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Synthesis, characterization and antimicrobial activity of mixed ligand Cu(II) and Co(II) complexes of beta-diketones with nitrogen-containing ligands

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Abstract

Mixed ligand copper(II) and cobalt(II) complexes of benzoylacetone and acetylacetone (BzacH and AcacH) with 2,2'-bipyridine (Bipy) and 1,10-phenanthroline (Phen), and Tetramethylethylenediamine (Tmen) have been synthesized and characterized by conductance measurement, magnetic susceptibility measurement, infrared spectroscopy and electronic spectroscopy. The in vivo antimicrobial screenings of the ligands and complexes were tested for their effect on bacteria and fungi by disc diffusion method. The conductivity measurement in nitromethane indicates that all the mixed ligand complexes are non-electrolytes and are in the range $8.22-50.50 \Omega^{-1}\text{cm}^2\text{mol}^{-1}$. The room temperature magnetic moments suggest that the mixed ligand complexes copper(II) are magnetically dilute having an electron each, while the mixed ligand cobalt(II) complexes are high spin complexes with three unpaired electrons. The electronic absorption spectra of the compounds suggest possible 4-, 5- and 6-coordinate geometries. The infrared spectra showed that there were lower frequency shifts of the carbonyl on complexation. The microbiostatic activities of the complexes revealed that all the complexes showed enhanced activities against *Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli* and *Pseudomonas aeruginosa*, but have moderate activity against *Candida albicans* and *Aspergillus niger*.

Keywords: Mixed Ligand complexes, β -diketones, spectral measurement, Magnetic susceptibility studies, Antimicrobial studies.

Introduction

β -diketones are prone to exist as enols because of conjugation of the enol or enolate with the other carbonyl group, and the stability gained in forming a six-membered ring (Lim *et al.*, 2007). Owing to their properties, β -diketones and their complexes have been used both in scientific research and in industry (Cullen and Wickenheiser, 1989). Metal complexes of β -diketone derivatives have played an important role in coordination chemistry and have been widely used in various aspects of industries, such as organic electroluminescent technology, luminescent materials and sensors for

bioinorganic applications (Sumathi *et al.*, 2012). β -diketone derived complexes show antimicrobial, anti-malarial, antitumorous activities, antioxidant and insecticidal activities (Sumathi *et al.*, 2012). β -diketone complexes (especially with transition metals) are often used as catalysts of reactions, such as olefin oxidation and epoxidation or oligomerisation. (Lewis, 1995). Complexes of β -diketones are reported to have potentially useful pharmacological properties (Onawumi *et al.*, 2008) and antidiabetic tendencies (Odunola and Woods, 2001). Furthermore, they are important for chemical analysis in which they are used for sample concentration (owing to their complexing

activity), for air pollution monitoring (formaldehyde) or as stationary phases in gas chromatography (olein analysis) (Urbaniak, 2011). It is well known that some drugs exhibit increased activity when administered as metal complexes and several metal chelates have been shown to inhibit tumor growth (Aljahdali and EL-Sherif, 2013). Copper(II) complexes reported in literature have shown activities such as antimicrobial, antitumor, photoinduced DNA cleavage and oxidation of ascorbic acid in the presence of oxygen (Lobana *et al.*, 2014). With the aim of investigating the antimicrobial activities, we have synthesized the Mixed ligand copper(II) and cobalt(II) complexes of benzoylacetone (BzacH) and acetylacetone(AcacH) with 2,2'-bipyridine(Bipy) and 1,10-phenanthroline(Phen) and Tetramethylethylenediamine(Tmen) and characterize them using conductance measurement, magnetic susceptibility measurement, infrared spectroscopy and electronic spectroscopy.

Materials and Method

Some of the reagents and solvents used are copper(II) nitrate trihydrate, cobalt(II) acetate

tetrahydrate, cobalt(II) chloride hexahydrate (Analytical grade), acetylacetone (Aldrich chemicals), benzoylacetone(Aldrich chemicals), 1,10-phenanthroline monohydrate, 2,2'-bipyridine, N,N,N',N'-tetramethylethylenediamine, ammonia, methanol and distilled water.

