات الفلزات ومركب الأموديكين من  
خلال الدراسات التحليلية والطيفية المختلفة. كما أُلقت الدراسة الضوء على  
الثبات الحرارى للمتراكبات الناتجة من خلال قياسات التحليل الحرارى التفاضلى  
والتحليل الحرارى الوزنى . كما أعزى التغير فى لون المتراكبات بالحرارة الى  
الديمرية وتغير التركيب الفراغى وفقد ماء التبلر.