

## Synthesis, Characterization and Chelating Properties of Benzofuran Containing Molecule

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### ABSTRACT

The reaction between ethyl 3-hydroxybenzofuran-2-carboxylate (BF) with aniline gives a 3-hydroxy-N-phenylbenzofuran-2-carboxamide (PBF). The transition metal complexes of Cu<sup>2+</sup>, Co<sup>2+</sup>, Ni<sup>2+</sup>, Mn<sup>2+</sup> and Zn<sup>2+</sup> of PBF have been prepared and characterized by elemental analyses, spectral studies, magnetic moment determination, molar conductivity measurement and microbicidal activity.

**Keywords:** Ethyl 3-hydroxybenzofuran-2-carboxylate (BF), metal chelates, spectral studies, magnetic moment, antibacterial and antifungal activity.

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### INTRODUCTION

Benzofuran is one of the most important heterocyclic compounds, which are widely distributed in nature amongst the plant kingdom. Benzofurans are bicyclic ring system with multiple applications. These compounds are containing biological as well as pharmacological activities. Benzofuran and its derivatives shows antibacterial activity, antifungal activity, anti-inflammatory activity, analgesic activity, antidepressant activity, anticonvulsant activity, antidiabetic activity, antitubercular activity and antioxidant activity[1-17]. Thus this may afford good chelating ligand with better microbicidal activity. Hence it was thought interesting to prepare the ligand having benzofuran moieties. Thus the present communication comprises the studies on metal chelate of benzofuran combined molecule and its metal chelates. The research work is shown in Scheme-1.

### MATERIALS AND METHODS

Ethyl 3-hydroxybenzofuran-2-carboxylate (BF) were prepared by method reported in literature[18-19]. All other chemicals used were of analytical grade.

#### Synthesis of 3-hydroxy-N-phenylbenzofuran-2-carboxamide (PBF)

A mixture of ethyl 3-hydroxybenzofuran-2-carboxylate (BF) (0.1 mole) and aniline (0.1 mole) in ethanol (70 ml) was heated under reflux for 3.5 hrs. Subsequently ethanol was distilled off and the lump mass obtained. It was triturated with petroleum ether (40-60° C). The solid designated as PBF was isolated and dried in air. Yield was 78%. It's m.p. was 168-70°C (uncorrected).

Elemental Analysis: C<sub>15</sub>H<sub>11</sub>NO<sub>3</sub> (253)

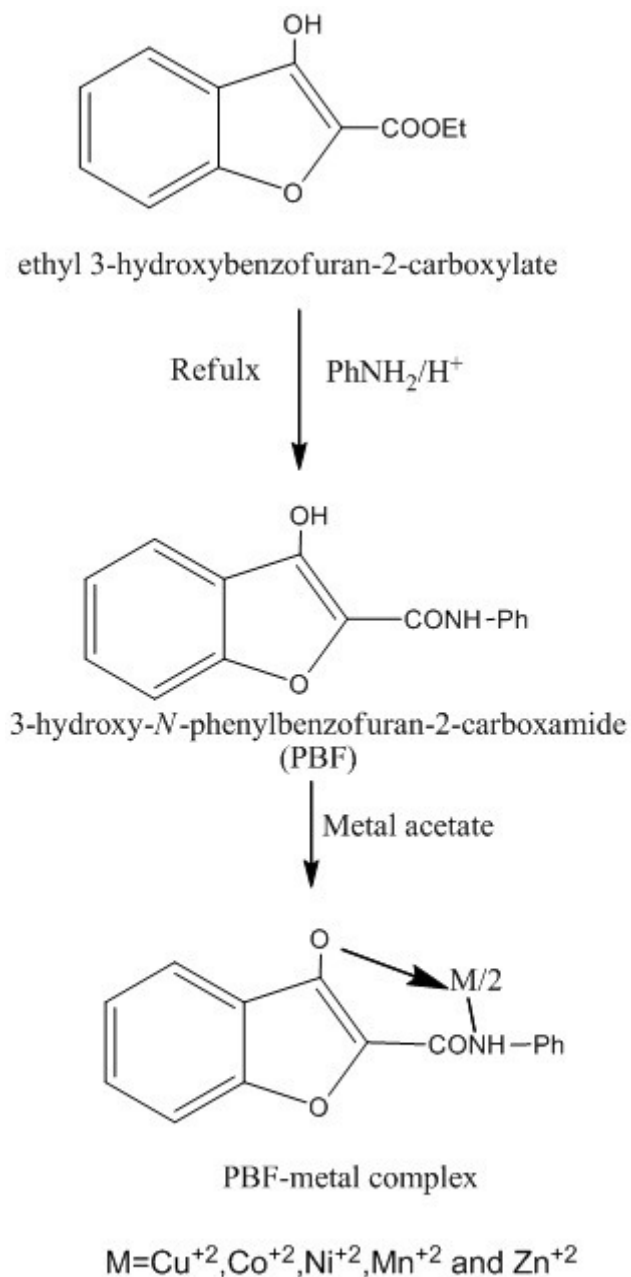
	C%	H%	N%
Calculated:	71.14	4.38	5.53
Found :	71.12	4.35	5.51