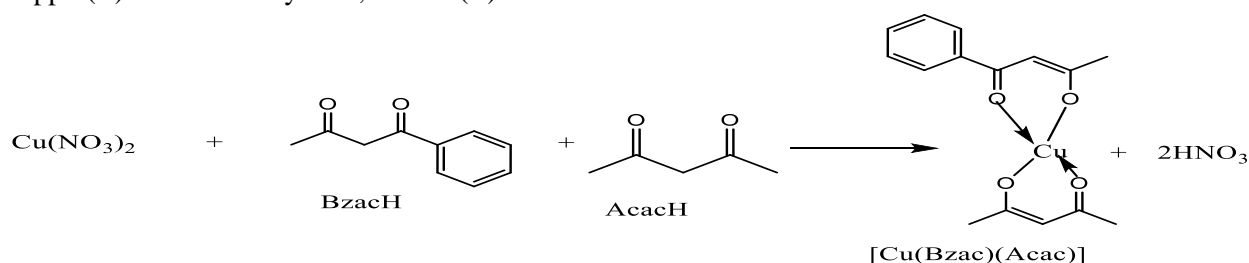
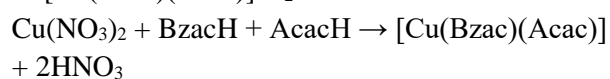
Synthesis of metal complexes

The complexes were prepared with a modification of the method used by Onawumi *et al.* (2011).

Synthesis of [Cu(Bzac)(Acac)]

AcacH (0.3 mL, 3.0 mmol) was added to BzacH (0.4971 g, 3.0 mmol) in 4 mL methanol and stirred. Cu(NO₃)₂.3H₂O (0.7451 g, 3.0 mmol) dissolved in water (1 mL) was added to the ligand solution in dropwise manner. 2drops of ammonia was added to the mixture while stirring and the mixture was maintained at pH 6. The mixture was allowed to stir for over an hour and the precipitates obtained were filtered using a suction pump and dried in a vacuum desiccator.

A similar method was adopted for the preparation of [Co(Bzac)(Acac)].H₂O



Scheme 1: Synthesis of [Cu(Bzac)(Acac)]

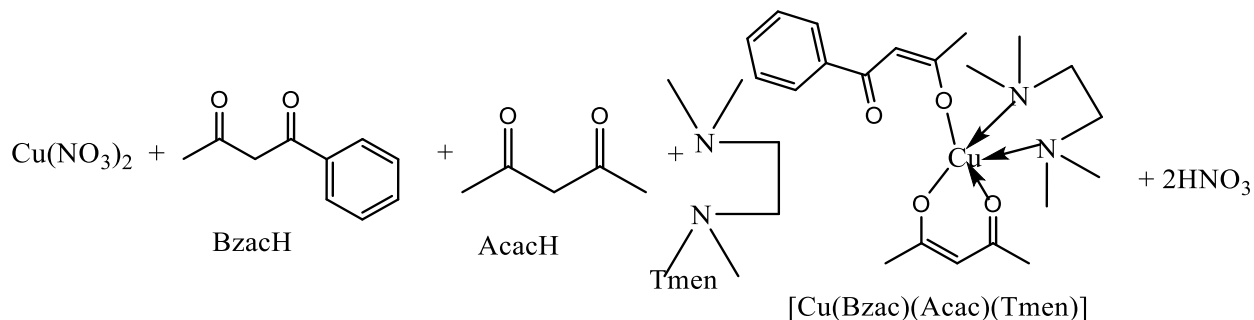
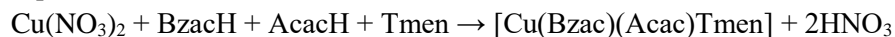
A similar method was adopted for the preparation of [Co(Bzac)(Acac)].H₂O

Synthesis of [Cu(Bzac)(Acac)Tmen]

Cu(NO₃)₂.3H₂O (0.4392 g, 1.8 mmol) was dissolved in 1 mL of water and 0.3 mL of Tmen was added to it in dropwise manner while stirring. BzacH (0.3 g, 1.8 mmol) was dissolved in methanol and AcacH (0.2 mL, mmol) was added to the dissolved BzacH solution. This resultant

solution was added in dropwise manner to the previously prepared metal and Tmen solution and the mixture were allowed to stir for over an hour and 2drops of NH₃ was added to maintain the pH at 6. The precipitate obtained was filtered using a suction pump and dried in a vacuum desiccator.

