



## Metal Complexes of Proline-Azo Dyes, Synthesis, Characterization, Dying Performance and Antibacterial Activity Studies

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### ABSTRACT

The synthesis, structural spectroscopic properties of 4-(2-benzimidazolylazo)proline (BMP) and its complexes derived from [Cu(II), Ag(I) and Au(III)] salts were done. The mode of bonding for the complexes were accomplished based on elemental analysis, FTIR, UV-Vis and HNMR spectroscopy, magnetic measurement and molar conductivity. It has been found that the ligand (BMP) behaves as N,N-neutral bidentate which was forming chelates with molar ratio (1:2) (M:L) stoichiometry for [Cu(II) and Ag(I)] while Au(III) complex form molar ratio (1:1) at optimum concentration and pH as well as ( $\lambda_{max}$ ). The stability constant and Gibbs free energy for the prepared complexes are evaluated by spectroscopic methods. The prepared ligand (BMP) in comparison to its metal complexes, were screened for their antibacterial activity against two bacterial species, *Escherichia coli* and *Staphylococcus*. Dying performance was also studied.

**Keywords:** Azo dyes, azo complexes, synthesis.

### INTRODUCTION

The expansions of new structure of azo compounds have been a subject of regard and much novel structure of these compounds<sup>1</sup>. Azo compounds with the hetrocyclic diazo component from colored complexes with universality metal ions<sup>2</sup> and are an important for industry and biological system<sup>3</sup>. In addition metal chelates have been studies and attracted much attention due to their interesting electronic and geometrical features in connection with their application various fields<sup>4</sup>. This

type of azo compounds which are characterized with (L)-acidic) azo imine (-N=N-C-N) which giving results with good rates and great stability as well as characterized with ease of purification and deep colors which have displacements in the wavelength when they are consistent with transition metal ions<sup>5,6</sup>. The chelate complexes that have five-membered or six-membered chelate rings are the most stable complexes<sup>7</sup>. In the fact that some drugs including discouraging the growth of germs<sup>8,9</sup>. In addition, the important uses of these compounds are analytical reagents<sup>10-12</sup> for solvent

extraction to determine some metal ions. The azoimidazole compounds have important role in spectral determination field to identify the amount of elements especially with transition metal ions because of its sensitivity and selectivity<sup>13</sup>. In our research we were able to prepare new ligand (BMP) and its complexes with [Cu(II), Ag(I) and Au(III)] taking into account a spectral study in order to obtain optimum condition (concentration and pH) and metal to ligand ratio for preparation the complexes.

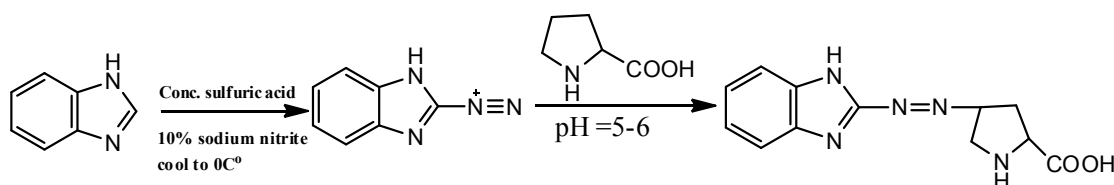
## EXPERIMENTAL

### Materials and Instruments

All elements and solvent are of best purity and used as found from the productions. Microelemental analysis (C.H.N) was gained on a (Eure EA 3000 Elemental analyzer). UV-Vis Spectra were performed in ethanol on a (Shimadzu UV-160A) ultra violet-visible spectrophotometer. FTIR-spectra were recorded on a (Shimadzu FTIR-8400s Fourier Transform Infrared) spectrophotometer (200-4000)  $\text{cm}^{-1}$  using CsI discs. The <sup>1</sup>HNMR spectra were gained on a (<sup>1</sup>HNMR Spectrometer 4000 MHz, Avance III 400 Bruker, Germany). The molar Conductivity for the complexes was determined in ( $10^{-3}$  M) DMSO at room temperature using (HANNA instruments / Conductivity Tester). pH measurement was performed using (HANNA instruments pH Tester / Pocket pH Tester). Melting points have been gained via using (Stuart Melting Point Apparatus). The percentage of metal in complexes was done by using a "GBC 933 Plus" "Flam Atomic Absorption Spectrophotometer. Thermal Analysis measurements TG, DTG and DSC were performed by using (Mettler) Thermogravimetric Analyzer.

### Synthesis of 4-[(2- benzimidazolyl) azo] proline (BMP)

This ligand was synthesized according to the method reported in the literature<sup>14</sup> with some modifications as shown in scheme (1):



Scheme (1): Preparation of BMP ligand

### Preparation of solutions

Ammonia acetate as a buffer solution was prepared with a range (5-9) by dissolving (0.01 M, 0.77 gm) in one liter of deionized water. pH was detected by adding acetic acid or ammonia solution. As for standard solutions for selected metal salts and ligand were prepared by dissolving appropriate weight to the extent ( $1 \times 10^{-5}$  M-  $3 \times 10^{-5}$  M).

### Synthesis of complexes

Three complexes were prepared via adding regularly with stirring hot ethanolic solution of (2 mmole) ligand to stoichiometry mole ratio of (1:2) (M: L) for [Cu(II) and Ag(I)] and (1:1) for [Au(III)] which were dissolved in the prepared buffer solution at optimum pH. Then the mixture was heated to (60°C) with stirring for 3h, after that left to cool at room temperature. The colored precipitates were filtered, washed and desiccated in vacuum desiccator. The suggested stoichiometry structure of the prepared complexes is shown in scheme (2).

## RESULTS AND DISCUSSIONS

The reaction of the prepared ligand (BMP) with selected transition metal ions [Cu(II), Ag(I) and Au(III)] at optimum pH and concentration, which mains to formation of the complexes with following formula [Cu(BMP)<sub>2</sub>Cl<sub>2</sub>], [Ag(BMP)<sub>2</sub>]NO<sub>3</sub> and [Au(BMP)Cl<sub>2</sub>]Cl. The ligand (BMP) doings as N, N'-chelator, where N of (azo) and N' of (benzimidazole). The structure of the complexes is supported via the analytical and spectral studies results. All complexes were stable in air and moisture as well as soluble in most organic solvents such as ethanol, DMSO, DMF, acetone ...etc. By studying the molar conductivity of the prepared complexes which were measured at ( $10^{-3}$  M) in DMSO found that Cu(II) complex was non electrolyte while Ag(I) and Au(III) complexes are (1:1) electrolyte, supporting the ionic behavior for Ag(I) and Au(III) complexes, (Table (1)).

