

PREPARATION, SPECTRAL STUDY AND ANTIMICROBIAL ACTIVITY OF BINARY Co(II) COMPLEXES DERIVED FROM 2'-HYDROXY CHALCONES

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ABSTRACT. The present work comprises preparation, characterization, thermal behavior and growth inhibitory activity of some novel Co(II) complexes derived from substituted (*E*)-1-(1-hydroxy-4-iodonaphthalen-2-yl)-3-phenylprop-2-en-1-one (**L1**) and (*E*)-1-(4-bromo-1-hydroxynaphthalen-2-yl)-3-phenylprop-2-en-1-one (**L2-L6**). Newly synthesized metal-ligand complexes were structurally confirmed with suitable spectroscopic technique such as FT-IR, EPR, NMR (both ¹H and ¹³C). XRD analysis for complex **C1** confirmed the crystal system; tetragonal and space group; P 4₂/n: 2 with unit cell dimensions a, b = 13.3516 Å, c = 10.8009 Å; α, β, γ = 90°. The IR and EPR study demonstrated that interaction between metal ions and ligand occurs through carbonyl oxygen and hydroxyl oxygen. From the values of magnetic moment (μ) it was observed that synthesized complexes (**C1-C6**) are paramagnetic with three unpaired electrons contain one electron in t_{2g} orbital and two electrons in e_g orbitals. Further all these complexes have been evaluated *in-vitro* for their antimicrobial activity against the Gram positive bacteria *Staphylococcus aureus*, Gram negative bacteria *Escherichia coli* and the yeast *Candida albicans*. The complex **C1** showed the significant antimicrobial activity, whereas the complexes **C2, C4, C5** and **C6** are moderately active against the tested pathogens. The antimicrobial data revealed that growth inhibitory activities of complexes were enhanced comparatively than its respective ligands. The enhanced antimicrobial activity is attributed to the presence of halogens (Br, Cl, I) and hydroxyl (OH) active substituents associated with the basic nucleus of complexes. Therefore, the present study helps to develop a new class of antimicrobial analogues.

KEY WORDS: Metal complexes synthesis, 1,3-Diaryl-2-propene-1-one, Crystal structure, Thermal properties, Antimicrobial activity

INTRODUCTION

Chalcone occurring naturally in many plants or they can also be synthetically prepared in laboratory [1]. They are biogenic key precursors of flavonoids in higher plants [2, 3]. Chalcones are important reactive intermediate to constitute a major class of oxygen containing heterocyclic compounds [4]. The chalcones and their related derivatives are well-known for wide range of biological activities such as antiviral [5], anti-inflammatory [6], antitumor [7], antimicrobial [8], antimicrobial [9], antioxidant [10], anti-diabetic [11] and antimalarial [12] activities. The reason for biological activity may be due to the presence of reactive keto vinyl group which allows for interference with cell membrane of fungi and moulds and demonstrates static properties against pathogens [13].

1,3-Diaryl-2-propene-1-one compounds possess the reactive keto-ethylenic group which interconverts to its isomeric form using acid or alkali makes them important ligands [14, 15]. Chalcones are effective metal ion chelators and can easily form metal-coordinated complex compounds. All types of chalcones possess three domains to react with metals such as functional groups present on aromatic ring, keto-enol moiety and olefinic moiety [16]. 2'-hydroxy chalcones, their related heterocyclic and naphthalene analogues have reported for binding ability to form coordination complexes [17]. In recent years, the metal ions play important role in living systems and various transition metal complexes have been used as medicinal compounds. Metal

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complexes possess great diversity in their action like anticancer [18], anti-inflammatory [19], antimycotic [20], anti-alzheimer [21], anti-oxidant, anti-microbial [22] and anti-diabetic [23] properties. Metal ions play vital roles in biological processes, for instance the divalent magnesium and calcium ions play important regulatory roles in cells. In fact, on coordination, ligands would enhance their bioactive profile or some inactive ligand could possess medicinal properties [24]. Co(II) ion is one of the important element in the transition element series, being involved in the many coordination complexes due to higher empty $3d$ -orbital. Redox behaviour of Co(II) complexes has medicinal application as biosensor, also redox-active element may lead to a new route in drug designing. Cobalt is an essential trace element, apart from being an important part of vitamin B₁₂ form, the presence of cobalt is necessary to play a decisive role in generating neurotransmitters [25-26]. Various Co(III) complexes have been reported with antimicrobial activities [27] and anticancer activities [28]. Co(II) complexes of the Schiff's bases had been reported for their antimicrobial and antifungal properties. In view of the above importance of metal complexes first time, we have synthesized the metal complexes of Co(II) and chalcones and evaluated them for their antimicrobial activities.