Equation of the reaction:



Scheme 2: Synthesis of [Cu(Bzac)(Acac)Tmen]

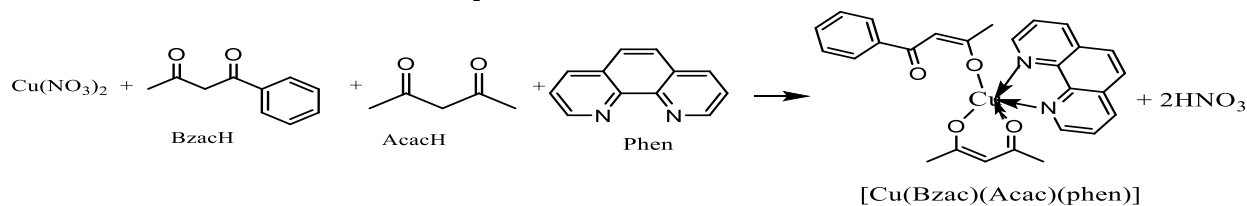
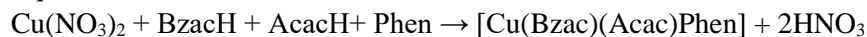
A similar method was adopted for the preparation of Co(Bzac)(Acac)Tmen.0.5H₂O

Synthesis of [Cu(Bzac)(Acac)Phen]

BzacH (0.5003 g, 3.0 mmol) was weighed and dissolved in 4 mL of methanol. AcacH (0.3 mL, mmol) was then added to it while stirring. Cu(NO₃)₂.3H₂O (0.7432 g, 3.0 mmol) dissolved in 1 mL of water was now added in dropwise manner to the dissolved ligand solution. A

greenish colouration was observed. 1,10-phen (0.6097 g, 3.0 mmol) was then added directly to the stirring mixture and a dark green colour was observed and 1 drop of NH₃ was added to maintain the pH at 6 and the mixture was allowed to stir for over 2 hours. The precipitate obtained was filtered using a suction pump and dried in a desiccator.

Equation for the reaction:



Scheme 3: Synthesis of [Cu(Bzac)(Acac)Phen]

A similar method was adopted for the preparation of [Cu(Bzac)(Acac)Bipy], [Co(Bzac)(Acac)Phen] and [Co(Bzac)(Acac)].0.5H₂O

Biological Studies

The antibacterial test was carried out at the Department of Pharmaceutical Microbiology, University of Ibadan, Ibadan, Nigeria. The biological studies were carried out as previously reported by Omoregie *et al* 2015.

Results and Discussion

Physical measurement

The analytical data are presented in Tables 1. The solubility tests for the prepared complexes were

carried out in eight common solvents namely; distilled water, methanol, acetone, dimethylsulfoxide, dimethylformamide, nitromethane, chloroform and n-hexane. The complexes exhibit different degree of solubility in each solvent, ranging from readily soluble to insoluble. All the complexes are soluble in DMSO, DMF, methanol, acetone, and nitromethane, except [Co(Bzac)(Acac)Phen] which was slightly soluble in methanol, acetone

and nitromethane. All complexes were insoluble in water except [Co(Bzac)(Acac)Tmen].0.5H₂O, which is slightly soluble. The colour observed for the different mixed ligand copper(II) and cobalt(II) complexes prepared are given in Table 1. All complexes obtained gave various shades of blue, green and orange. All complexes decomposed at temperature range of 168-265°C. The molar conductivities of most complexes are very low with value of 8.22 - 50.50Ω⁻¹cm²mol⁻¹, which suggest that they are non-electrolyte.

Magnetic susceptibility

Regardless of the stereochemistry, the magnetic moment of copper(II) compounds are expected to be in excess of the spin-only value due to orbital contributions and the mixing of excited T terms into the ground terms (Odunola et al., 2003). The prepared copper(II) complexes had magnetic moment in the range 1.80-2.19 BM corresponding to the presence of an unpaired electron. [Cu(Bzac)(Acac)Tmen] had magnetic moment $\mu_{\text{eff}} = 1.86$ BM at room temperature which is normal for mononuclear having no appreciable interaction between the metal ion. (David et al., 1999). A room temperature magnetic moment of 4.20-4.60 BM is expected for a d⁷ cobalt(II) complex in a tetrahedral field (Sanja and Ljiljana, 2003), while higher moments, even up to 5.2 BM, have been reported for octahedral complexes due to orbital contribution (Earnshaw, 1980). The magnetic moment for the prepared cobalt(II) complexes are in the range 4.32 - 4.87 B.M. This reveals that they are high spin complexes with three unpaired electrons. [Co(Bzac)(Acac)].H₂O showed μ_{eff} 4.32 BM and it is expected for a tetrahedral Co(II) complex (Table 1).