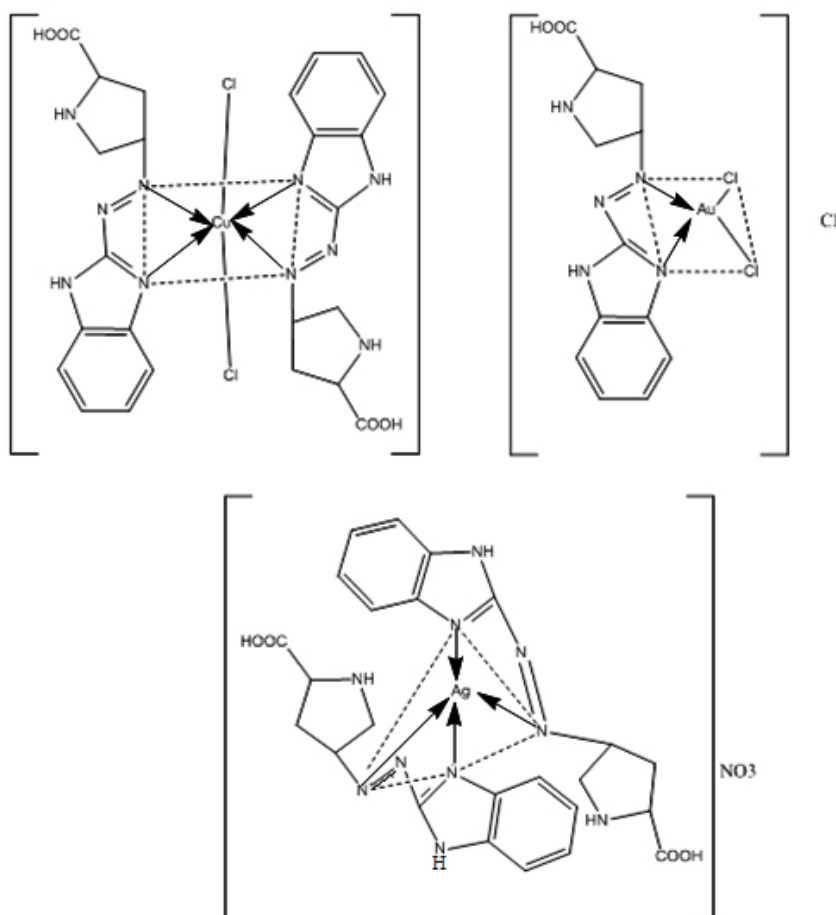
The UV-Vis spectra of the prepared ligand (BMP) and its complexes under examination as was shown in Figures (1 and 2) were shown mainly two peaks observed in ethanol ( $10^{-4}$ ) within the range (250-1100) nm. The first peak at (339) nm for ligand (BMP) was owing to the  $\pi \rightarrow \pi^*$  transition of the aromatic rings. The second peak ( $\lambda_{max}$ ) at (449) nm ligand (BMP) was related to the  $\pi \rightarrow \pi^*$  this is assigned to the transition of (GT) intramolecular charge-transfer taken place through the azo moiety (-N=N-)<sup>15</sup>.

It has been saw red shift in the visible region when a competitive study between the spectra of mixing aqueous solutions for [Cu(II), Ag(I) and Au(III)] with ethanolic solutions of ligand (BMP) which ranged between (250-1100)nm. The change

in the appearance color of free ligand (BMP) solution and high shift in the ( $\lambda_{max}$ ) gives a good sign for coordination and formation of complexes.

On the other hand the UV-Vis spectra were studied for mixed solutions of [Cu(II), Ag(I) and Au(III)] and ligand (BMP) within the range of concentration from ( $10^{-3}$ M- $10^{-6}$ M), only  $10^{-5}$  obey Lambert Beer law, while the pH sequence was from (5-9). Figure (3) was appeared best suitable straight lines, with correlation factor ( $r > 0.989$ ) when the absorbance plotted against molar concentration in the rang from ( $1 \times 10^{-5}$ M-  $3 \times 10^{-5}$ M).

The pH effect was also examined at the range (5-9). Figure (4) was shown the absorbance-pH curves which are completed at ( $\lambda_{max}$ ) and various



**Scheme (2): The suggested structure for the prepared complexes**

concentrations for each metal ion solution under study. A high band on the pH curves it is considered as a mark of the complex formation and acceptance as optimum pH for all preparation complexes. But the descent part of the curves may be referring to the dissociation of complex at this point. Therefore, we conclude that all prepared chelate complexes with selected metal ions are formed in neutral or basic medium<sup>16, 17</sup>:

Spectrophotometry is one of the most useful tools for elucidation of the composition of complexes in solution. The power of the technique lies in the fact that quantitative absorption measurements can be performed without fear of disturbing the equilibria under consideration. Two of the most common

techniques employed for identify the composition of the complexes in solution without isolation are the mole ratio procedure and continuous variations method or Job method<sup>18</sup> (Figures (5 and 6)):

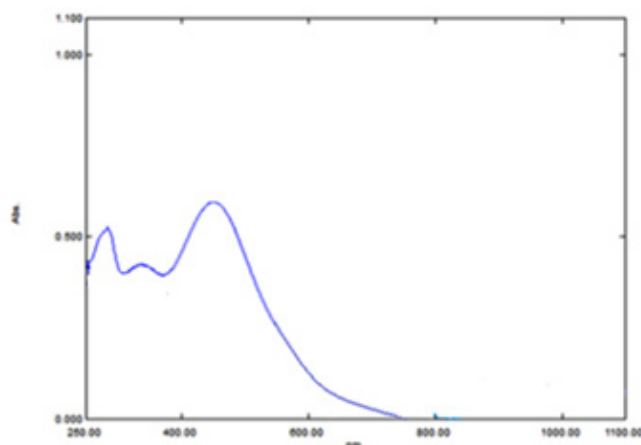
The two methods support same result about mole ratio of the complexes. It will be taking into account all the result we have obtained to install optimal condition to prepare the complexes of [Cu(II), Ag(I) and Au(III)] with the ligand (BMP).

Determination of Stability Constant and Gibbs free energy of prepared complexes:-

The stability constant (K) for Cu(II) and Ag(I) complexes in a mole ratio (M:L)(1:2) was computed based on the equation<sup>19</sup>:

**Table 1: physiochemical properties, elemental analysis, mole ratio, molar conductance for the ligand (BMP) and selected metal ions**

Complexes (M.wt) (gm/mol)	pH (M:L)	Color $\lambda$ (nm)	C	% Found % (Calculated)				$\Delta$ Cl (S.mol <sup>-1</sup> cm <sup>2</sup> )
				H	N	M	Cl	
BMP (C <sub>12</sub> H <sub>13</sub> N <sub>5</sub> O <sub>2</sub> ) (260.13)	-	Yellow-green	56.87 (56.907)	5.38 (5.471)	25.47 (25.535)	-	-	-
[Cu(C <sub>24</sub> H <sub>26</sub> N <sub>10</sub> O <sub>4</sub> )Cl <sub>2</sub> ] (654.8)	7 (1:2)	Blue-violet(610)	44.79 (44.02)	4.43 (3.97)	20.77 (21.70)	9.77 (9.70)	10.91 (10.84)	10
[Ag(C <sub>24</sub> H <sub>26</sub> N <sub>10</sub> O <sub>4</sub> )]NO <sub>3</sub> (690.13)	8.5 (1:2)	Red (497)	40.66 (41.73)	4.19 (3.76)	22.71 (22.31)	15.60 (15.63)	-	34
[Au(C <sub>12</sub> H <sub>13</sub> N <sub>5</sub> O <sub>2</sub> )Cl <sub>2</sub> ]Cl (563.6)	8 (1:1)	Red (496)	25.43 (25.55)	2.19 (2.129)	11.97 (12.42)	34.90 (34.94)	18.99 (18.89)	35



**Fig. 1: UV-Vis spectrum of the ligand (BMP)**

$$K = \frac{1-\alpha}{4\alpha^2 C^2}$$

As for the stability constant for Au(III) complex in a mole ratio (M:L) (1:1) was computed based on the equation<sup>19</sup>:

$$K = \frac{1-\alpha}{\alpha^2 C}$$

Where:

$$\alpha = \frac{A_m - A_s}{A_m}$$

$\alpha$ = degree of dissociation.

