



## SYNTHESIS AND SPECTROSCOPIC STUDIES OF TERNARY METAL COMPLEXES OF ISONITROSOACETOPHENONE [Hpgaldox] AND ANTHRANILIC ACID [HAA] AND THEIR ANTIMICROBIAL ACTIVITY AGAINST STANDARD STRAINS OF *ESCHERICHIA COLI* AND *STAPHYLOCOCCUS AUREUS*

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### ABSTRACT

Mixed ligand complexes formulated as M(Pgaldox)(AA), (M=Mn(II), Co(II), Ni(II), Cu(II), Zn(II) and Cd(II) where Pgaldox and AA represent the deprotonated ligands while Cr(III) complex can be formulated as Cr(Pgaldox)(AA) Cl have been synthesized and characterized by elemental analysis, molar conductance, magnetic susceptibility, electronic, PMR and IR spectra. The molar conductance values, measured in nitrobenzene solution at  $10^{-3}$  M concentration are quite low indicating their non-electrolytic nature. The magnetic moments and electronic spectra indicate octahedral geometry for Cr(III) and Ni(II) complexes and tetrahedral geometry for Co(II) complexes. The reflectance spectrum of Cu(Pgaldox)(AA) exhibits a broad band near  $14925\text{ cm}^{-1}$ . The nature and position of the band suggests that it is due to d-d transitions and may envelope two or more absorption bands in a distorted octahedral Cu(II) environment. The non-transition mixed ligand complexes Zn(Pgaldox)(AA) and Cd(Pgaldox)(AA) show intra-ligand and charge transfer transitions. The Co(II) complex exhibited antibacterial activity against gram negative *E. Coli* and gram positive *S. Aureus*.

**KEYWORDS:** Ternary complexes octahedral geometry, tetrahedral geometry, antibacterial activity



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## INTRODUCTION

Anthranilic acid (amino-benzoic-acid) is one of the current sunscreen with highest protection index in the 280-320 nm range of ultra-violet radiations. It does have a legitimate use in combination with salicylates in the treatment of rheumatic fever, it retards the conjugation of salicylic acid and hence prolongs the action of salicylates. Co-ordination ability of different Schiff bases derived from anthranilic acid and their analytical applications have been studied extensively.<sup>1-5</sup> Similarly Schiff base derived from aniline/vanillin and anthranilic acid and their metal complexes have also been studied.<sup>6-10</sup> The research in the field of transition metal complexes has been expanded enormously. It also widens in the areas of organometallic compounds.<sup>6</sup> In view of potential interesting structural features and properties, it is considered worthwhile to attempt synthesis of several ternary metal complexes of isonitrosoacetophenone and anthranilic acid. The ligand isonitrosoacetophenone was prepared by the procedure described by Welcher<sup>11</sup>. This ligand is used to synthesize the complexes of Cr(III), Mn(II), Co(II), Ni(II), Cu(II), Zn(II) and Cd(II) along with anthranilic acid. The complexes have been characterized by elemental analysis, magnetic moments, molar conductance along with electronic and infra red spectral studies. The geometry for these complexes has been proposed on the basis of magnetic and spectral studies. The antimicrobial activity of metal complexes have been screened.

## MATERIALS AND METHODS

### *Preparation of ligand<sup>11</sup> (isonitrosoacetophenone)*

40g of freshly cut pieces of sodium metal were added slowly to 1200 mL of absolute alcohol at 4-5°C. 117mL of n-amyl nitrite was added in small portions with constant stirring to the above solution of sodium in alcohol. This mix was treated with 120mL of acetophenone and refrigerated for four days. A dark brown colored sodium salt of Hpgaldox was separated which was filtered and washed with dry ether and dried in air. The dried sodium salt was dissolved in a minimum quantity of H<sub>2</sub>O and cooled to 0°C. The solution was then treated with calculated quantity of glacial acetic acid when Hpgaldox precipitated. It was filtered, washed and sucked dry. It was purified by hot water and animal charcoal. Shinning needle-shaped crystals of pure Hpgaldox were obtained (m.p. 127°C).