Infrared spectra

The relevant infrared spectra data of the complexes are presented in Table 2. The main stretching mode in the infrared spectra of the complex resulting from BzacH, AcacH, 1,10-phenanthroline, 2,2'-bipyridine, Tetramethylethylenediamine are $\nu(\text{C}=\text{O})$, $\nu(\text{C}=\text{C})$,

$\nu(\text{C}-\text{O})$, $\nu(\text{C}-\text{N})$, and $\nu(\text{C}-\text{H})$ (Harding et al., 2009). The absence of any absorption above 1700 cm⁻¹, as well as the broad band observed around 3465 cm⁻¹ due to hydrogen bonded O-H in the β -diketone is an indication that AcacH and BzacH are in the enol form. Insertion of metal(II) shifted the broad band to 3460 cm⁻¹ $\nu(\text{H}_2\text{O})$ (Oladipo et al., 2013). A slight shift to lower frequencies of $\nu(\text{C}=\text{O})+\nu(\text{C}=\text{C})$ absorption between 1588 cm⁻¹ and 1511 cm⁻¹ was observed on complexation. The $\nu(\text{C}=\text{C})$ vibrations of the nitrogen containing ligands were observed at lower frequency relative to the parent ligand. Likewise a shift in the $\gamma(\text{C}-\text{H})$ deformation band of Bipy, Phen and Tmen to higher frequency, is attributed to the positive inductive effect of the alkyl groups (Omoriegie and Woods, 2010). The coupled vibrations of M-O and M-N stretching modes appeared below 700 cm⁻¹ in the mixed ligand complexes (Nakamoto et al., 1978, Patel and Woods, 1990). The bands 694-416 cm⁻¹ have been assigned to $\nu(\text{M}-\text{N})+\nu(\text{M}-\text{O})$ vibrations.

The electronic spectra of the compounds were studied in chloroform and methanol and the band and assignments are presented in Table 3. The bands observed in the ultraviolet region between 30,211-32,679 cm⁻¹ in methanol and chloroform have been assigned to $\pi_3-\pi_4^*$ transition while bands in the visible region between 13,812-18,214 cm⁻¹ have been assigned to d-d transition.

The visible spectra of copper(II) β -diketonates are more intense and locate at lower energy in coordinating solvents which was indicative of a probable four coordinate square-planar geometry, while higher energy shift was indicative of a probable, five-coordinate, square-pyramidal geometry. Thus, [Cu(Bzac)(Acac)] has probable, four-coordinate, square planar geometry due to lower frequency shifts in methanol relative to chloroform (15,923 cm⁻¹ in chloroform → 13,850 cm⁻¹ in methanol). In a study, the visible spectra of the mixed ligand copper(II) complexes showed single transition which is consistent with the adoption of a square pyramidal geometry for

copper(II) complexes (Odunola *et al.*, 2003). This is supported by the higher frequency shifts which were observed in methanol relative to chloroform in [Cu(Bzac)(Acac)Tmen] ($15,503\text{ cm}^{-1} \rightarrow 15,723\text{ cm}^{-1}$), [Cu(Bzac)(Acac)Phen] ($15,873\text{ cm}^{-1} \rightarrow 16,129\text{ cm}^{-1}$) and [Cu(Bzac)(Acac)Bipy] ($15,873\text{ cm}^{-1} \rightarrow 16,129\text{ cm}^{-1}$). These hypsochromic shifts suggest that they are square pyramidal in chloroform.