EXPERIMENTAL

Chemical material and apparatus

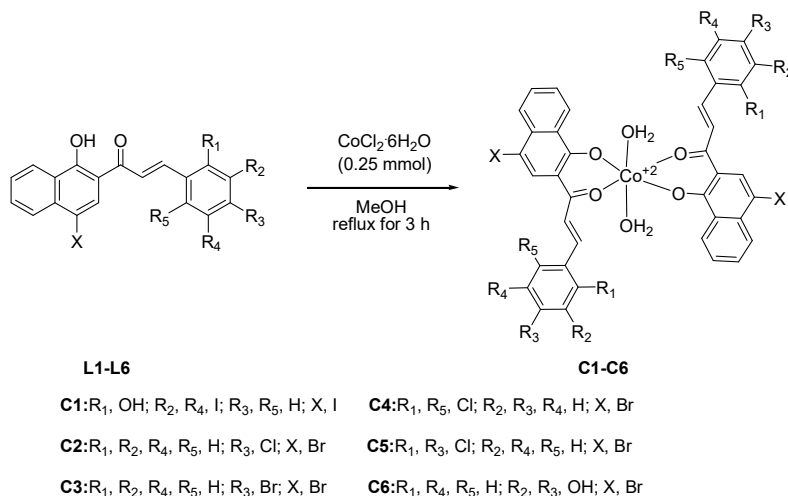
Starting materials, solvents and reagents were purchased from commercial sources and were used without purification. FTIR spectra were recorded as KBr pellets on a Perkin Elmer System 2000. ¹H NMR and ¹³C NMR spectra were acquired in dimethylsulfoxide solvent on a Bruker Avance NEO500 Spectrometer at 500 MHz. TGA analysis was performed on the instrument Mettler Toledo in an inert atmosphere. XRD was measured on an instrument X-ray diffractometer, Ultima IV, Rigaku corporation. ESR analysis was performed on the instrument ESR-JEOL, JES-FA200 ESR spectrometer with X band (8.75-9.65 GHz) at room temperature. In our previous work, we have reported the synthesis of ligand 1,3-diaryl-2-propene-1-one derivatives [29].

General procedure for synthesis of ligand 1,3-diaryl-2-propene-1-one derivatives

A mixture of substituted 2-hydroxy acetophenone (0.01 mol) and substituted benzaldehyde (0.01 mol) were dissolved in 20 mL of 2-methoxyethanol. Weighed accurately and transferred 0.02 mol (4.24 g) of anhydrous K₃PO₄ in to reaction solution. The reaction mixture was refluxed for 5 hours and progress of the reaction was monitored by TLC in hexane: ethyl acetate (4:1). After completion of refluxing, reaction mixture was cooled and poured into 20 mL of ice-water, stirred then treated with dil. HCl to precipitate crude solid product. Solid mass observed were filtered, washed with sufficient amount of water and dried under vacuum. The crude product was purified by column chromatography to give pure sample.

General procedure for synthesis of metal complex [Co(Ln)₂2H₂O] complex

The cobalt chloride solution of 0.25 mmol was prepared from CoCl₂.6H₂O in 10 mL of methanol. The ligand solution of 0.50 mmol was prepared in 20 mL of methanol and set the pH of the solution around 7.0-8.0 with dilute NaOH solution. To this ligand solution, the metal salt solution was added dropwise with constant shaking in a round bottom flask. Then the mixture was refluxed for 3 h, the obtained product was filtered off, washed with 20 mL warm methanol and dried at room temperature. The schematic representation for complex formation is outlined in Scheme 1. All the synthesized complexes were characterised by instrumental analysis.

Scheme 1. Schematic representation of synthesis of binary of Co²⁺ octahedral complexes C1-C6.

Diaquobis((2-((*E*)-3-(2-hydroxy-3,5-diiodophenyl)acryloyl)-4-iodonaphthalen-1-yl)oxy)cobalt(II) (**C1**). FT-IR (KBr, ν , cm^{-1}): 3449.9 (H₂O), 1636.5 (C=O), 1596.2 (C=C), 1241.5 (C-O), 578.7 (Co-O); ¹H NMR (500 MHz, DMSO, δ /ppm): 5.37 (2H, s), 7.21 (2H, d, $J = 16$ Hz), 7.61 (2H, d, $J = 16$ Hz), 7.76-8.29 (14H, m); ¹³C NMR (125 MHz, DMSO, δ /ppm): 83.2, 99.5, 103.2, 117.1, 112.5, 128.9, 138.5, 140.2, 143.7, 146.2, 151.4, 153.3, 157.7, 162.8, 180.6, 184.2.

Diaquobis((4-bromo-2-((*E*)-3-(4-chlorophenyl)acryloyl)naphthalen-1-yl)oxy)cobalt(II) (**C2**). FT-IR (KBr, ν , cm^{-1}): 3429.8 (H₂O), 1588.6 (C=O), 1525.0 (C=C), 1248.2 (C-O), 571.6 (Co-O); ¹H NMR (500 MHz, DMSO, δ /ppm): 7.29 (2H, d, $J = 16$ Hz), 7.73 (2H, d, $J = 16$ Hz), 7.83-8.59 (18H, m); ¹³C NMR (125 MHz, DMSO, δ /ppm): 99.8, 103.1, 108.8, 123.9, 132.4, 144.2, 147.9, 158.65, 174.2, 178.2, 186.2.