### *Preparation of metal complexes*

Alcoholic solutions of anthranilic acid, Hpgaldox and metal chloride were mixed in 1:1:1 proportion. The mix was refluxed for four hours. The pH of the solution was raised to 8.0 with dilute NaOH solution (0.1N) when the solid complexes were separated. The complexes were digested on a hot water bath for about half an hour.

They were filtered, washed copiously with hot water and dried in an oven at 110°C.

### *Magnetic Susceptibility*

Magnetic susceptibility measurements were carried out by Gouy method using Hg[Co(SCN)<sub>4</sub>] as a calibrant.

### *ESR Spectrum*

ESR spectrum of Cu(II) complex was recorded on a varian-eline, E-112 Electron Spin Resonance spectrometer using TCNE as a standard.

### *Electronic Spectra*

Reflectance spectra of complexes in the visible range were taken on Carl-Zeiss VACU 2P Jena spectrophotometer.

### *FTIR Spectra*

The infrared spectra were recorded in KBr disc on Perkin-Elmer FTIR spectrophotometer.

### *Antimicrobial activity*

Antimicrobial activity was determined by Agar plate method<sup>12</sup> (Mueller-Hinton Agar). Agar plate was inoculated with the test organism. Discs of filter paper containing known amounts of bacteriostatic complexes are placed on the plate. As the organism begins to grow the antimicrobial diffuses from disc. When the antimicrobial reaches inhibitory (or greater) concentrations in the agar, there will be no growth of organisms and the zones of inhibitions were found around the disc.

### *Preparation of Bacteriostatic Discs*

Discs of 6.25 mm diameter, punched from the whatman filter paper no.1 in batches of 100 were placed in screw capped bottles and sterilized in hot air-oven at 150°C for one hour. 0.1 mg/ml solution of the substance under examination prepared in sterile ethanol/chloroform was added to each bottle containing the discs. Since 100 discs absorbed this unit volume of the substance, each disc contained 10µg of the substance.

### *Measurement of inhibition zones*

The zones of inhibition found around each disc were measured by means of calipers. The end point was taken as the complete inhibition of growth as it appeared to the unaided eye. The diameters of the zones were recorded and reported as resistant (showing growth) or sensitive (showing no growth) to each microbial tested.

## RESULTS AND DISCUSSION

The transition metal complexes are colored while the complexes of Zn(II) and Cd(II) are greenish white and cream colored respectively. They are non-hygroscopic and thermally stable. The electrical conductance values support their non-ionic nature (<1.0 mho cm<sup>-2</sup> mole<sup>-1</sup>).

**Table 1**  
**ANALYTICAL AND PHYSICAL DATA OF TERNARY METAL**  
**COMPLEXES OF HPgaldox AND HAA**

| Compound               | Colour         | Decomposition Temp. (°C) | Elemental Analysis (% Found / Calculated) |               |             |             | Molar Conductance <sup>a</sup> mho cm <sup>2</sup> mol <sup>-1</sup> at 10 <sup>-3</sup> M |
|------------------------|----------------|--------------------------|---|---------------|-------------|-------------|--|
|                        |                |                          | M   | C             | N           | H           |  |
| Cr (Pgaldox) (AA) . Cl | Greenish Grey  | > 280                    | 13.65 (14.00)                             | 48.10 (48.45) | 7.85 (7.54) | 3.65 (3.23) | 0.033  |
| Mn (Pgaldox) (AA)      | Light Brown    | > 280                    | 16.10 (16.21)                             | 53.05 (53.10) | 8.20 (8.26) | 3.70 (3.54) | 0.074  |
| Co (Pgaldox) (AA)      | Dark Brown     | > 270                    | 17.40 (17.20)                             | 52.15 (52.48) | 8.25 (8.16) | 3.55 (3.50) | 0.010  |
| Ni (Pgaldox) (AA)      | Green          | > 300                    | 16.80 (17.13)                             | 52.10 (52.53) | 8.35 (8.17) | 3.60 (3.50) | 0.064  |
| Cu (Pgaldox) (AA)      | Green          | 260                      | 18.25 (18.28)                             | 52.00 (51.79) | 7.90 (8.06) | 3.20 (3.45) | 0.084  |
| Zn (Pgaldox) (AA)      | Greenish White | > 310                    | 18.70 (18.71)                             | 51.30 (51.52) | 8.25 (8.01) | 3.40 (3.44) | 0.927  |
| Cd (Pgaldox) (AA)      | Cream          | 240                      | 28.30 (28.35)                             | 45.40 (45.41) | 7.65 (7.06) | 3.35 (3.03) | 0.011  |