The electronic spectra of cobalt(II) in a tetrahedral field with a 4A_2 ground term is expected to have three transitions which are assigned to ${}^4A_2(F) \rightarrow {}^4T_2(F)$ (ν_1), ${}^4A_2(F) \rightarrow {}^4T_1(F)$ (ν_2) and ${}^4A_2 \rightarrow {}^4T_1(P)$ (ν_3) transitions respectively (Lever, 1986). Consequently, the transitions $18,832$, $19,531$ and $20,876\text{ cm}^{-1}$ have been assigned to ${}^4A_2(F) \rightarrow {}^4T_2(F)$ (ν_1), ${}^4A_2(F) \rightarrow {}^4T_1(F)$ (ν_2) and ${}^4A_2 \rightarrow {}^4T_1(P)$ (ν_3) respectively of tetrahedral [Co(Bzac)(Acac)].H₂O, which is in agreement with the room temperature magnetic moment ($\mu_{\text{eff}} = 4.32\text{ BM}$) of the complex. The electronic spectrum of the octahedral cobalt(II) complex exhibit three absorption bands which may be assigned to the transitions ${}^4T_{1g}(F) \rightarrow {}^4T_{2g}(F)$ (ν_1), ${}^4T_{1g}(F) \rightarrow {}^4A_{2g}(F)$ (ν_2) and ${}^4T_{1g}(F) \rightarrow {}^4T_{1g}(P)$ (ν_3) (Farina and Rice, 1995). [Co(Bzac)(Acac)Bipy].0.5H₂O showed three absorptions, $13,245$, $18,796$ and $20,449\text{ cm}^{-1}$ assigned to octahedral geometry ${}^4T_{1g}(F) \rightarrow {}^4T_{2g}(F)$ (ν_1), ${}^4T_{1g}(F) \rightarrow {}^4A_{2g}(F)$ (ν_2) and ${}^4T_{1g}(F) \rightarrow {}^4T_{1g}(P)$ (ν_3) respectively. In some complexes, the ν_2 transition is not observed, since it is essentially a two-electron transition from $t_{2g}^5 e_g^2$ to $t_{2g}^3 e_g^4$ and is expectedly weak (Lever, 1986 and Ajaykumar *et al.*, 2009). Two transitions $13,568$ and $18,798\text{ cm}^{-1}$ assigned to ${}^4T_{1g}(F) \rightarrow {}^4T_{2g}(F)$ (ν_1) and ${}^4T_{1g}(F) \rightarrow {}^4T_{1g}(P)$ (ν_3) respectively, were observed for [Co(Bzac)(Acac)Phen]. (ν_2) was not observed. These transitions are also in agreement with ϵ value and room temperature magnetic moment

($\mu_{\text{eff}} = 4.77$ and 4.87 BM respectively) for a high spin octahedral cobalt(II) complex.

[Co(Bzac)(Acac)Tmen].0.5H₂O showed a single transition, $15,105\text{ cm}^{-1}$ assigned to ${}^4T_{1g}(F) \rightarrow {}^4T_{2g}(F)$ (ν_1). ν_2 and ν_3 were not observed.

A distorted octahedral geometry has been proposed because the ϵ value ($14\text{ Lmol}^{-1}\text{cm}^{-1}$) lies in the range of that expected for an octahedral geometry and the room temperature magnetic moment ($\mu_{\text{eff}} = 4.59\text{ BM}$) is in the range of those expected for an high spin tetrahedral cobalt(II) complex. The bands observed around $29,600$ – $32,300\text{ cm}^{-1}$ and $27,000$ – $29,000\text{ cm}^{-1}$ have been assigned to $\pi_3 \rightarrow \pi_4^*$ and $n \rightarrow \pi^*$ transition respectively.

Antimicrobial studies

The antimicrobial screening of the synthesized complexes were investigated using two-gram positive bacteria (*Staphylococcus aureus* and *Bacillus subtilis*), two-gram negative bacteria (*Escherichia coli* and *Pseudomonas aeruginosa*) and two fungi (*Candida albicans* and *Aspergillus niger*). The ligands showed very good activity in the tested bacteria compared to the fungi. [Cu(Bzac)(Acac)] and [Cu(Bzac)(Acac)Tmen] were found to be active in *Staphylococcus aureus* and moderately active in other bacteria and fungi while [Cu(Bzac)(Acac)Phen] and [Cu(Bzac)(Acac)Bipy] showed good activity in *Pseudomonas aeruginosa* but moderately active in other bacteria and fungi. All the cobalt complexes showed moderate activity in the bacteria and fungi except [Co(Bzac)(Acac)].H₂O which is active in *Pseudomonas aeruginosa* and [Co(Bzac)(Acac)Tmen].0.5H₂O and [Co(Bzac)(Acac)Phen] that are active in *Staphylococcus aureus*.