Diaquobis((4-bromo-2-((*E*)-3-(4-bromophenyl)acryloyl)naphthalen-1-yl)oxy)cobalt(II) (**C3**). FT-IR (KBr, ν , cm^{-1}): 3415.9 (H₂O), 1578.9 (C=O), 1526.1 (C=C), 1252.5 (C-O), 576.7 (Co-O); ¹H NMR (500 MHz, DMSO, δ /ppm): 7.26 (2H, d, $J = 16$ Hz), 7.59 (2H, d, $J = 16$ Hz), 7.66-8.47 (18H, m); ¹³C NMR (125 MHz, DMSO, δ /ppm): 98.4, 102.2, 106.2, 118.2, 125.4, 134.3, 141.5, 144.3, 154.5, 161.2, 171.4, 182.1, 189.3.

Diaquobis((4-bromo-2-((*E*)-3-(2,6-dichlorophenyl)acryloyl)naphthalen-1-yl)oxy)cobalt(II) (**C4**). FT-IR (KBr, ν , cm^{-1}): 3421.3 (H₂O), 1583.0 (C=O), 1526.5 (C=C), 1248.1 (C-O), 579.0 (Co-O); ¹H NMR (500 MHz, DMSO, δ /ppm): 7.18 (2H, d, $J = 16$ Hz), 7.64 (2H, d, $J = 16$ Hz), 7.78-8.42 (16H, m); ¹³C NMR (125 MHz, DMSO, δ /ppm): 98.5, 105.4, 107.5, 127.3, 133.0, 154.3, 156.6, 161.6, 169.4, 172.4, 184.1, 187.4, 189.9.

Diaquobis((4-bromo-2-((*E*)-3-(2,4-dichlorophenyl)acryloyl)naphthalen-1-yl)oxy)cobalt(II) (**C5**). FT-IR (KBr, ν , cm^{-1}): 3434.1 (H₂O), 1630.5 (C=O), 1580.5 (C=C), 1247.2 (C-O), 580.6 (Co-O); ¹H NMR (500 MHz, DMSO, δ /ppm): 7.41 (2H, d, $J = 16$ Hz), 7.69 (2H, d, $J = 16$ Hz), 7.75-8.67 (16H, m); ¹³C NMR (125 MHz, DMSO, δ /ppm): 96.2, 106.3, 105.4, 124.5, 134.2, 152.8, 158.5, 162.8, 166.4, 175.2, 182.3, 189.6.

Diaquobis((4-bromo-2-((*E*)-3-(3,4-dihydroxyphenyl)acryloyl)naphthalen-1-yl)oxy)cobalt(II) (**C6**). FT-IR (KBr, ν , cm^{-1}): 3429.8 (H₂O), 1617.4 (C=O), 1591.7 (C=C), 1249.8 (C-O), 576.4

(Co-O); ^1H NMR (500 MHz, DMSO, δ /ppm): 7.31 (2H, d, J = 16 Hz), 7.70 (2H, d, J = 16 Hz), 7.82-8.64 (16H, m); ^{13}C NMR (125 MHz, DMSO, δ /ppm): 99.4, 101.2, 105.1, 111.1, 125.6, 134.4, 142.1, 149.3, 156.2, 168.3, 175.4, 185.3, 189.4.

Antimicrobial activity

In vitro antimicrobial activity of compounds was determined by the agar cup plate method. The antibacterial activity was evaluated against the Gram positive bacteria *Staphylococcus aureus* (ATCC6538) and Gram negative bacteria *Escherichia coli* (ATCC8739) and the antifungal activity was evaluated against the *Candida albicans* (ATCC10231). The antibacterial standard drug Ampicilin and the antifungal standard drug Fluconazole was used for evaluation and result comparison. The stock solution of concentration 1 mg/mL of each compound and standard was prepared in dimethylsulfoxide. The Gram positive bacterial slant *Staphylococcus aureus* (ATCC6538) and Gram negative bacterial slant *Escherichia coli* (ATCC8739) were incubated at condition 35 °C for 24 h in growth media soyabean casein digest agar. The fungal slant *Candida albicans* (ATCC10231) was incubated at condition 25 °C for 72 h in growth media sabourauds dextrose agar. After incubation, well grown slant was inoculated in saline solution and vortexed to uniform suspension. Then, adjusted the O.D. with saline water at 530 nm on calorimeter and at viable count was 1×10^7 colony forming unit (CFU/mL). These culture suspensions were inoculated on Mueller-Hinton agar, and plates were bored by cork borer (6 mm) to create wells. From the stock solution, added a volume of 100 μL of the sample solution in to each well. Two controls were maintained for each test. These included reference drug control and blank control. Then plates were incubated for bacteria at 35 °C for 24 h and for the yeast and mould incubated at 25 °C for 48 h to examine the zone of inhibition. All the experiments were performed in triplicate and the average zone of inhibition was reported.