### MAGNETIC SUSCEPTIBILITY MEASUREMENTS AND ESR STUDIES

**Table 2**  
**MAGNETIC SUSCEPTIBILITY DATA OF TERNARY**  
**COMPLEXES OF HPgaldox and HAA**

| Complex               | Formula Weight | Magnetic Moment (μ <sub>eff</sub> ) B.M. |
|-----------------------|----------------|--|
| Cr (Pgaldox) (AA) Cl. | 371.5          | 3.25                                     |
| Mn (Pgaldox) (AA)     | 339.0          | 6.25                                     |
| Co (Pgaldox) (AA)     | 342.9          | 4.48                                     |
| Ni (Pgaldox) (AA)     | 342.7          | 2.95                                     |
| Cu (Pgaldox) (AA)     | 347.5          | 1.56                                     |

Room Temperature = 308° K

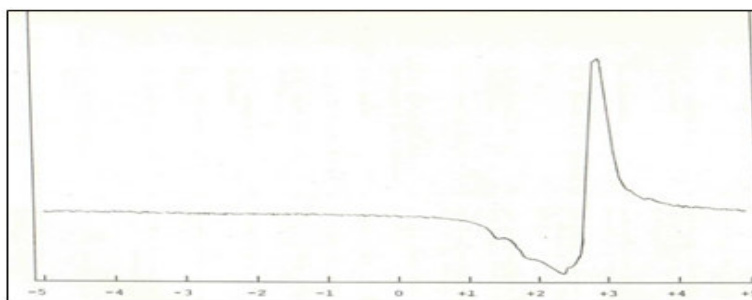
The observed room temperature magnetic moment for Cr (III) complex is 3.25 B.M. which is lower than the expected spin-only value of 3.88 B.M.<sup>13</sup> for three unpaired electrons of a d<sup>3</sup> system in an octahedral field. The lower magnetic moment suggests anti-ferromagnetic interaction possible through bridging chlorine atom in a dimeric or a polymeric structure involving octahedral geometry around Cr (III). The light brown Mn(Pgaldox) (AA) shows magnetic moment of 6.25 B.M. Corresponding to five unpaired electrons in a high-spin Mn(II). This value is slightly higher than the spin-only value expected for Mn(II) d<sup>5</sup> ion. The observed magnetic moment value for ternary Co (II) complex is 4.48 B.M. suggestive of a tetrahedral structure for this

complex. An octahedral geometry is proposed for mixed ligand Ni(II) complex as its magnetic moment is 2.95 B.M. which is slightly higher than the spin-only value for Ni(II) d<sup>8</sup> ion in an octahedral environment. Complex Cu (Pgaldox)(AA) shows a room temperature magnetic moment of 1.56 B.M. which is slightly lower than the expected value of a single unpaired electron for d<sup>9</sup> system in a distorted octahedral environment. On the basis of the fact that complex is insoluble in water and sparingly soluble in common organic solvents, a dimeric or polymeric structure involving a distorted octahedral or nearly planar environment for Cu(II) ion is proposed for Cu (Pgaldox)AA.

**Table 3**  
**ESR PARAMETERS FOR Cu(II) COMPLEX OF HPgaldox and HAA**

| Compound          | g <sub>j</sub> | g <sub>⊥</sub> | g <sub>av</sub> | A <sub>  </sub> x 10 <sup>-4</sup> cm | A <sub>⊥</sub> x 10 <sup>-4</sup> cm | A <sub>av</sub> x 10 <sup>-4</sup> cm | G    | a <sup>2</sup> |
|-------------------|----------------|----------------|-----------------|---------------------------------------|--------------------------------------|---------------------------------------|------|----------------|
| Cu (Pgaldox) (AA) | 2.206          | 2.021          | 2.083           | 150.0                                 | 30.56                                | 70.37                                 | 9.81 | 0.672          |