Acid Value      Theoretical: 192.5 g KOH/1g. Sample.

Found: 194 KOH/1g Sample.

IR Features	1685cm <sup>-1</sup>	CO
	2850-3600 cm <sup>-1</sup>	OH
	3410 cm <sup>-1</sup>	Sec.NH
	3030, 1500, 1600 cm <sup>-1</sup>	Aromatic

	1150-1240 $\text{cm}^{-1}$	C-O-C	
NMR	$\delta$ ppm		
(DMSO)	7.2 – 7.9 (9H)	Multiplet	Aromatic
	4.4 (1H)	Singlet	OH
	3.3 (1H)	Singlet	NH



**Scheme-1 Synthesis of PBF-metal complex**

**Synthesis of metal chelates of PBF**

The  $\text{Cu}^{2+}$ ,  $\text{Co}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Mn}^{2+}$  and  $\text{Zn}^{2+}$  metal ion chelates of PBF have been prepared in a similar manner. The procedure is as follow.

To a solution of PBF (25.3 g, 0.1 mole) in ethanol-acetone (1:1v/v) mixture (150ml), 0.1N KOH solution was added dropwise with stirring. The pasty precipitates were obtained at neutral pH. These were dissolved by addition of water up to clear solution. It was diluted to 250 ml. by water and was known as stock solution. 25 ml of the stock solution (which contains 0.01 mole PBF) was added drop wise to the solution of metal salt (0.005 mole for divalent metal ions) in water at room temperature. Sodium acetate or ammonia was added up to complete precipitation. The precipitates were digested on water bath at 80° C for 2hrs. The digested precipitates of chelates were filtered washed with water and air dried. It was amorphous powder. Yield was almost quantitative. The details are given in Table-1.

Table-1: Analytical Data of the Metal Chelates of HL<sub>1</sub> (i.e. PBF)