Minimum inhibitory concentrations of each compound were determined against the standard concentrations. The agar dilution method was employed for the determination. Different concentrations of sample and standard such as 1.0, 0.5, 0.25 and 0.12 mg/mL were prepared in dimethylsulfoxide by serial dilution. The volume of 100 μL was added to each well. Standard and blank control was maintained for each test. After incubation, visually the lowest concentration of test solution with no detectable bacterial growth was considered as minimum inhibitory concentration.

RESULTS AND DISCUSSION

The ligand and its metal complexes were synthesized by the general procedure mentioned above in the experimental section. All the metal complexes are brown coloured in nature and are stable towards air and moisture at room temperature. All these metal complexes are insoluble in most of the organic solvents except DMSO and DMF. Metal complexes are characterized by FTIR, X-ray diffraction, TGA, ESR and NMR analysis.

FT-IR spectra

FT-IR measurement analysis of all the complexes was performed by potassium bromide pellet technique. The appearance of medium vibrational stretching band for OH group in ligand at 3230-3425 cm^{-1} [27] whereas strong and broad band at around 3400 cm^{-1} in metal complexes, confirms the formation of Co(II) complexes. The coordinated water molecule in the complex was confirmed by the presence of strong absorption broad band at 3415-3450 cm^{-1} . The vibrational bands observed at 1578-1631 cm^{-1} , 1525-1597 cm^{-1} and 1241-1294 cm^{-1} demonstrated to corresponding functional groups C=O, C=C, C-O, respectively. Similarly, the characteristics band that appeared at 540-581 cm^{-1} demonstrates the Co-O (metal-ligand) bond stretching present in formed metal complexes.

Powder X-ray diffraction analysis

The X-ray powder diffraction analysis was performed on X-ray powder diffractometer with parameters scanning mode; 2Theta/Theta, scanning type; continuous, X-ray; 40 kV/20 mA, fixed monochromator with 2θ range 10 to 90 degree at step 0.01degree. To observe the novelty of synthesized complex comparison was made between the observed pattern and reported pattern with peak search method. The observed pattern is shown in Figure 1. The measurement showed the peaks present at different 2θ values (Table 1). From these values calculated the grain size, dislocation density, strain and unit cell parameters and the values are shown in Table 2.

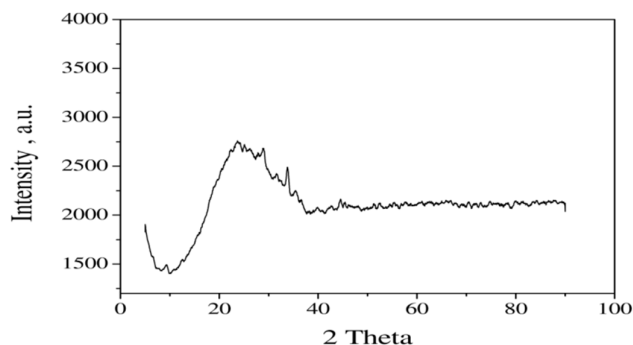


Figure 1. Indexed X-ray powdered diffraction peak for complex $[\text{Co}(\text{C}_{19}\text{H}_{10}\text{O}_3\text{I}_3)_2 \cdot 2\text{H}_2\text{O}]$ (C1).

Table 1. 2 Theta values identified in XRD spectrum of complex C1.

Pos. [°2Th.]	Height [cts]	FWHM [°2Th.]	d-spacing [Å]	hkl
9.36	21	0.09	9.44103	110
25.1346	355.1	0.8801	3.5402	321
28.7945	64.26	1.152	3.09801	213
33.8416	130.26	0.384	2.64663	104
44.5402	306.69	0.265	2.0326	215
55.32	282.69	0.001	1.65933	741
74.8394	283.34	0.1964	1.26767	952

Table 2. Crystallographic data collection and structure refinement of complex C1.