## ESR SPECTRUM FOR Cu(II) COMPLEX OF HPgaldox and HAA



The ESR spectrum of Cu (Pgaldox)(AA) was recorded at room temperature as well as at liquid N<sub>2</sub>(LNT) in chloroform solution using TCNE ( $g=2.00277$ ) as a marker. The spectrum of LNT exhibits four line hyperfine structure at  $g_{||}$  position. The spectrum does not show any super hyperfine splitting of  $g_{\perp}$  line due to interaction with nitrogen nucleus, which is expected for the mixed ligand character of the complex and confirms the mixed Cu-N bond and Cu-O bonding also supported

by the results of infrared studies on the complex. The spectrum yields only two  $g$  values with  $g_{||} > g_{\perp} > 2.0$  suggestive of axially elongated tetragonal structure. The value of the lowest  $g$ , normally  $g_{\perp}$  is only slightly less than 2.03 indicating that the unpaired electron is localized in the  $d_{x^2-y^2}$  orbital. The  $\alpha^2$  value suggests appreciable covalent character.

## ELECTRONIC SPECTRA

**Table 4**  
**ELECTRONIC SPECTRAL DATA OF METAL**  
**COMPLEXES OF HPgaldox AND HAA**

| Sr.No. | Compound             | Observed band position $\lambda_{nm}$ ( $\nu_{cm^{-1}}$ ) | Assignment (transition)        |
|--------|----------------------|---|--------------------------------|
| 1      | Cr (Pgaldox) (AA) Cl | 212 (47,170)  | Intra-ligand                   |
|        |                      | 247(40485)  | Intra-ligand                   |
|        |                      | 331 (30,211)  | Charge transfer                |
|        |                      | *580 (17,241)   | $A_{2g} \rightarrow T_{2g}$    |
| 2      | Mn (Pgaldox) (AA)    | 219 (45,662)  | Intra-ligand                   |
|        |                      | 247 (40,485)  | Intra-ligand                   |
|        |                      | 306 (32,680)  | Charge transfer                |
|        |                      | *348 (28,735)   | Charge transfer                |
|        |                      | *480 (20,833)   | d-d transition                 |
| 3      | Co (Pgaldox) (AA)    | 221(45,248)   | Intra-ligand                   |
|        |                      | 292(34,246)   | Intra-ligand                   |
|        |                      | 383(26,110)   | Charge transfer                |
|        |                      | *356(28,089)  | Charge transfer                |
|        |                      | *640(15,625)  | $A_{2g} \rightarrow T_{1g}(P)$ |
| 4      | Ni (Pgaldox) (AA)    | 222(45,045)   | Intra-ligand                   |
|        |                      | 269(37,175)   | Intra-ligand                   |
|        |                      | 330(30,303)   | Charge transfer                |
|        |                      | *390(25,641)  | $A_{2g} \rightarrow T_{1g}(P)$ |
|        |                      | *630(15,873)  | $A_{2g} \rightarrow T_{1g}(F)$ |
| 5      | Cu (Pgaldox) (AA)    | *1050(09,523)   | $A_{2g} \rightarrow T_{2g}$    |
|        |                      | 230(43,478)   | Intra-ligand                   |
|        |                      | 325(30,769)   | Charge transfer                |
|        |                      | *360(27,777)  | Charge transfer                |
|        |                      | *370(14,925)  | d-d transition                 |
| 6      | Zn (Pgaldox) (AA)    | 218(45,872)   | Intra-ligand                   |
|        |                      | 251(39,840)   | Intra-ligand                   |
|        |                      | 325(30,769)   | Charge transfer                |
|        |                      | *359(27,855)  | Charge transfer                |
|        |                      | *460(21,739)  |                                |
| 7      | Cd (Pgaldox) (AA)    | *656(15,241)  |                                |
|        |                      | 221(45,248)   | Intra-ligand                   |
|        |                      | 243(41,152)   | Intra-ligand                   |
|        |                      | 294(34,014)   | Intra-ligand                   |
|        |                      | 371(26,954)   | Charge transfer                |
|        | *342(29,239)         | Charge transfer   |                                |
|        | *700(14,285)         |   |                                |