$A_m$ = the absorption of solution containing the same volume of metal and excess of ligand.

$A_s$  = the absorption of solution containing a stoichiometric volume of ligand and metal ion.

$c$  = the concentration of the complex solution in mole/ L.

From Table (3) we calculated that Cu(II) and Ag(I) complexes more stable than Au(III) complex. The thermodynamic parameters of Gibbs free energy ( $\Delta G$ ) were also studied. The  $\Delta G$  data have been calculated from the equation below<sup>20</sup>:

$$\Delta G = -R T \ln k$$

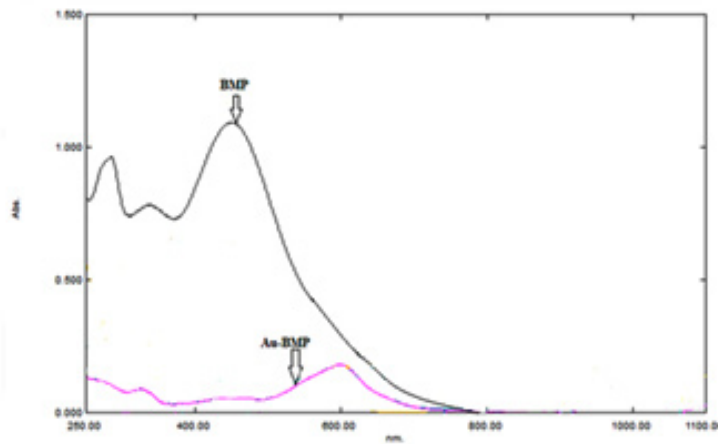


Fig. 2: UV-Vis spectra of the ligand BMP and Au-BMP complexes solution

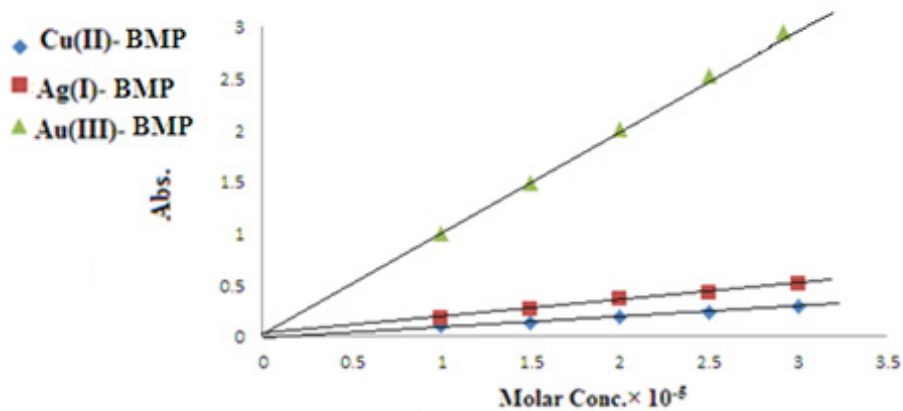


Fig. 3 : Linear relationship between molar concentration and absorbance for metal ion-BMP complexes solution at optimum pH &  $\lambda_{max}$

Where R = gas constant =  $8.3 \text{ J.mol}^{-1}.\text{K}$ , T = absolute temperature (Kelvin).

Table (3) was shown that the formations of all prepared complexes are spontaneous.

### Electronic Spectra and Magnetic measurement for solid complexes

The UV-Vis absorption spectra of the coordination compounds provide a convenient method for determining the magnitude of the effect

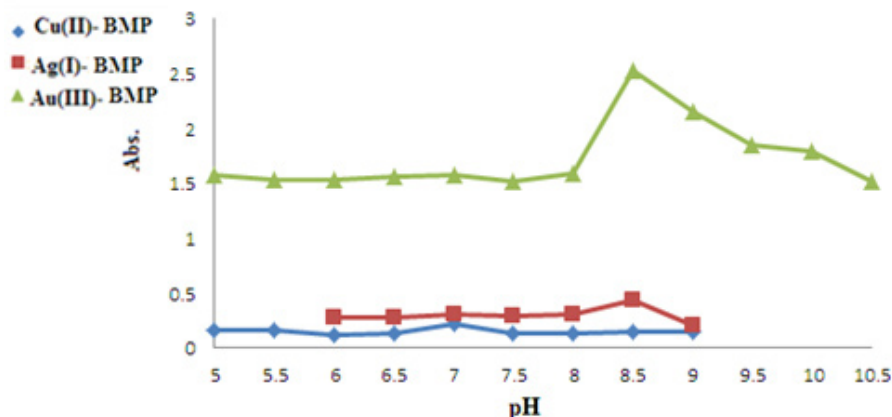


Fig. 4: Effect of pH on absorbance at  $\lambda_{\max}$  for metal ions-BMP complexes solution

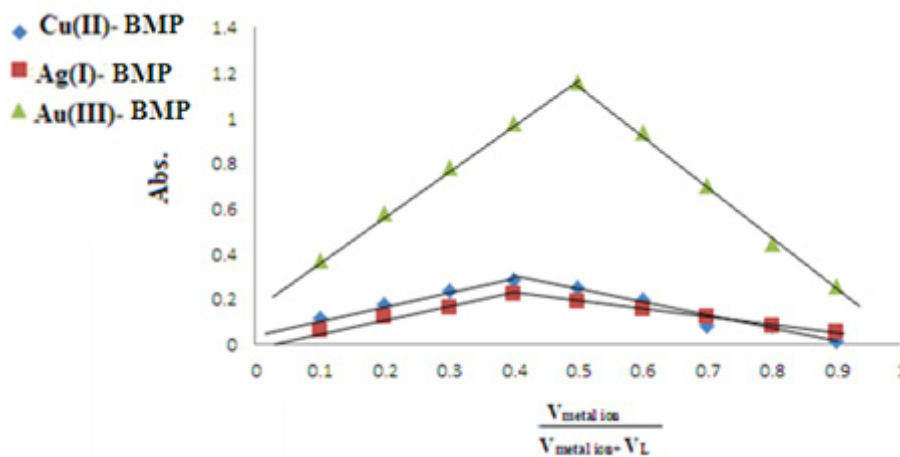


Fig. 5: Job Method plot of metal ion-BMP ligand complexes solution at optimum pH and  $\lambda_{\max}$