Complex	$[\text{Co}(\text{C}_{19}\text{H}_{10}\text{O}_3\text{I}_3)_2 \cdot 2\text{H}_2\text{O}]$
Empirical formula	$\text{Co C}_{38}\text{H}_{20}\text{O}_6\text{I}_6 \cdot 2\text{H}_2\text{O}$
Formula weight	1428.95
Temperature (K)	298
Crystal system	Tetragonal
Space group	P 42/n :2
a, (Å)	13.3516
b, (Å)	13.3516
c, (Å)	10.8009
α , (°)	90°
β , (°)	90°
γ , (°)	90°
Volume (Å ³)	1925.42
Z	2
ρ_{calc} (g/cm ³)	4.929

μ (cm^{-1})	193.133
Crystallite Size (D, nm)	34.98051
Dislocation density(δ , nm^{-2})	0.81724
Micro strain (ϵ)	8.50920

Thermal gravimetric analysis

Thermal investigation of synthesized complexes was performed to know the information about thermal stability, the water molecule is present or absent inside or outside the coordination sphere of central metal ion and their thermal decomposition. TGA analysis was performed in a nitrogen inert atmosphere. In the first initial step complex started decomposing gradually till it attained the temperature of 170 °C, which demonstrates the loss of coordinated water molecule. After 200 °C anhydrous complex started decomposing till the temperature around 950 °C which corresponds to the elimination of the ligand molecule. The total mass loss was around 69 to 74%. The final residue left was around 26-31% which corresponds to the formation of cobalt oxide. The overlaid thermogram pattern (Figure 2) of complexes **C1**, **C2** and **C5** is almost comparable; it indicates that studied complexes start to reduce their weight at a reasonably high temperature which signifies that the presence of water molecule is inside the coordination sphere of cobalt ion.

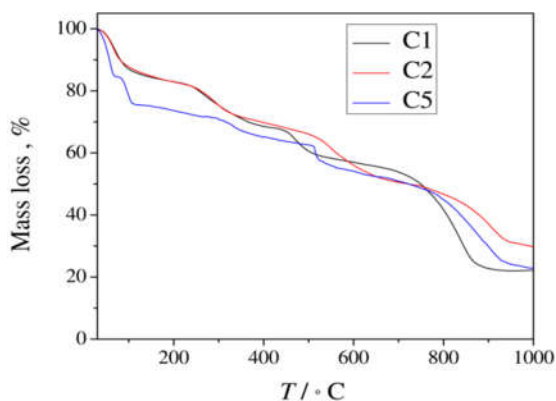


Figure 2. TGA curve for complex $[\text{Co}(\text{C}_{19}\text{H}_{10}\text{O}_3\text{I}_3)_2 \cdot 2\text{H}_2\text{O}]$ (**C1**), $[\text{Co}(\text{C}_{19}\text{H}_{11}\text{O}_2\text{ClBr})_2 \cdot 2\text{H}_2\text{O}]$ (**C2**) and $[\text{Co}(\text{C}_{19}\text{H}_{10}\text{O}_2\text{Cl}_2\text{Br})_2 \cdot 2\text{H}_2\text{O}]$ (**C5**).

EPR analysis

The EPR analysis of synthesized complexes was performed at room temperature. From the representative spectrum Figure 3, the calculated value of g_{\parallel} and g_{\perp} are 2.0153 and 2.0066, respectively. The trend $g_{\parallel} > g_{\perp} > g_e$ observed for the complex, it designates that the observed complex has octahedral geometry and unpaired electron lies in $d_{x^2-y^2}$ orbital.

Magnetic moments

Co(II) complexes are paramagnetic and exhibit magnetic moments at room temperature in the solid state. The Co(II) complexes showed the magnetic moments in the range 4.42-4.87 B.M., suggests three unpaired electron in octahedral environment.