The electronic absorption spectra of the ternary metal complexes of Hpgaldox and HAA show intra-ligand transitions in the region 47170-34013  $\text{cm}^{-1}$ . The charge transfer transitions are observed in the range of 32680-26110  $\text{cm}^{-1}$ . The diffused reflectance spectrum of Cr(Pgaldox) (AA) Cl shows a strong absorption band at 17241  $\text{cm}^{-1}$  which is assigned to  $4A_{2g} \rightarrow 4T_{2g}$  in octahedral Cr(III). The other crystal field transitions are masked by the high energy charge transfer transitions. The reflectance spectrum of Mn (Pgaldox)(AA) shows only one d-d transition band at 20833  $\text{cm}^{-1}$  while that of Co (Pgaldox)(AA) shows a broadband at 28089  $\text{cm}^{-1}$  due to a charge transfer transition. It shows a weak shoulder near 15625  $\text{cm}^{-1}$ . Tetrahedral Co(II) complexes are expected to show an absorption band due to the principle transition<sup>14,15</sup>  $4A_2 \rightarrow 4T_1$  (P). Spin-orbit coupling of  $4T_1$  (P) state and a fine structure of absorption band often appears. The weak shoulder near 15625  $\text{cm}^{-1}$  appears to be due to the transition  $4A_2 \rightarrow 4T_1$  (P) in tetrahedral Co(II) configuration. No fine structure is visible. The assignment is in confirmation with the tetrahedral geometry for the complex suggested on the basis of the observed magnetic moment. The dark color of the complex maybe accounted for a high intensity

charge transfer band around 28089  $\text{cm}^{-1}$ . The diffused reflectance spectrum of Ni (Pgaldox)(AA) shows three bands at 9523, 15873 and 25641  $\text{cm}^{-1}$  which are assigned to three spin allowed crystal field transitions<sup>16</sup>  $3A_{2g} \rightarrow 3T_{2g}$  ( $v_1$ ),  $3A_{2g} \rightarrow 3T_{1g}$  (F) ( $v_2$ )  $4A_{2g} \rightarrow 3T_{1g}$  (P) ( $v_3$ ) respectively. The ratio  $v_2/v_1=1.66$  is in accord with their assignment with their transitions in octahedral Ni(II) complexes. The reflectance spectrum of Cu(Pgaldox)(AA) exhibits a broad band near 14925  $\text{cm}^{-1}$ . The nature and position of the band suggests that it is due to d-d transition<sup>17</sup> and may envelope two or more bands in a distorted octahedral Cu(II) environment. The non transition mixed ligand metal complexes of Zn(Pgaldox)(AA) and Cd(Pgaldox)(AA) show intra-ligand and charge transfer transitions. No d-d transitions are expected. Hence no absorption bands in the visible region should be observed. However spectrum of Zn(II) complex shows a hump near 21739  $\text{cm}^{-1}$  and a broadband around 15243  $\text{cm}^{-1}$  while a hump observed near 21739  $\text{cm}^{-1}$  appears to be due to charge transfer transition. The two absorption bands appear to be responsible for unusual greenish white colour of the complex. The spectrum of Cd (Pgaldox) also shows a low intensity broad band around 14285  $\text{cm}^{-1}$ .

**Table 5**  
**INFRA RED SPECTRA SOME IMPORTANT INFRARED BANDS FOR ANTHRANILIC ACID IN SODIUM ANTHRANILATE AND THEIR ASSIGNMENTS**

| Band Position ( $\text{cm}^{-1}$ ) | Assignment                |
|------------------------------------|---------------------------|
| 3472s                              | $\nu_{N-H}$ (asymmetric)  |
| 3371s                              | $\nu_{N-H}$ (symmetric)   |
| 3026bs                             | $\nu_{O-H}$ (carboxylic)  |
| 1673s                              | $\nu_{C=O}$               |
| 1616                               | $\nu_{C=C}$ skeletal ring |
| 1586                               | $\nu_{C=C}$ skeletal ring |
| 1521*                              | $\nu_{COO}$ (asymmetric)  |
| 1398*                              | $\nu_{COO}$ (symmetric)   |