Table 3: Stability constant (K) and Gibbs free energy ( $\Delta G$ ) for the prepared complexes

Complexes	Am	As	$\alpha$	K	Log K	$\Delta G$
[Cu(BMP) <sub>2</sub> Cl <sub>2</sub> ]	0.304	0.155	0.4901	$1.7325 \times 10^9$	9.23869	-52969.47322
[Ag(BMP) <sub>2</sub> ]NO <sub>3</sub>	0.194	0.100	0.4845	$1.8130 \times 10^9$	9.25842	-53082.57391
[Au(BMP)Cl <sub>2</sub> ]Cl	0.532	0.175	0.6710	$2.9228 \times 10^4$	4.4658	-25604.44463

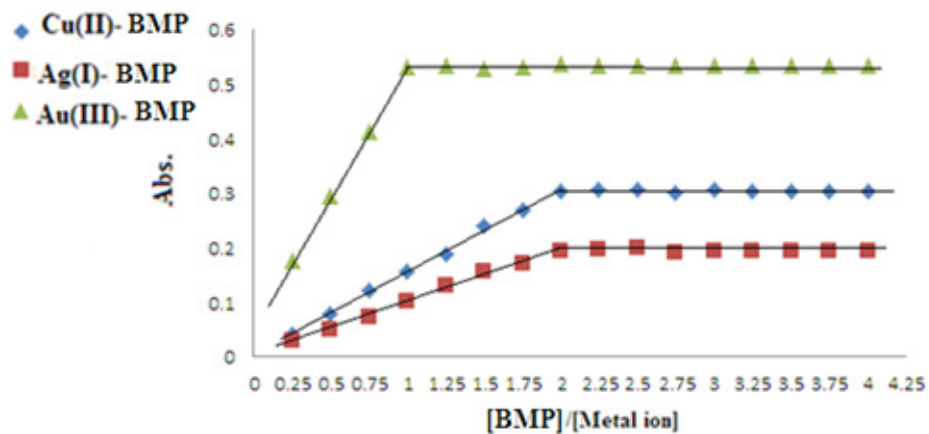


Fig. 6: Mole ratio plot for metal ion-BMP complex solution at optimum pH and  $\lambda_{\max}$

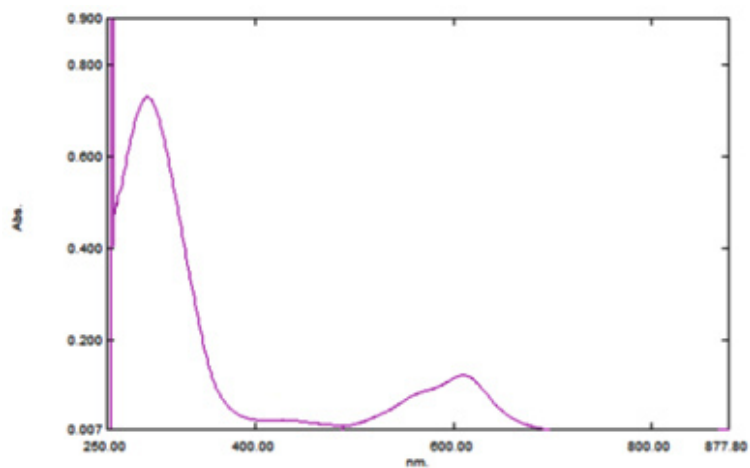


Fig. 7: UV-Vis spectrum of the Cu-BMP complex

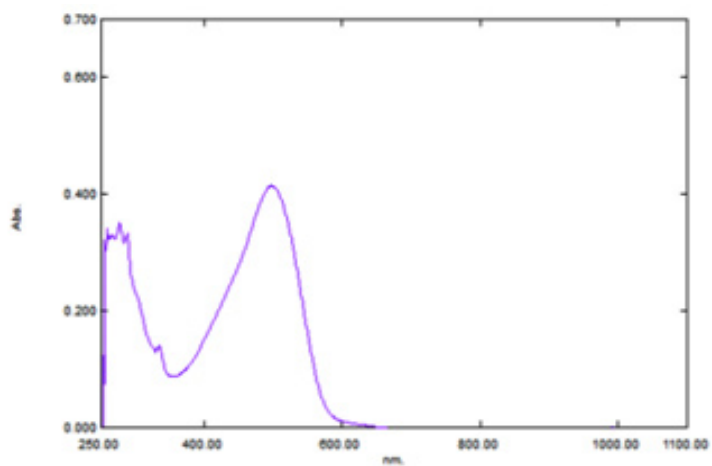


Fig. 8: UV-Vis spectrum of the Ag-BMP complex

of ligand filed on the d-orbitals of the metal ions. The UV-Vis spectrum of Cu-Complex with ligand (BMP) was shown in Figure (7) showed three absorption bands. The first band looked at (610) nm, (16393)  $\text{cm}^{-1}$ . This is assigned to the transition ( ${}^2B_{1g} \rightarrow {}^2A_{1g}$ ). The second band was observed at (427) nm, (23419)  $\text{cm}^{-1}$  which is assigned to the transition ( ${}^2B_{1g} \rightarrow {}^2B_{2g}$ ). The third band at (291) nm (34362)  $\text{cm}^{-1}$  and was assigned to C.T transition. These three transitions characterized distorted octahedral ( $d^9$ ) geometry  $D_4h^{21}$ . With paramagnetic properties (Table (4)).

As for the Ag-complexes ( $d^{10}$ ), one absorption band at (497)nm (20120) $\text{cm}^{-1}$  which is related to ( $\pi \rightarrow \pi^*$ ) (MLCT) transition (Figure(8)). These complexes are to be tetrahedral<sup>22</sup>. The

magnetic properties are diamagnetic for Ag-complexes (Table (4)).

Recently the UV-Vis spectrum for Au-complexes  $d^8$  low spin square planer structure, was appeared (d-d) transition. The  $[Au(BMP)Cl_2]Cl$  have four absorption bands at (980, 861, 653 and 496)nm (10204, 11614, 15313 and 20161) $\text{cm}^{-1}$  which are due to transition of  ${}^1A_{1g} \rightarrow {}^2A_{2g}$ ,  ${}^1A_{1g} \rightarrow {}^1E_g$ ,  ${}^1A_{1g} \rightarrow {}^1A_{2u}$  and  ${}^1A_{1g} \rightarrow {}^1B_{1g}$  respectively as was shown in (Figure (9))<sup>23</sup>. With diamagnetic properties (Table (4)).