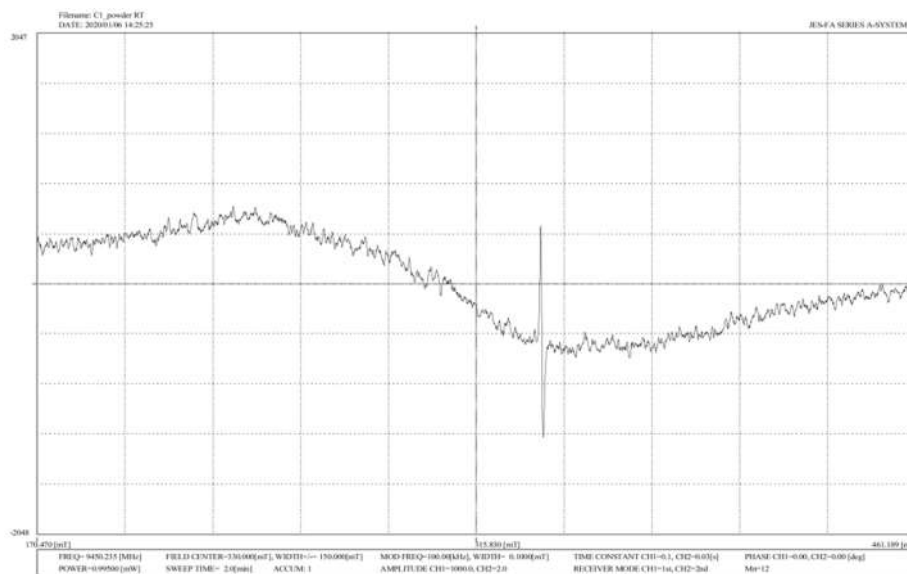


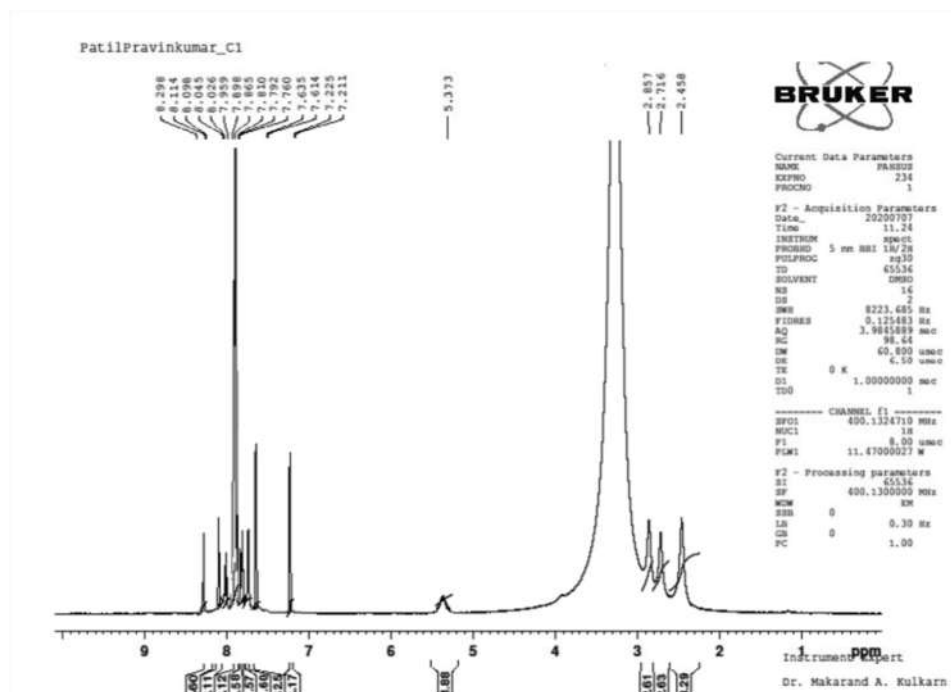
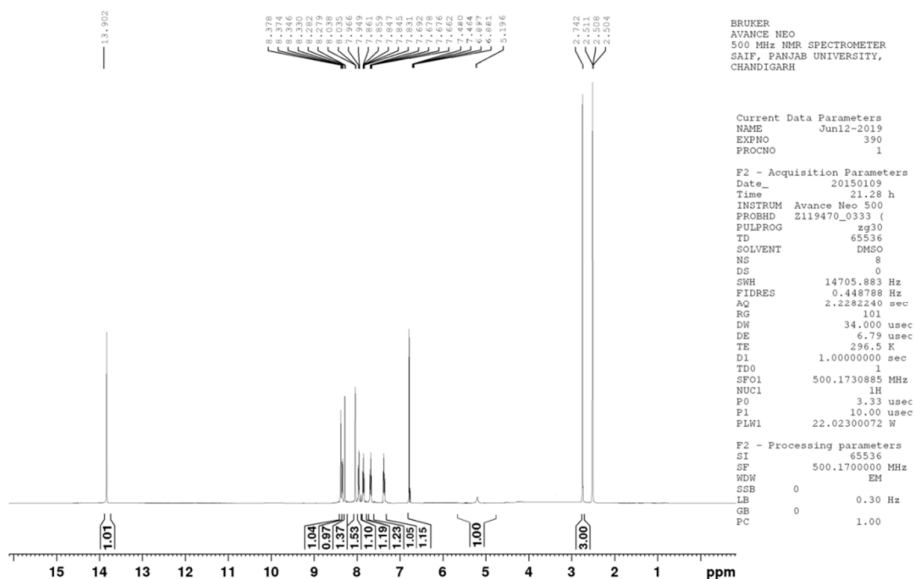
Figure 3. EPR spectrum of complex $[\text{Co}(\text{C}_{19}\text{H}_{10}\text{O}_3\text{I}_3)_2 \cdot 2\text{H}_2\text{O}]$ (**C1**).

^1H NMR and ^{13}C NMR analysis

^1H NMR and ^{13}C NMR analyses were performed in dimethylsulfoxide. The representative spectra of complex **C1** and corresponding ligand **L1** are shown in Figure 4-6. In ^1H NMR analysis, the proton belonging to the aromatic ring displayed chemical shifts between 7.66-8.67 ppm. The characteristic peak at 7.18-7.41 ppm and 7.61-7.73 specify for H_α and H_β protons of α,β -unsaturated carbonyl system with the coupling constant $J = 16$ Hz. The peak at δ 5.37 ppm signifies the presence of phenolic -OH group in coordination complex **C1** and **C6**. While the absence of characteristic chemical shift for -OH proton of 2-hydroxy acetophenone moiety of ligand at 14.0 ppm demonstrates that deprotonation of -OH and coordination occurs through the oxygen. In ^{13}C NMR analysis peaks appeared in the range 96.28 to 189.92 ppm show the aromatic carbon, olefinic carbon and carbonyl carbon. While the peak at δ 83.25 ppm demonstrates the carbon linked to -I substituent.