Table 1: Analytic data of synthesized complexes

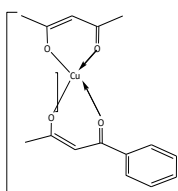
Complexes	M.Wt.	Colour	% Metal Expected	% Metal Observed	% Yield	Conductance $\Omega^{-1} \text{ cm}^2 \text{ mol}^{-1}$	Melting point (°C)/Decomposition	μ_{eff} (BM)
[Cu(Bzac)(Acac)]	323.79	Blue	16.61	16.40	49.67	24.50	188	2.19
[Cu(Bzac)(Acac)Tmen]	440.00	Blue	14.43	14.67	62.06	10.05	168	1.86
[Cu(Bzac)(Acac)Phen]	522.02	Green	12.16	11.89	65.66	20.40	245	1.80
[Cu(Bzac)(Acac)Bipy]	479.98	Blue	13.23	13.14	80.69	50.50	240	1.86
[Co(Bzac)(Acac)].H ₂ O	337.19	Orange	17.47	17.67	14.80	8.22	214	4.32
[Co(Bzac)(Acac)Tmen].0.5H ₂ O	444.40	Orange	13.25	13.46	30.54	17.60	230	4.59
[Co(Bzac)(Acac)Phen]	517.42	Orange	11.09	11.33	57.60	20.10	265	4.87
[Co(Bzac)(Acac)Bipy].0.5H ₂ O	474.38	Orange	12.42	12.47	37.55	19.36	225	4.77

D = Decomposition

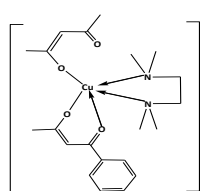
Table 2: Infrared Spectra data (cm⁻¹)

Complexes	$\nu(\text{O-H})$	$\nu(\text{C=O})+\nu(\text{C=C})$	$\nu(\text{C-N})$	$\nu(\text{C-O})$	$\gamma(\text{C-H})\text{Phen/Bipy/Tmen}$	$\nu(\text{M-N})+\nu(\text{M-O})$
AcacH	3413b	1713s 1614s				
BzacH	3465b	1600b				
Tmen	3400b		1260s			
Phen	3436b	1621s, 1567s	1295m		837vs, 729vs	
Bipy	3445b	1161m, 1557s	1309m		893s, 758s	
[Cu(Bzac)(Acac)]	3460b	1588s, 1557b		1214s		453s, 423w
[Cu(Bzac)(Acac)Tmen]	3461b	1579s, 1520s	1275s	1214s	784vs, 717vs	685m, 459w
[Cu(Bzac)(Acac)Bipy]	3432b	1594s, 1566s, 1517s	1310s	1206m	773vs, 731s	694m, 457m
[Cu(Bzac)(Acac)Phen]	3454b	1590s, 1563s, 1518s	1318s	1225m	843vs, 791vs	685m, 447m
[Co(Bzac)(Acac)].H ₂ O	3436b	1592s, 1559s, 1515s		1219m		445w, 423m
[Co(Bzac)(Acac)Tmen].0.5H ₂ O	3445b	1591s, 1564s, 1515s	1287s	1211s	846s, 766s, 713s	691s, 441m
[Co(Bzac)(Acac)Phen]	3447b	1592s, 1566s, 1513s	1306w	1221m	845vs, 776w, 751s	639m, 419s
[Co(Bzac)(Acac)Bipy].0.5H ₂ O	3441b	1593s, 1563m, 1511s	1306w	1204w	845s, 763s, 714s	650m, 419s

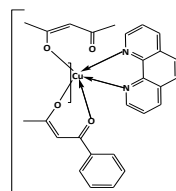
Proposes structures of complexes



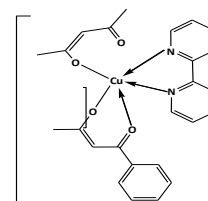
[Cu(Acac)(Bzac)]



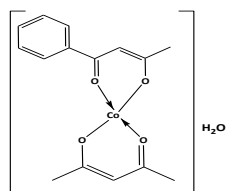
[Cu(Acac)(Bzac)Tmen]



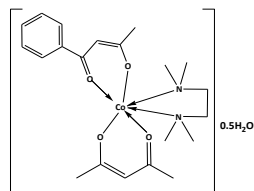
[Cu(Acac)(Bzac)Phen]