### IR Spectra of prepared Ligands and Complexes

For identification and detect the coordination site that may be involved in complexation. The FTIR spectra of all prepared complexes using Csl were compared with the prepared ligand (BMP) (Figures

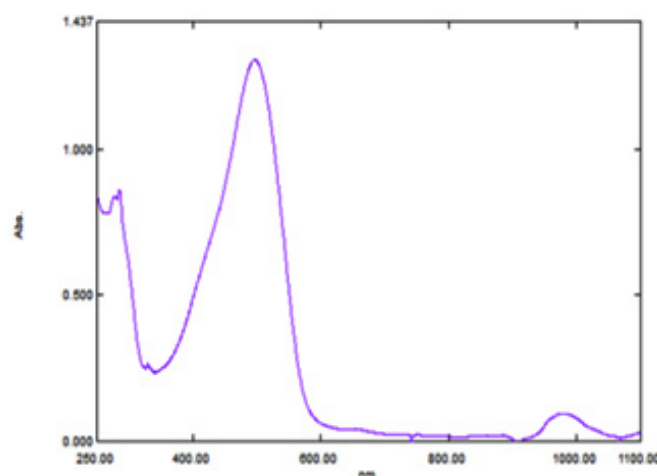


Fig. 9: UV-Vis spectrum of the Au-BMP complex

Table 4: The UV-Vis spectra for the prepared complexes at ( $10^{-4}M$ )

Compounds	$\lambda$ nm	Wave Number $\text{cm}^{-1}$	$\epsilon_o \times 10^4$ $\text{L.mol}^{-1}.\text{cm}^{-1}$	Assignment	Magnetic properties
$[Cu(BMP)_2Cl_2]$	610	16393	0.124	${}^2B_{1g} \rightarrow {}^2A_{1g}$	Paramagnetic
	427	23419	0.028	${}^2B_{1g} \rightarrow {}^2B_{2g}$	
	291	34362	0.731	MLCT	
$[Ag(BMP)_2]NO_3$	497	20120	0.414	$\pi \rightarrow \pi^*$ (MLCT)	Diamagnetic
$[Au(BMP)Cl_2]Cl$	980	10204	0.096	${}^1A_{1g} \rightarrow {}^2A_{2g}$	Diamagnetic
	861	11614	0.018	${}^1A_{1g} \rightarrow {}^1E_g$	
	653	15313	0.040	${}^1A_{1g} \rightarrow {}^1A_{2u}$	
	496	20161	1.305	${}^1A_{1g} \rightarrow {}^1B_{1g}$	



(10-13)). The spectra of the prepared complexes presented the bands specific to the ligand with some differences in the shape and positions of the

bands mention to the formation and coordination of complex, Table (5) induced the main infrared spectral bands of the free ligand and its complexes.

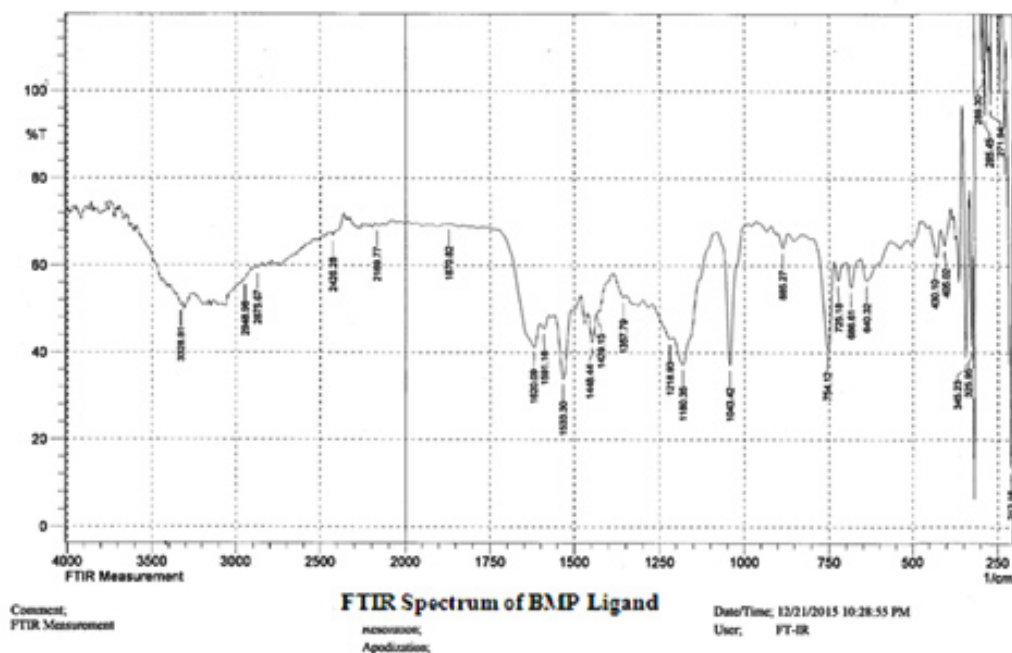


Fig. 10: FTIR spectrum of BMP ligand

Table 5: Main band of FTIR for the ligand (BMP) and its Complexes

Compound	BMP	[Cu(BMP) <sub>2</sub> Cl <sub>2</sub> ]	[Ag(BMP) <sub>2</sub> ]NO <sub>3</sub>	[Au(BMP)Cl <sub>2</sub> ]Cl
$\nu(\text{N-H}_{\text{Pro.}})$	3328 w.b	3357 w	3335w	3336w
$\nu(\text{O-H})$ in COOH	3440 w.b.	3442m	3423w	3434w
$\nu(\text{N-H}_{\text{imd}^+})$	3128m	3125w	3125w	3126w
$\nu(\text{C-H}_{\text{Ar.}})$	3056w	3056m	3055m	3053
$\nu(\text{C=N})$	1620 d.	1606 d, m	1616 d., s	1623 d,m
	1591 m	1580	1604	1593
$\nu(\text{N=N})$	1450 t.	1429 d.	1452 w	1448 t.m
	1448 m	1407		14271409
	1429			
$\nu(\text{-C-N=N-C-})$	1357 w.	1334 d.	1263 m	1313 d,w
		1311		1286
$\nu(\text{M-N}_{\text{imd.}})$	-	405 w.	430 w.	430 w.
$\nu(\text{M-N}_{\text{azo}})$	-	366 w.	395 w.	395 w.
$\nu(\text{M-Cl})$	-	231s	227sh	225sh
$\nu(\text{M-NO}_3)$	-	-	1035m	-
			835 w	

s=strong, m=medium, w=weak, v=very, sh=sharp, br=broad, d=doublet, t=triplet.