Antimicrobial activity

The *in-vitro* antimicrobial activity of complexes and their ligands are presented in Table 3. The complexes **C1** and **C6** exhibit significant antibacterial activity against the pathogen *Staphylococcus aureus*, depicted the largest zone of inhibition 23.62 mm and 18.36 mm, respectively, which were even higher than the zone of inhibition 18.14 mm of bactericidal drug Ampicilin. The complexes **C1**, **C4** and **C5** demonstrate the significant antifungal activity against the pathogen *Candida albicans*, depicted the largest zone of inhibition 19.25 mm, 16.43 mm and 16.58 mm, respectively, which were higher than zone of inhibition 16.24 mm of fungicidal drug Fluconazole. However, all the complexes showed moderate antibacterial activity against the pathogen *Escherichia coli*, depicted the lower zone of inhibition with respect to bactericidal drug Ampicilin.

Figure 4. ^1H NMR spectrum of complex $[\text{Co}(\text{C}_{19}\text{H}_{10}\text{O}_3\text{I}_3)_2 \cdot 2\text{H}_2\text{O}]$ (C1).Figure 5. ^1H NMR spectrum of ligand (L1).

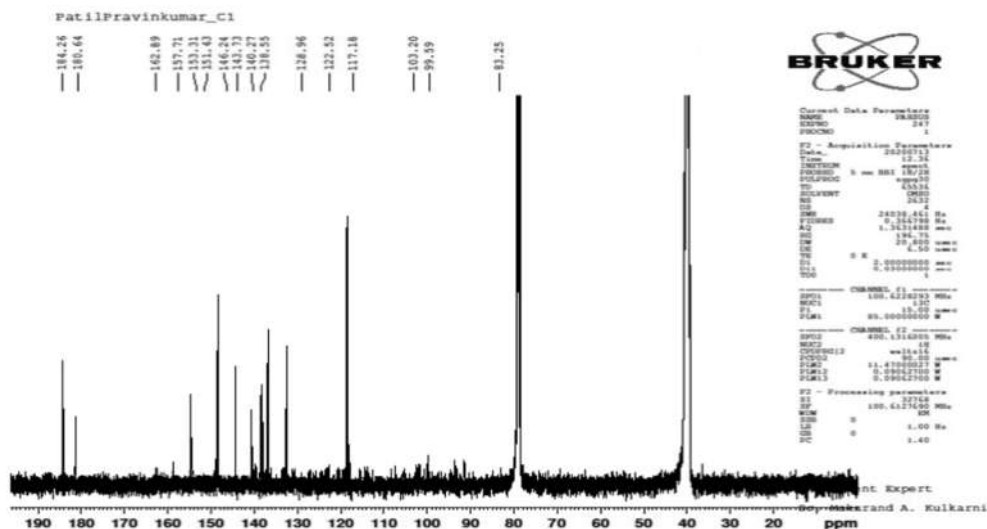


Figure 6. ^{13}C NMR spectrum of complex $[\text{Co}(\text{C}_{19}\text{H}_{10}\text{O}_3\text{I}_3)_2 \cdot 2\text{H}_2\text{O}]$ (C1).

Consequently, the complexes **C1**, **C4**, **C5** and **C6** showed the even higher activity index with respect to strain and standard drugs, indicates significant potency. Activity data showed that inhibition found enhanced in all complexes than its respective ligand. Structurally similar activity data were reported in our previous study for Cu(II) and Zn(II) complexes of 2'-hydroxy chalcones [30]. The reason is that synthesized complexes contain di-dentate coordinating sites, their ligands associated with multiple halogen or hydroxyl substituents. These substituent supports to boost the pharmacological activity. The activity index (A.I.) was calculated using average zone of inhibition by following formula.

$$\text{Activity index (A.I.)} = \frac{\text{Mean zone of inhibition of derivatives}}{\text{Zone of inhibition of standard drug}}$$

The minimum inhibitory concentrations of complexes were performed at the concentrations 1.0, 0.5, 0.25 and 0.12 mg/mL. The observed MIC values of complexes and respective ligands are presented in Table 4. The complex **C1** was most sensitive, being inhibited at MIC value 0.12 mg/mL against all pathogens with respect to the standard drug Ampicilin and Flucanazole inhibited at MIC values 0.25 mg/mL and 1.0 mg/mL, respectively. The complexes **C2**, **C5** and **C6** were most potent, being inhibited at MIC values 0.12 mg/mL against the pathogen *Escherichia coli* with respect to the standard drug Ampicilin inhibited at MIC values 0.25 mg/mL. The complexes **C2**, **C4** and **C5** were the most resistant, being inhibited at MIC values 0.12 mg/mL against the pathogen *Candida albicans* with respect to the standard drug Flucanazole inhibited at MIC values 1.0 mg/mL. All complexes showed the improved MIC values than the respective ligands. The increased potency is due to the presence of halogens or hydroxyl substituents in the ligands.