Compound	Empirical Formula	Mol. Cal. gm/mol	Yield (%)	Elemental Analysis							
				C%		H%		N%		M%	
				Cald.	Found	Cald.	Found	Cald.	Found	Cald.	Found
HL (PBF)	C <sub>15</sub> H <sub>11</sub> NO <sub>3</sub>	253	78	71.14	71.12	4.38	4.35	5.53	5.51	--	--
(L) <sub>2</sub> Cu <sup>2+</sup>	C <sub>30</sub> H <sub>20</sub> N <sub>2</sub> O <sub>6</sub> Cu <sup>2+</sup> ·2H <sub>2</sub> O	603.54	81	59.64	59.61	3.97	3.95	4.63	4.62	10.52	10.50
(L) <sub>2</sub> Co <sup>2+</sup>	C <sub>30</sub> H <sub>20</sub> N <sub>2</sub> O <sub>6</sub> Co <sup>2+</sup> ·2H <sub>2</sub> O	598.94	76	60.10	60.08	4.00	3.99	4.67	4.65	9.84	9.81
(L) <sub>2</sub> Ni <sup>2+</sup>	C <sub>30</sub> H <sub>20</sub> N <sub>2</sub> O <sub>6</sub> Ni <sup>2+</sup> ·2H <sub>2</sub> O	598.71	77	60.12	60.10	4.00	3.97	4.67	4.64	9.80	9.78
(L) <sub>2</sub> Mn <sup>2+</sup>	C <sub>30</sub> H <sub>20</sub> N <sub>2</sub> O <sub>6</sub> Mn <sup>2+</sup> ·2H <sub>2</sub> O	594.94	80	60.51	60.48	4.03	4.00	4.70	4.68	9.23	9.21
(L) <sub>2</sub> Zn <sup>2+</sup>	C <sub>30</sub> H <sub>20</sub> N <sub>2</sub> O <sub>6</sub> Zn <sup>2+</sup> ·2H <sub>2</sub> O	605.38	79	59.46	59.44	3.96	3.93	4.62	4.59	10.79	10.77

### Measurements

The elemental analysis for C, H and N were carried out on elemental analyzer TF-EA.1101 (Italy). IR spectra of PBF and its metal complexes were scanned on a Nicolet 760 FTIR spectrophotometer in KBr. The NMR spectrum of PBF was scanned on Bruker NMR3 spectrophotometer using DMSO solvent. The metal content of the metal chelate were performed by decomposing a weighed amount of each metal complexes followed by EDTA titration as reported in literature [20]. Magnetic susceptibility measurement of the entire metal complex was carried out at room temperature by the Gouy method. Mercury tetrathiocyanatocobaltate (II) was used as a calibrant. The diffused reflectance spectra of solid metal complex were recorded on a Beckman DK Spectrophotometer with a solid reflectance attachment, MgO was employed as the reflectance compound. The electrical conductivity of all the complexes was measured in acetonitrile at 10<sup>-3</sup> M concentration.

Table -2: Magnetic Moment and Reflectance Spectral data of Metal Chelates of PBF ligand

Metal chelates	Magnetic Moment μ <sub>eff</sub> (B.M.)	Molar Conductivity Ωm ohm <sup>-1</sup> cm <sup>2</sup> mol <sup>-1</sup>	Absorption band (cm <sup>-1</sup> )	Transitions
Cu-HL	1.92	37.8	22792 15958	C.T <sup>2</sup> T→ <sup>2</sup> T <sub>2g</sub>
Ni-HL	3.87	36.6	14780 23083	3 A <sub>2g</sub> → 3T <sub>1g</sub> (p) 3 A <sub>1g</sub> → 3T <sub>1g</sub> (F)
Co-HL	4.53	35.5	15469 22821	4 T <sub>1g</sub> (F)→ 4T <sub>2g</sub> (F) 4 T <sub>1g</sub> (F)→ 3A <sub>2g</sub>
Mn-HL	5.11	37.2	15472 17751 23052	6 A <sub>1g</sub> → 4T <sub>1g</sub> (4Eg) 6 A <sub>1g</sub> → 4T <sub>2g</sub> (4G) 6 A <sub>1g</sub> → 4T <sub>1g</sub> (4G)

### Antifungal activity

The fungicidal activity of all the compounds was studied at 1000 ppm concentration in vitro plant pathogenic organisms listed in Table-3. The antifungal activities of all the samples were measured by cup plate method [21]. Each of the plant pathogenic strains on potato dextrose agar (PDA) medium. Such a PDA medium contained potato

200 gms, dextrose 20gms, agar 20gms and water 1 litre. 5 days old cultures were employed. The compounds to be tested were suspended (1000ppm) in a PDA medium and autoclaved at 120° C for 15 min. at 15 atm pressure. These medium were poured into sterile Petri plate and the organisms were inoculated after cooling the Petri plate. The percentage inhabitation for fungi was calculated after 5 days using the formula given below.

$$\text{Percentage of inhibition} = \frac{100(X-Y)}{X}$$

Where, X: Area of colony in control plate

Y: Area of colony in test plate

The fungicidal activity all compounds are shown in Table-3.