In sodium anthranilate<sup>18</sup>

**Table 6**  
**FTIR SPECTRAL DATA OF METAL COMPLEXES OF HPgaldox AND HAA**

| Sr. No. | Compound             | $\nu_{N-H}$ $\text{cm}^{-1}$ | $\nu_{C=O}$ $\text{cm}^{-1}$ | $\nu_{C=C}$ $\text{cm}^{-1}$ | $\nu_{asCOO^-}$ $\text{cm}^{-1}$ | $\nu_{C=C}$ (MSP) $\text{cm}^{-1}$ | $\nu_{sym COO^-}$ $\text{cm}^{-1}$ | $\nu_{N-O}$ $\text{cm}^{-1}$ | $\nu_{N-O}$ $\text{cm}^{-1}$ | $\nu_{M-N}$ $\text{cm}^{-1}$ | $\nu_{M-O}$ $\text{cm}^{-1}$ |
|---------|----------------------|------------------------------|------------------------------|------------------------------|----------------------------------|------------------------------------|------------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| 1       | Cr (Pgaldox) (AA) Cl | 3478<br>3370                 | 1619                         | 1578                         | 1542                             | 1450                               | 1400                               | 1257                         | --                           | 512                          | 434                          |
| 2       | Mn (Pgaldox) (AA)    | 3304<br>3142                 | 1610                         | 1590                         | 1543                             | 1454                               | 1407                               | ---                          | 1001                         | 632                          | 412                          |
| 3       | Co (Pgaldox) (AA)    | 3306<br>3137                 | 1605                         | 1592                         | 1538                             | 1456                               | 1407                               | ---                          | 1038                         | 643<br>516                   | 417                          |
| 4       | Ni (Pgaldox) (AA)    | 3303<br>3121                 | 1610                         | 1595                         | 1540                             | 1456                               | 1408                               | ---                          | 1042                         | 612<br>517                   | 419                          |
| 5       | Cu (Pgaldox) (AA)    | 3445<br>3336                 | 1620                         | 1591                         | 1550                             | 1448                               | 1375                               | 1215                         | ---                          | 525                          | 474                          |
| 6       | Zn (Pgaldox) (AA)    | 3299<br>3128                 | 1610                         | 1597                         | 1544                             | 1458                               | 1404                               | --                           | 1040                         | 525                          | 417                          |
| 7       | Cd (Pgaldox) (AA)    | 3233b                        | 1600                         | 1589                         | 1530                             | 1453                               | 1400                               | --                           | 1020                         | 520                          | 407                          |

The infrared spectra of HAA and ternary metal complexes of HPgaldox AND HAA in KBr discs were recorded and their assignments are summarized in table 5 and 6. These are in close agreement with reported assignments<sup>18</sup>. The characteristic broad IR absorption bands due to  $\nu_{O-H}$  of either =NOH of HPgaldox or of -COOH of HAA, observed around 3256  $\text{cm}^{-1}$  and around 3026  $\text{cm}^{-1}$  in the respective spectra, are absent in the infrared spectra of ternary metal complexes. The absence of free oxime of carboxylic acid group is further

supported by the fact that these complexes are insoluble in dilute Alkali solutions. This suggests, therefore, that both HPgaldox AND HAA act as monobasic anionic ligands which lose their oximino and carboxylic protons during the formation of the ternary complexes. The asymmetric and symmetric  $\nu_{N-H}$  modes of HAA observed at 3472 and 3371  $\text{cm}^{-1}$  in the spectrum of HAA, are observed at nearly the same position in the spectrum of Cr (Pgaldox) (AA). Cl. However, they are found to be shifted to ranges 3299-3445  $\text{cm}^{-1}$  and 3121-3336  $\text{cm}^{-1}$  in

