



Synthesis, characterization and biological properties of benzimidazol-8-hydroxy quinoline clubbed azodye and its transition metal chelates

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ABSTRACT

The 1-(4-((8-hydroxyquinolin-5-yl)diazenyl)phenyl)-2-(2-methyl-1H-benzo[d]imidazol-1-yl)ethanone (**H₁L**) was synthesized by Diazotization reaction of diazonium salt (**DAMBE**) of 1-(4-aminophenyl)-2-(2-methyl-1H-benzo[d]imidazol-1-yl) ethanone (**AMBE**) and 8-hydroxyquinolinol (**HQ**). The synthesized novel ligand was characterized by elemental analysis, IR, NMR, CMR and Mass spectral studies. The transition metal chelates viz. Cu^{2+} , Ni^{2+} , Co^{2+} , Mn^{2+} and Zn^{2+} of ligand (**H₁L**) were prepared and characterized by metal-ligand (M:L) ratio, IR spectral study, reflectance spectroscopy and magnetic properties. The antibacterial and antifungal activity of ligand and its transition metal chelates was evaluated against various microbial strains.

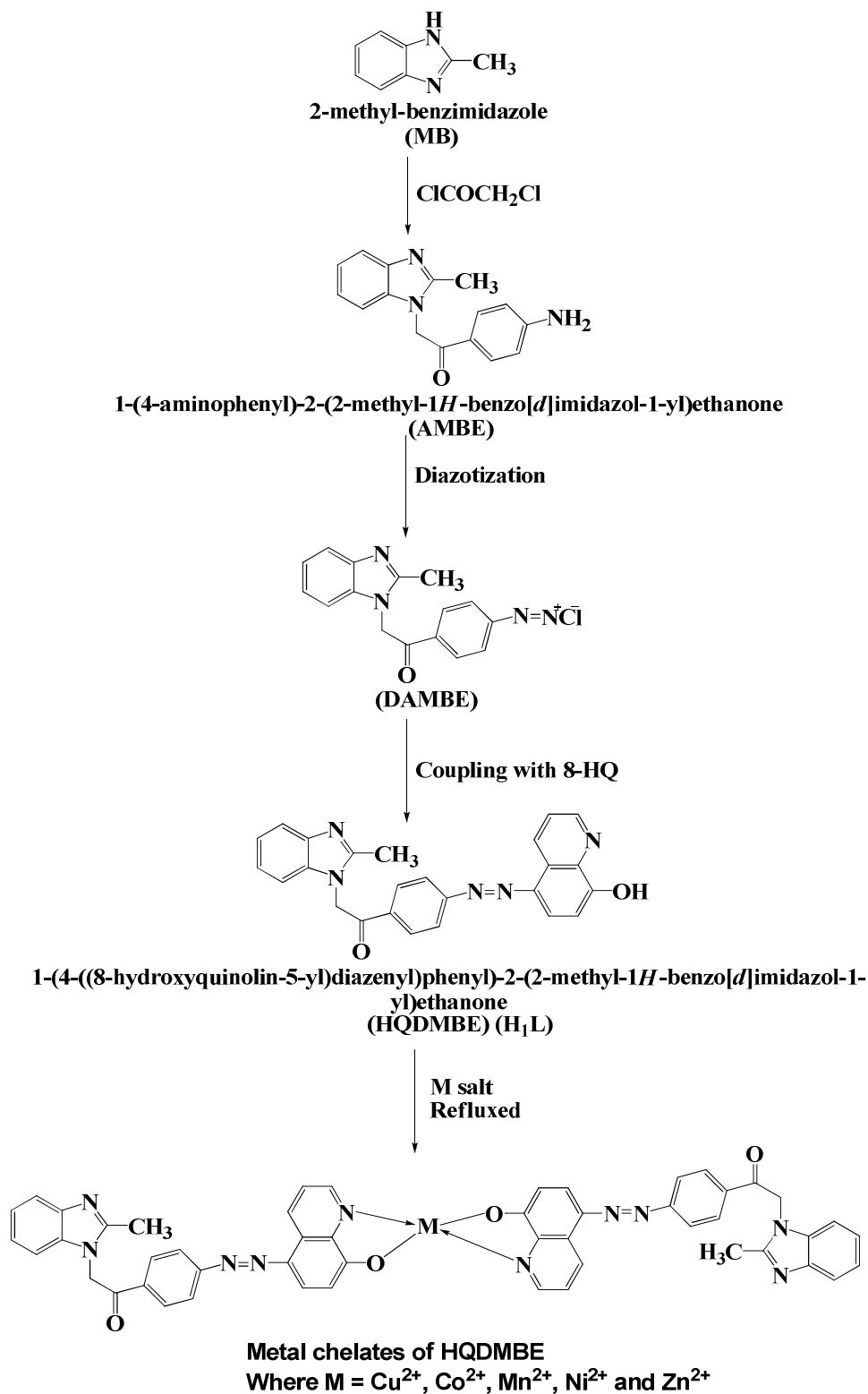
Keywords: 1-(4-aminophenyl)-2-(1H-benzo[d]imidazol-1-yl)ethanone, 8-hydroxy quinolinol, Reflectance spectroscopy, Magnetic moment, Antibacterial and Antifungal properties.