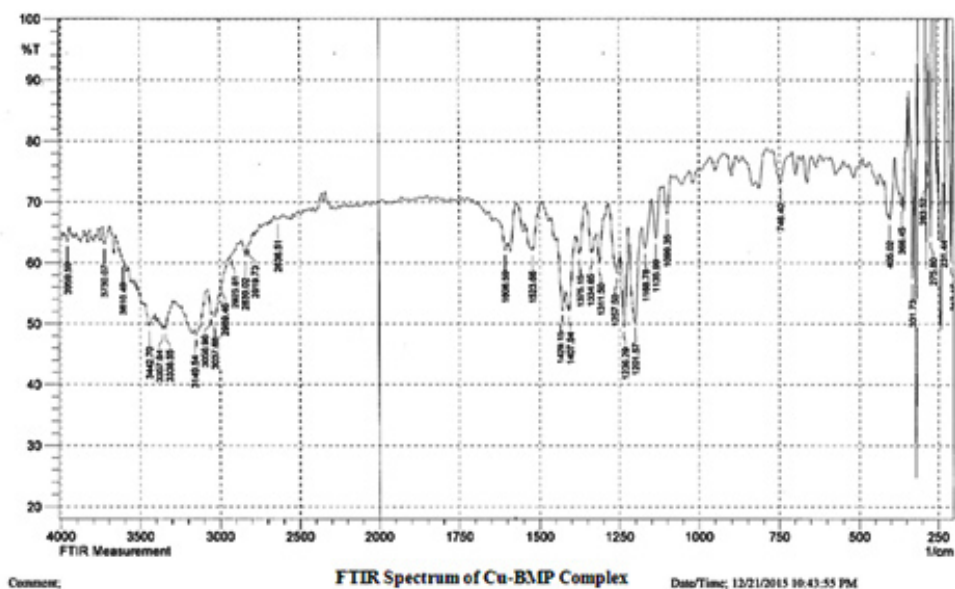


Fig. 11: FTIR spectrum of Cu-BMP Complex

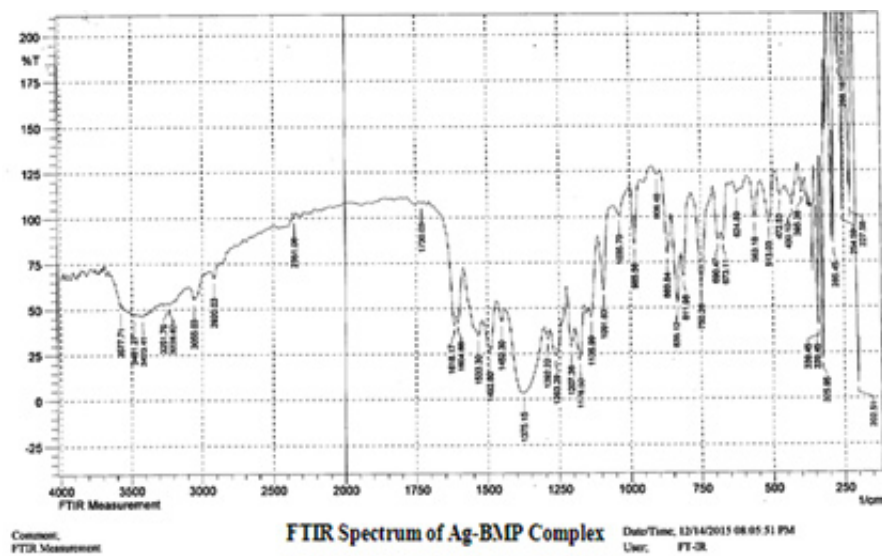


Fig. 12: FTIR spectrum of Ag-BMP Complex

Table 6: <sup>1</sup>HNMR spectra of BMP and its Complexes

Compound	-COOH	Ar-H	-NH <sub>(imd.)</sub>	-NH <sub>(Pro.)</sub>	Aliph-H <sub>(Pro.)</sub>
BMP	15.3	(8.4-7.2)	5.5	2.5	(1.1-1.0)
[Cu(BMP) <sub>2</sub> Cl <sub>2</sub> ]	15.4	(7.5-6.8)	5.5	2.6	(1.2-1.0)
[Ag(BMP) <sub>2</sub> ]NO <sub>3</sub>	15.4	(8.1-7.0)	5.5	2.6	(1.2-1.0)
[Au(BMP)Cl <sub>2</sub> ]Cl	15.4	(7.7-7.0)	5.5	2.6	(1.15-1.0)

The FTIR spectrum of the ligand (BMP) has been appeared a band at ( $3440\text{ cm}^{-1}$ ) that refer to  $\nu(\text{O-H})$  of carboxylic group in proline moiety<sup>24</sup>. Another band was appeared at ( $3328\text{ cm}^{-1}$ ) refer to  $\nu(\text{N-H})$  group of proline moiety, these two bands stay unchanged in position in the spectra of prepared complexes mention that there were no coordination through

N-H and COOH group for proline. A doublet bands was prepared at ( $1620$  and  $1591\text{ cm}^{-1}$ ), these bands have been refer to  $\nu(\text{C=N})$  in imidazole moiety which were showed changes in shape and shifted to low wave number in the spectra of all complexes due to coordination through N3 for imidazole moiety. The ligand (BMP) also showed triplet bands at ( $1450$ ,

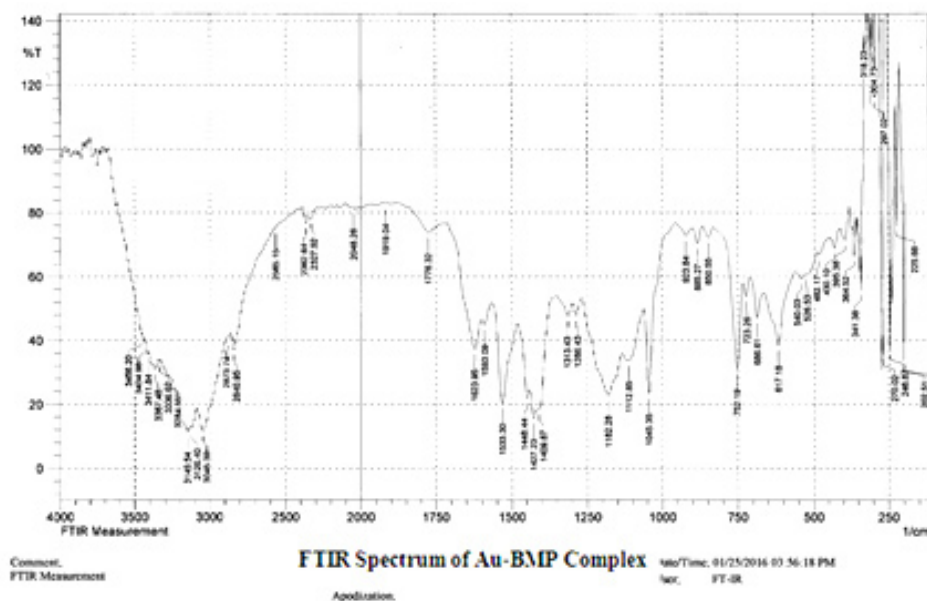


Fig. 13: FTIR spectrum of Au-BMP Complex

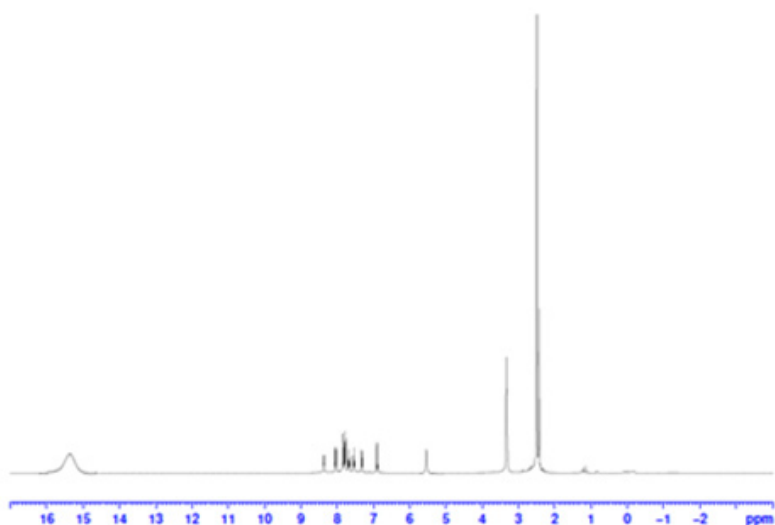


Fig. 14:  $^1\text{H}$ NMR Spectrum for the BMP Ligand

1448 and 1429)  $\text{cm}^{-1}$  which refer to (N=N) azo moiety<sup>25</sup>. These bands were a specific feature of azo composites. The strength of these band reduced in the complexes spectra, in spite of were shifted to lower frequency by (43)  $\text{cm}^{-1}$  for ligand (BMP) which is due to coordination through azo moiety. The band of (-C=N=N-C-) was appeared in the spectrum of the ligand and on complexation was showed a negative shift of order (74-23) $\text{cm}^{-1}$  for ligand (BMP)