the spectra of the ternary complexes. These negative shifts suggest coordination of the  $-NH_2$  Group of the ligand to metal ion. On the other hand  $\nu_{COO^-}$  (asymmetric) and  $\nu_{COO^-}$  (symmetric) Modes of the carboxylate ion, observed at  $1521$  and  $1398\text{cm}^{-1}$  respectively in the spectrum of sodium anthranilate<sup>18</sup>, occur in the region  $1538-1550$  and  $1400-1408\text{cm}^{-1}$  respectively in the spectra of the complexes except in case of Cu (II) complex, thus showing positive shift in both the stretching modes and indicating bridging bidentate behavior of the carboxylate ion of the ligand.<sup>18</sup> This observation together with the observed negative shift in the  $\nu_{as-N-H}$  and  $\nu_{s-N-H}$  indicates tridentate behavior of the ligand.<sup>18</sup> However in the spectrum of the Cu(II) complex,  $\nu_{COO^-}$  (asymmetric) exhibits a positive shift while  $\nu_{COO^-}$  (symmetric) shows a negative shift suggesting monodentate bonding of the  $COO^-$  ion. The  $\nu_{C=O}$  stretching of ligand HPgaldox, observed at  $1680\text{cm}^{-1}$ , undergoes negative shift on complexation and is observed in the range of  $1605-1620\text{cm}^{-1}$ , thus indicating involvement of carbonyl oxygen. The  $\nu_{C=N}$  stretch, observed at  $1595\text{cm}^{-1}$  in the spectrum of HPgaldox, appears to have remained at the same position or seems to have undergone small positive shift. It is not clearly observed in the spectra of all the metal complexes possibly because of the overlap with  $\nu_{C-C}$  or  $\nu_{C=O}$  bands in the region. This observation is suggestive of coordination of the oximefunction through oximino

oxygen donor. The spectra of Cr(III) and Cu(II) complexes show  $\nu_{N\rightarrow O}$  stretching frequency at  $1257$  and  $1215\text{cm}^{-1}$  respectively. They do not show any band assignable to  $\nu_{N-O}$  mode in the region  $1000-1100\text{cm}^{-1}$ , thus leading to conclusion that the group coordinates through its nitrogen donor atom in these complexes which, therefore, may be represented by the structures (I) and (II). The sixth coordination in the octahedral Cr (Pgaldox) (AA) Cl may be achieved by coordination through chlorine atom from neighbouring molecule. The  $\nu_{M-N}$  and  $\nu_{M-O}$  stretching vibrations required by these structures are observed around  $512 - 525\text{cm}^{-1}$  and  $417-434\text{cm}^{-1}$  respectively.  $\nu_{Cr-Cl}$  mode, expected to occur well below  $350\text{cm}^{-1}$ , could not be observed because of the instrumental limitations. The spectra of Mn(II), Co(II), Ni(II), Zn(II) and Cu(II) complexes, on the other hand, do not show  $\nu_{N\rightarrow O}$  band, expected to be of medium to strong intensity in the range  $1200-1300\text{cm}^{-1}$ . Instead they reveal a band around  $1000-1040\text{cm}^{-1}$ , attributable to  $\nu_{N-O}$  stretching mode, thus suggesting coordination through oxygen of the oxime<sup>19</sup> function, leading to a six membered chelate link involving HPgaldox. Structure (III) can be assigned to these complexes. The 5<sup>th</sup> and 6<sup>th</sup> coordination sites in the octahedral Ni(II) complex can be reached through O-coordination from the neighbouring molecules in a dimeric or polymeric state.