Table-3: Antifungal Activity of Ligand HL<sub>1</sub> and its metal chelates

Sample	Zone of inhibition of fungus at 1000ppm (%)			
	<i>Nigrospra sp.</i>	<i>Trichothesium sp.</i>	<i>Aspergillus niger.</i>	<i>Botrydepladia thiobromine</i>
HL	68	67	64	58
HL-Cu <sup>2+</sup>	77	78	82	73
HL-Co <sup>2+</sup>	75	74	75	77
HL-Ni <sup>2+</sup>	78	79	77	74
HL-Mn <sup>2+</sup>	76	73	74	72
HL-Zn <sup>2+</sup>	72	73	79	71

Zn<sup>2+</sup> Diamagnetic in Nature.

## RESULTS AND DISCUSSION

The parent ligand PBF was an amorphous pale green powder, soluble in various solvents like dioxane, DMSO and DMF. The results of elemental analysis of the ligand are reported in experimental part. They are consistent with the predicted structure as shown in Scheme-I.

Examination of IR spectrum (not shown) of PBF reveals that broad band of phenolic hydroxyl stretching is observed at 2850-3600 cm<sup>-1</sup> as well as additional absorption bands at 3030,1620,1530,1150-1240 cm<sup>-1</sup> are characteristics of the benzofuran moiety. The strong bands at 1685 cm<sup>-1</sup> for C=O and band at 3410 cm<sup>-1</sup> for sec. NH. The NMR data (shown in experimental part) also confirm the structure of PBF.

The Metal chelates of PBF with ions Cu<sup>2+</sup>, Co<sup>2+</sup>, Ni<sup>2+</sup>, Mn<sup>2+</sup> and Zn<sup>2+</sup> differ in colours. On the basis of the proposed structure as shown in Scheme-1, the molecular formula of the PBF ligand is C<sub>15</sub>H<sub>11</sub>NO<sub>3</sub>. This upon complexion coordinates with one central metal atom at four coordination sites and with two water molecules. Therefore the general molecular formula of the resulting metal chelate is [C<sub>15</sub>H<sub>10</sub>NO<sub>3</sub>]<sub>2</sub>M.2H<sub>2</sub>O for divalent metal ions. This has been confirmed by results of elemental analysis reported in Table-1. The data are in agreement with the calculated values.

Inspection of the IR Spectra (not shown) of metal chelates reveals that all the spectra are identical in all respects. The comparison of IR spectrum of the parent ligand PBF with that of its each metal chelates has revealed certain characteristics differences.

One of the significant differences to be expected between the IR spectrum of the parent ligand and its metal chelates is the presence of more broadened bands in the region of 3200-3600 cm<sup>-1</sup> for the metal chelates as the oxygen of the O-H group of the ligands forms a coordination bond with the metal ions [21-23]. This is explained by the fact that water molecule might have strongly absorbed to the metal chelates samples during their formation. Another noticeable difference is that the bands due to the CO at 1730 cm<sup>-1</sup> in the IR spectrum of the each metal chelates. The band at 1400 cm<sup>-1</sup> in the IR Spectrum of HL assigned to in plane OH determination[21-23] is shifted towards higher frequency in the spectra of confirmed by a weak bands at 1095 cm<sup>-1</sup> corresponding to C-O-M stretching [21-23]. Thus all of these characteristics features of the IR studies suggested the structure of the metal chelates as shown in scheme.