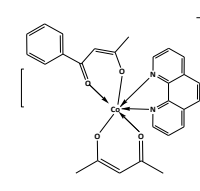
[Cu(Acac)(Bzac)Tmen]



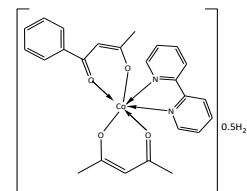
[Co(Acac)(Bzac)]H₂O



[Co(Acac)(Bzac)Tmen]0.5H₂O



[Co(Acac)(Bzac)Phen]



[Co(Acac)(Bzac)Bipy] 0.5H₂O

Table 3: Electronic Spectra data for the complexes

Complexes	$\pi_3\text{-}\pi_4^*$ (cm^{-1})	d-d (cm^{-1}) in CHCl_3	d-d (cm^{-1}) in CH_3OH	Transitions	Tentative Geometry
[Cu(Bzac)(Acac)]	31,056	15,923	13,850	${}^2\text{T}_{2g} \rightarrow {}^2\text{E}_g$	Square Planar
[Cu(Bzac)(Acac)Tmen]	32,679	15,503	15,723	${}^2\text{E}_g \rightarrow {}^2\text{T}_{2g}$	Square Pyramidal
[Cu(Bzac)(Acac)Phen]	30,303	15,873	16,129	${}^2\text{E}_g \rightarrow {}^2\text{T}_{2g}$	Square Pyramidal
[Cu(Bzac)(Acac)Bipy]	32,258 30,211	16,129	16,286	${}^2\text{E}_g \rightarrow {}^2\text{T}_{2g}$	Square Pyramidal
[Co(Bzac)(Acac)]. H_2O	32,679		20,876 19,531 18,832	${}^4\text{A}_2(\text{F}) \rightarrow {}^4\text{T}_1(\text{P})$ ${}^4\text{A}_2(\text{F}) \rightarrow {}^4\text{T}_1(\text{F})$ ${}^4\text{A}_2(\text{F}) \rightarrow {}^4\text{T}_2(\text{F})$	Tetrahedral
[Co(Bzac)(Acac)Tmen].0.5 H_2O	31,545		15,105	${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{2g}(\text{F})$	Distorted Octahedral
[Co(Bzac)(Acac)Phen]	31,645		18,796 13,568	${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{A}_{2g}(\text{F})$ ${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{2g}(\text{F})$	Octahedral
[Co(Bzac)(Acac)Bipy].0.5 H_2O	31,545		20,449 18,796 13,245	${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{1g}(\text{P})$ ${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{A}_{2g}(\text{F})$ ${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{2g}(\text{F})$	Octahedral

Table 4: Antimicrobial activity data of β -diketone and the mixed Ligand copper(II) and cobalt(II) complexes

Compound	<i>S. aur</i>	<i>B. sub</i>	<i>E. coli</i>	<i>P. aer</i>	<i>C.albican</i>	<i>A.niger</i>
Bipy	20	13	18	36	ND	ND
Phen	20	34	30	25	ND	ND
AcacH	28	26	28	30	18	18
BzacH	24	32	32	34	16	14
Tmen	28	28	32	32	18	18
[Cu(Bzac)(Acac)]	20	16	16	14	14	18
[Cu(Bzac)(Acac)Tmen]	26	14	18	16	18	14
[Cu(Bzac)(Acac)Phen]	18	14	14	20	14	14
[Cu(Bzac)(Acac)Bipy]	18	18	17	20	16	20
[Co(Bzac)(Acac)]. H_2O	18	16	20	18	14	14
[Co(Bzac)(Acac)Tmen].0.5 H_2O	20	16	18	14	18	14
[Co(Bzac)(Acac)Phen]	20	16	18	14	14	14
[Co(Bzac)(Acac)Bipy].0.5 H_2O	16	16	14	14	14	14

Moderately Active: 10-19, Active: 20-29, Very Active: 30-above

Conclusion

A probable four, five and six coordinate geometry has been proposed for the complexes. The copper(II) mixed ligand complexes adopt square planar and square pyramidal geometry, while the cobalt(II) complexes adopt a tetrahedral and an octahedral geometry. The room temperature magnetic susceptibility measurement suggests that the prepared complexes are paramagnetic in nature. The synthesized complexes are non-electrolyte and also exhibit potential antimicrobial properties.

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