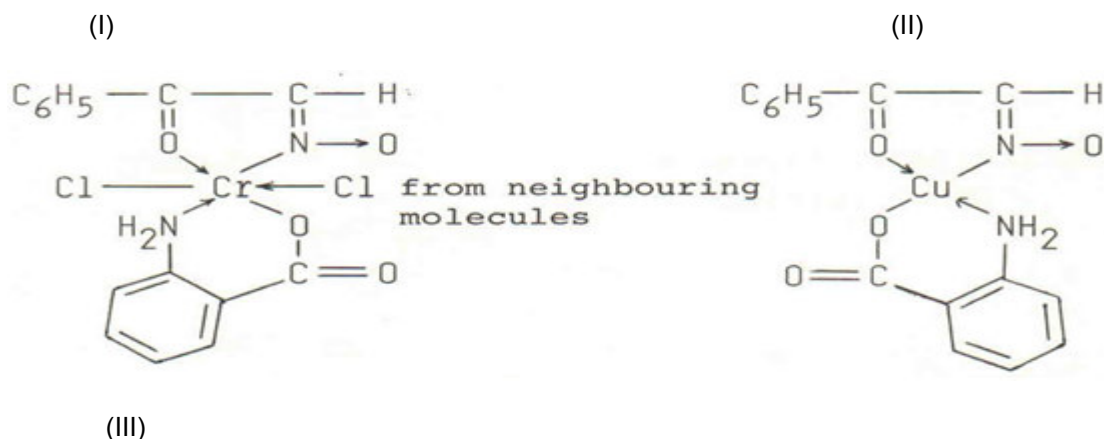
**Table 7**  
**ANTIMICROBIAL ACTIVITIES OF ANTHRANILIC ACID (HAA) AND**  
**TERNARY COMPLEXES OF HPgaldox and HAA**

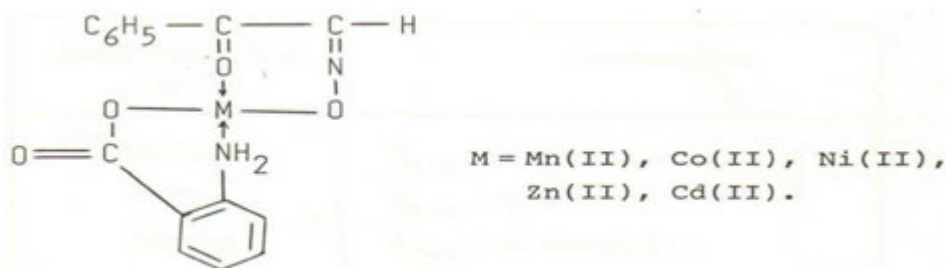
| Sr No. | Compound             | <i>Escherchia coli</i> | <i>Staphylococcus aureus</i> (zone of inhibition) |
|--------|----------------------|------------------------|---|
|        | HAA                  | +                      | +   |
| 1      | Cr (Pgaldox) (AA) Cl | +                      | +   |
| 2      | Mn (Pgaldox) (AA)    | +                      | +   |
| 3      | Co (Pgaldox) (AA)    | +                      | 11mm  |
| 4      | Ni (Pgaldox) (AA)    | +                      | +   |
| 5      | Cu (Pgaldox) (AA)    | +                      | +   |
| 6      | Zn (Pgaldox) (AA)    | +                      | +   |
| 7      | Cd (Pgaldox) (AA)    | +                      | +   |

+ : Showing growth (resistant) (No zone of inhibition)

The results of the present study need, and are worth a comparison with those reported<sup>20</sup> on similar compounds. Amongst the mixed ligand complexes of HPgaldox, those with 8-hydroxyquinoline of the type  $M(Pgaldox)(8-Q).2H_2O$ , show no activity against *E.coli*, but the Mn(II), Cu(II), Zn(II), and Cd(II) complexes are active against *S.aureus*. Similarly, metal complexes of

HPgaldox and salicylic acid or oxalic acid do not show any activity against *E.coli*, but some of them show activity against *S.aureus*. Amongst ternary Co(II) complexes of HPgaldox, those with salicylic acid and oxalic acid are active against *S.aureus*, while those with 8HQ and HAA (present work) are not.





## CONCLUSION

Based on the above analytical and physicochemical data it has been observed that both HPgaldox and HAA act as monobasic anionic ligands which lose their oximino and carboxylic protons during the formation of ternary complexes. Electronic spectra and magnetic susceptibility measurement reveals octahedral geometry for Cr(III) and Ni(II) complexes and tetrahedral geometry for Co(II) complex, distorted octahedral geometry for

Cu(II). The 5<sup>th</sup> and 6<sup>th</sup> co-ordination sites in the octahedral Ni(II) complex can be reached through O-coordination from neighbouring molecules in a dimeric or polymeric state. The ternary complex Co(Pgaldox) (AA) shows increase in the zone size (~11 mm).  
Proposed Structure of Complex.

## CONFLICT OF INTEREST

Conflict of interest declared none.

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