Table 3. Antimicrobial activity of complexes and their ligands.

Compound	Antibacterial				Antifungal	
	<i>S. aureus</i>		<i>E. coli</i>		<i>C. albicans</i>	
	Average zone of inhibition (in mm)	Activity index (A.I.)	Average zone of inhibition (in mm)	Activity index (A.I.)	Average zone of inhibition (in mm)	Activity index (A.I.)
L ₁ *	-	1.2471	-	0.8358	-	1.0313
C1 : [Co(L ₁) ₂].2H ₂ O	23.62	1.3021	17.47	0.9045	19.25	1.1858
L ₂ *	-	0.5914	-	0.8749	-	0.82447
C2 : [Co(L ₂) ₂].2H ₂ O	12.51	0.6897	18.78	0.9725	15.77	0.9713
L ₃ *	-	0.8044	-	0.6854	-	0.7051
C3 : [Co(L ₃) ₂].2H ₂ O	16.75	0.9234	15.11	0.7824	14.32	0.8821
L ₄ *	-	0.8131	-	0.6981	-	0.8629
C4 : [Co(L ₄) ₂].2H ₂ O	17.15	0.9456	15.04	0.7785	16.43	1.0122
L ₅ *	-	0.7841	-	0.8309	-	0.8422
C5 : [Co(L ₅) ₂].2H ₂ O	16.91	0.9325	19.47	0.9914	16.58	1.0215
L ₆ *	-	0.8218	-	0.7096	-	0.7707
C6 : [Co(L ₆) ₂].2H ₂ O	18.36	1.0125	18.86	0.9765	15.67	0.9654
DMSO	No zone	-	No zone	-	No zone	-
Ampicilin	18.14	1.0000	19.32	1.0000	-	-
Fluconazole	--	-	---	-	16.24	1.0000

* Growth inhibitory activity of ligand against tested pathogens [29].

Table 4. MIC values of complexes and their ligands.

Ligand and complex	MIC in mg/mL		
	<i>S. aureus</i>	<i>E. coli</i>	<i>C. albicans</i>
L ₁ *	0.12	0.25	0.12
C1 : [Co(L ₁) ₂].2H ₂ O	0.12	0.12	0.12
L ₂ *	0.50	0.25	0.25
C2 : [Co(L ₂) ₂].2H ₂ O	0.50	0.12	0.12
L ₃ *	0.50	1.0	1.0
C3 : [Co(L ₃) ₂].2H ₂ O	0.25	0.25	0.25
L ₄ *	0.25	0.50	0.25
C4 : [Co(L ₄) ₂].2H ₂ O	0.12	0.25	0.12
L ₅ *	0.50	0.25	0.25
C5 : [Co(L ₅) ₂].2H ₂ O	0.25	0.12	0.12
L ₆ *	0.25	0.50	0.50
C6 : [Co(L ₆) ₂].2H ₂ O	0.25	0.12	0.25
Ampicilin	0.25	0.25	
Fluconazole			1.0

*Displays the MIC of ligands [29].

CONCLUSION

A series of bi-coordinated Co(II) complexes with 1,3-diaryl-2-propene-1-ones derivatives have been synthesized. All synthesized complexes have been spectrally characterised by IR, NMR, TGA, XRD and EPR analysis. The data suggested the octahedral geometry of Co(II) and bidentate ligands complexes with 1:2 stoichiometry. The *in-vitro* antimicrobial activity of complexes evaluated against the gram positive bacteria *Staphylococcus aureus*, gram negative bacteria *Escherichia coli* and the yeast *Candida albicans*. All these complexes showed much improved antimicrobial activity than its ligands associated with halogen and hydroxyl moiety. The complex

C1 showed significant activity against all tested pathogens. The complexes **C2**, **C5** and **C6** showed significant activity against the *Escherichia coli* and *Candida albicans* and the complexes **C4** showed significant activity against the *Staphylococcus aureus* and *Candida albicans*. The complex **C1** exhibited the MIC value of 0.12 mg/mL against all pathogens, the complex **C2** and **C5** showed the MIC value of 0.12 mg/mL against *Escherichia coli* and *Candida albicans*, whereas the complex **C4** showed the MIC value of 0.12 mg/mL against *Staphylococcus aureus* and *Candida albicans*. Hence, this synthetic methodology and antimicrobial results might serve as preliminary screening for the development of new antimicrobial agents with structural modification.

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