Examination of data of the metal content in each compound revealed a 1:2 metal: ligand (M: L) stoichiometry in all of the chelate of divalent metal ions. Magnetic moment ( $\mu_{\text{eff}}$ ) of each of the metal chelates is given in Table-2. Examination of these data reveals that all chelates other than that of  $\text{Zn}^{2+}$ , are Para magnetic while those of  $\text{Zn}^{2+}$  are diamagnetic.

The diffuse electronic spectrum of the  $[\text{CuHL}(\text{H}_2\text{O})_2]$  metal complex shows broad bands at 15958 and 22792  $\text{cm}^{-1}$  due to the  ${}^2\text{T} \rightarrow {}^2\text{T}_{2\text{g}}$  transition and charge transfer, respectively suggesting a distorted octahedral structure [24-26] for the  $[\text{CuHL}(\text{H}_2\text{O})_2]$  complex. Which is further confirmed by the higher value of  $\mu_{\text{eff}}$  of the  $[\text{CuHL}(\text{H}_2\text{O})_2]$  complex. The  $[\text{NiHL}(\text{H}_2\text{O})_2]$  and  $[\text{CuHL}(\text{H}_2\text{O})_2]$  complex gave two absorption bands respectively at 115469, 22821 and 15958, 22792  $\text{cm}^{-1}$  corresponding to  ${}^4\text{T}_{1\text{g}} \rightarrow {}^2\text{T}_{1\text{g}}$  and  ${}^4\text{T}_{1\text{g}}$  (p) transitions. Thus absorption bands at the diffuse, reflectance spectra and the value of the magnetic moments  $\mu_{\text{eff}}$  indicate an octahedral configuration for the  $[\text{NiHL}(\text{H}_2\text{O})_2]$  and  $[\text{CuHL}(\text{H}_2\text{O})_2]$  complex. The spectra of  $[\text{MnHL}(\text{H}_2\text{O})_2]$  shows weak bands at 15472, 17751 and 23052  $\text{cm}^{-1}$  assigned to the transitions  ${}^6\text{A}_{1\text{g}} \rightarrow {}^4\text{T}_{1\text{g}}$  (4G),  ${}^6\text{A}_{1\text{g}} \rightarrow {}^4\text{T}_{2\text{g}}$  (4G) and  ${}^6\text{A}_{1\text{g}}$  (F)  $\rightarrow {}^4\text{T}_{1\text{g}}$ , respectively suggesting an octahedral structure for the  $[\text{MnHL}(\text{H}_2\text{O})_2]$  chelate. The high intensities of the bands suggests that they might be charge transfer in origin  $\mu_{\text{eff}}$  is found to be lower than normal range. In the absence of low temperature moments it is difficult to give any significance. As the spectrum of the  $[\text{ZnHL}(\text{H}_2\text{O})_2]$  polymer is not well resolved, it is not interpreted but its  $\mu_{\text{eff}}$  value shows that it is diamagnetic as expected.

Conductivities of all the complexes were measured in acetonitrile solvent and all the complexes were found to be electrolytic [27] in nature of 1:2 type and molar conductivity values are in the range of 35.5-37.8  $\text{ohm}^{-1} \text{cm}^{-1}$ .

The antifungal activity of all the compounds measured for various plant pathogens. Inspection of the result shown in Table-3 indicates that all compounds are good toxic for fungi. Out of all the compounds copper chelates is more toxic than other. These compounds almost inhibit the fungi about 78%. Hence produced metal chelates can be employed as garden fungicides. Further work in the direction is in progress.

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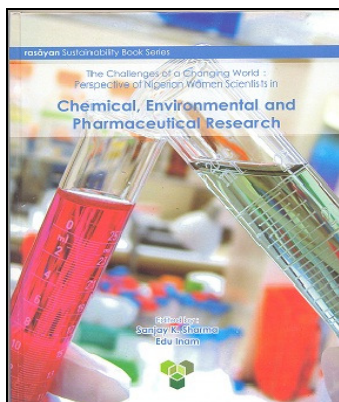
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