with changing in intensity and shape, this another indicating the engagement of azo moiety in the coordination with the metal ion. In addition there are new set of bands do not exist in the spectrum of free prepared ligand but display in the spectra of the complexes such as  $\nu(\text{M-N})_{\text{azo}}$ ,  $\nu(\text{M-N})_{\text{im}}$ ,  $\nu(\text{M-Cl})$  in Cu and Au complexes and  $(\text{M-NO}_3)$ <sup>26</sup>. These mention to the coordination places of the prepared ligand (BMP) with metals ion.

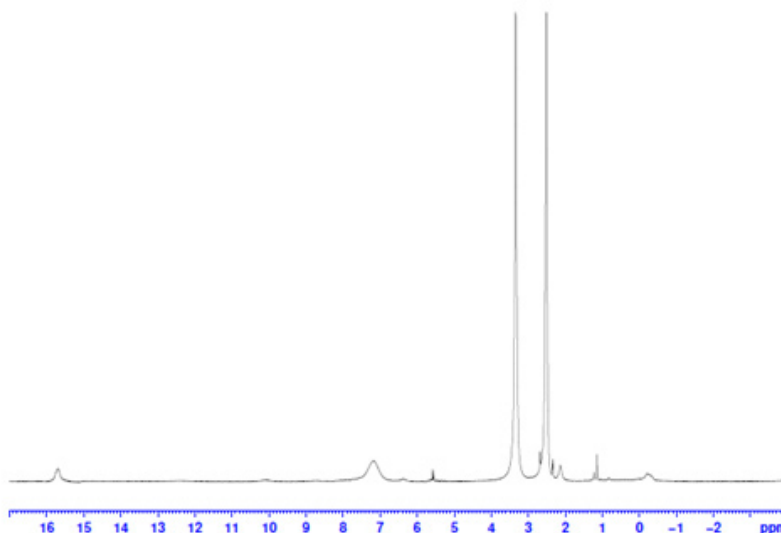


Fig. 15: <sup>1</sup>H NMR Spectrum for the Cu-BMP Complex

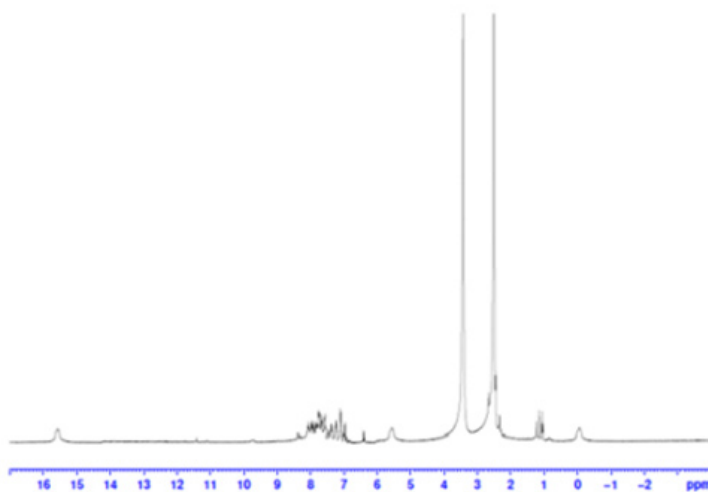


Fig. 16: <sup>1</sup>H NMR Spectrum for the Ag-BMP Complex

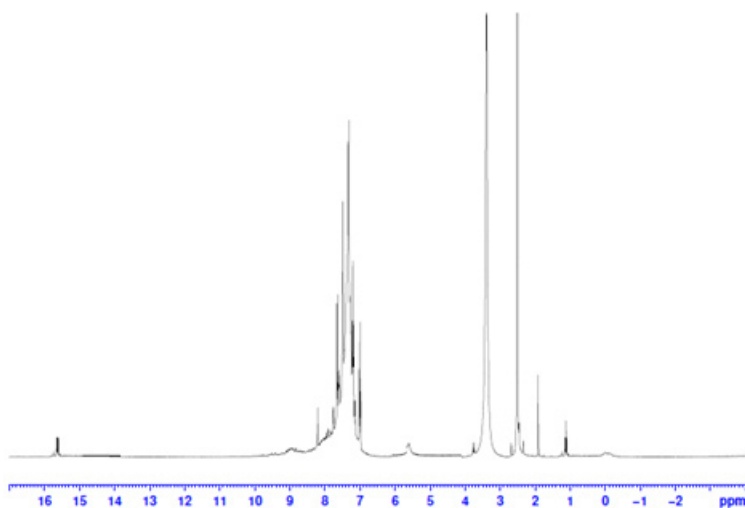


Fig. 17: <sup>1</sup>H NMR Spectrum for the Au-BMP Complex

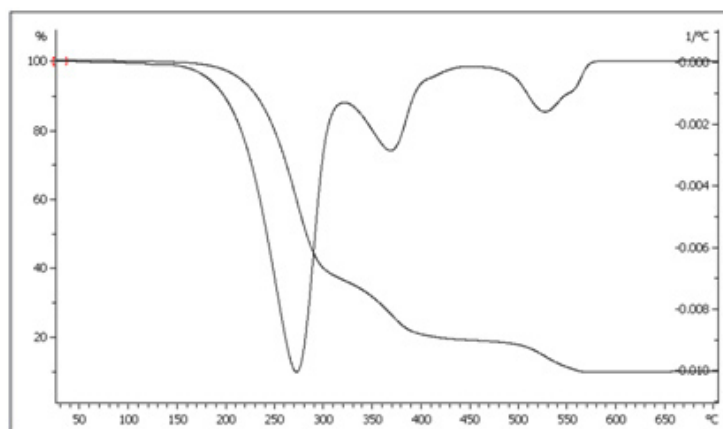


Fig. 18: TG and DTG for BMP Ligand

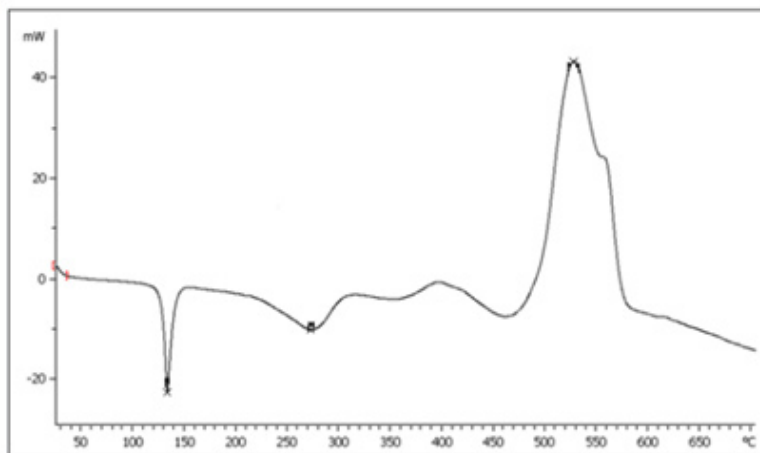


Fig. 19: DSC for BMP Ligand

**<sup>1</sup>H NMR Spectra of prepared Ligands and Complexes**

<sup>1</sup>H NMR spectra for the prepared ligand (BMP) and its complexes with Cu(II), Ag(I) and Au(III) (in DMSO) are shown in (Figures(14-17)) and the peak assignments are explained in Table (6). A singlet peak was appeared at δ(15.3) ppm in the spectrum for ligand (BMP) which was due to one proton of free carboxyl moiety in proline<sup>27</sup>. Another singlet signal peak noted at δ(5.5) ppm in these spectrum for the ligand (BMP) owing to a proton for (NH) imidazole. These signal peaks don't affect in coordination but stay almost without any chemical shift. The multiple signals noted in the region δ(8.4-7.2) ppm for ligand (BMP), these were

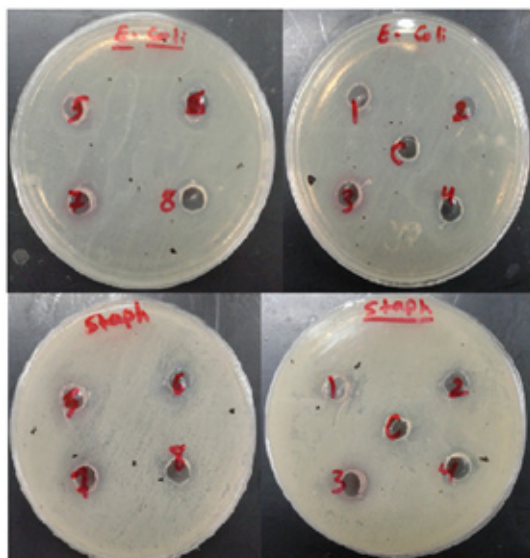
denoted to aromatic proton (4H) for benzene ring in benzimidazole moiety. So little shift happen when complex formation. Furthermore a singlet signal detected in the region δ(2.6) ppm for ligand (BMP) which were attributed to (-NH) proton of proline ring<sup>27</sup>, there are no shift were looked in the position in the spectra of the complexes. Also another signal peaks were looked in the spectra of the prepared ligand (BMP) and its complexes which were described in Table (6):

**Thermal analysis of the Ligand (BMP)**

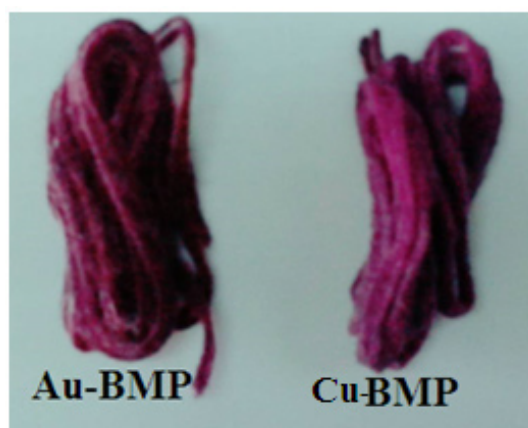
Figure (18) have been appeared the thermo gravimetric analysis (TG and DTG) curves for the prepared ligand (BMP) at room temperature up to 900C° under helium as inert gas and differential scanning calorimetric (DSC) curve (Figure (19)). The ligand (BMP) with the formula (C<sub>12</sub>H<sub>13</sub>N<sub>5</sub>O<sub>2</sub>), it showed three decomposition steps at the temperature range (60-800) C°. The first step of (50-310) C° with mass loss of benzimidazole and azo moiety (60.14%) (Calculated 60.76%) indicated by the DTG peak at (273) C° with an endothermic peak in DSC curve at (131.4) C°. The second temperature of range (310-450) C° the decomposition step assigned to mass loss (COOH) group (18.82%) (Calculated 17.30%) and the DTG peak at temperature (370) C° and an endothermic peak at (271.73) C° in DSC curve. And finally the third step was represented by mass loss for (C<sub>2</sub>H<sub>3</sub>) (11.00%) (Calculated 11.15%) fragment at temperature range (450- 700) C°. The DTG peak was appeared at (555) C° while the DSC curve was shaw exothermic peak at (527.22 C°). The

**Table 7 : The Diameters (mm) of deactivation of two bacteria of the prepared ligand (BMP) and its complexes**

No.	Compound	G+ (Staph)	G- (E-Coli)
2	BMP	9	-
4	[Cu(BMP) <sub>2</sub> Cl <sub>2</sub> ]	10	-
6	[Ag(BMP) <sub>2</sub> ]NO <sub>3</sub>	15	10
8	[Au(BMP)Cl <sub>2</sub> ]Cl	11	15
9	Ciprofloxacin	18.15	18.5
10	Control (C) (DMSO)	0	0

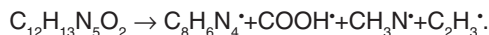


**Fig. 20: Antibacterial Activity of prepared Ligand (BMP) and its Complexes**



**Fig. 21: Dying of prepared Ligand (BMP) and Au-BMP complex**

residue represented the fragment (CH<sub>3</sub>N<sup>+</sup>) (10.04 %) (Calculated 10.36%).

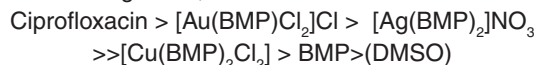


#### Antibacterial Activity of Prepared Ligands and its Complexes

Two types of bacteria were used in this experiment, Gram Negative Bacteria, *Escherichia Coli (E-Coli)* and Gram Positive Bacteria, *Staphylococcus aureus (Staph)* and Ciprofloxacin used as reference.

The ligand (BMP) and its complexes have been appeared low antibacterial activity against *Staphylococcus* and no antibacterial activity against *E-coli* exception of Ag-complex had low activity while Au-complex had high activity when comparable with the activity for Ciprofloxacin.

Generally the (ZI) mm compounds were in the following order;



The increased inhibition activity of the metal complexes can be explained on the basis of Tweedy's chelation theory<sup>28</sup>, Further; it increases the delocalization of δ- electrons over the whole chelate ring<sup>29,30</sup>.

#### Dying performance

The dying method of the Cu-BMP and Au-BMP complex were studies and applied on acrylic fabric. These set dyes were given colors purple and brown. Figure (21) show a clear color.

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