INTRODUCTION

The no of metal chelates containing 8- hydroxy quinolinol (HQ) can be synthesize easily and studied recently for their biological activities [1-4]. 8-Hydroxyquinoline and its derivatives are well known pharmaceutical agent as well as an analytical reagent [5-9]. Several azo dyes based on 8-quinolinol are reported for dyeing of textiles, chelating properties and ion exchange properties [10-14]. The history of heterocyclic compounds was aged in the field of pharmaceutical as well as biological activity [15-17]. The heterocyclic nitrogen compounds especially benzimidazole derivatives play a vital role in many biological processes like Antibacterial, Antifungal, Anti-tuberculosis, Anticancer, Analgesic and Anti-inflammatory activity [18-23]. The reaction of methyl-benzimidazole derivatives with HQ has not been reported so far. Based on the above facts, it was thought that combined molecule of methyl-benzimidazole and 8-HQ may explore good biological active compound. The present article comprises the synthesis, characterization and biological properties of transition metal chelates containing heterocyclic azo dye as ligand.

EXPERIMENTAL SECTION

2-methyl-benzimidazole (**MB**) was purchased from local market. 1-(4-aminophenyl)-2-(2-methyl-1H-benzo[d]imidazol-1-yl) ethanone (**AMBE**) was prepared according to reported method [24]. All other chemicals and solvents used were of analytical grade.



Scheme-1

Diazotization of 1-(4-aminophenyl)-2-(2-methyl-1H-benzo[d]imidazol-1-yl) ethanone (AMBE)

1-(4-aminophenyl)-2-(2-methyl-1H-benzo[d]imidazol-1-yl)ethanone (0.01 mole) was taken in a beaker. Nitrosyl sulphuric acid was added drop wise to a well-stirred solution of 1-(4-aminophenyl)-2-(2-methyl-1H-benzo[d]imidazol-1-yl)ethanone. The reaction mixture was maintained at 0-5 °C. When the addition was completed, the resultant solution was kept for few minutes with occasional stirring (till completion of the diazotization). The diazotization was confirmed by the positive test of nitrous acid on starch iodide paper or Congo red paper. The resultant diazo component was used for subsequent coupling reaction to prepare a heterocyclic azo dye compound.

Synthesis of 1-(4-((8-hydroxyquinolin-5-yl)diazenyl)phenyl)-2-(2-methyl-1H-benzo[d]imidazol-1-yl)ethanone (H₁L):

8-hydroxy quinoline (0.01 mole) was dissolved in required amount of diluted hydrochloric acid and the solution was then cooled to 0-5 °C. To this well stirred solution, the above diazonium salt of 1-(4-aminophenyl)-2-(2-methyl-1H-benzo[d]imidazol-1-yl)ethanone was added slowly to maintain the temperature below 5 °C while keeping the pH between 4.5-5.5 by the action of sodium acetate solution (10% w/v). The mixture was then stirred for 1hr. at 0-5 °C. After completion of the reaction, the compound was filtered and washed with water to remove salt material, further it dried to get colored precipitates.

TABLE-1: Physical properties of ligand (H₁L)

Molecular Formula: C ₂₅ H ₁₉ N ₅ O ₂	Elemental Analysis			
Molecular Weight: 421 gm/mole		%C	%H	%N
Melting Point: 230-232 °C (Uncorrected)	Calculated	71.25	4.54	16.62
Yield: 72%	Found	71.2	4.5	16.6
Infrared Spectral Features around cm⁻¹	PMR spectral Features (δ, Ppm)			
3250 -OH	6.8-8.1	(13H, m, Ar-H)		
2945, 1370 Aromatic stretching	6.30	(2H, s, -CH ₂)		
1630, 1575 Azo (-N=N-)	4.22	(1H, s, -OH)		
1730 C=O stretching	2.34	(3H, s, -CH ₃)		
1540 C=C conjugate	¹³CMR spectral Features (δ, Ppm)			
1165 C-O stretching	125-137	Ar-C		
	150,151	-C=N		
	158	C-O		
	175	-CO		
	56	-CH ₂ of imidazole		
	18.7	-CH ₃		

Synthesis of transition metal chelates of 1-(4-((8-hydroxyquinolin-5-yl)diazenyl)phenyl)-2-(2-methyl-1H-benzo[d]imidazol-1-yl)ethanone (H₁L):

All the metal chelates of ligand (H₁L) with Cu²⁺, Co²⁺, Mn²⁺, Ni²⁺, and Zn²⁺ metal ions were prepared according to a same two step method.

(1) Preparation of ligand solution:

To the dried ligand sample (H₁L) (0.01 M) was added to 85 ml formic acid till slurry formed. To this slurry water was added until dissolution of sample. The resulting solution was designated as the reagent solution. This reagent solution was used for preparing metal chelate.

Synthesis of metal chelates:

The reagent solution of ligand (0.01 mole) was added drop wise to a solution of metal salt (0.005 mole) in 100 ml. of water with constant stirring. The pH of the resultant solution was maintained at 4.5 by NH₃. A greenish blue solid precipitated out was allowed to settle, further it was digested on water bath at 70 °C for about 2-3 hours. The solid mass was filtered, washed with 1:1 mixture of water - ethanol followed by acetone. The resulting metal chelates in powdered form were dried at 70 °C over a period of 24 hrs.

Measurements:

The elemental contents were determined by Thermo Finigen Flash1101 EA (Italy) the metals were determined volumetrically by Vogel's method [25].

Infrared spectra of the synthesized compounds were recorded on Nicolet 760 FT-IR spectrometer. NMR and CMR spectrum of ligand was recorded on 400 MHz bruker-NMR spectrophotometer.

Magnetic susceptibility measurement of the synthesized complexes was carried out on Gouy Balance at room temperature. Mercury tetrathiocyanatocobalate (II) $\text{Hg}[\text{Co}(\text{NCS})_4]$ was used as a calibrant. The electronic spectra of complexes in solid were recorded on at room temperature. MgO was used as reference.

Antibacterial and Antifungal activity of all the samples was monitored against various strains, following the method reported in literature [26].

Table-2: Analysis of metal chelates

Empirical Formula	Yield (%)	Elemental Analysis							
		C%		H%		N%		M%	
		Cald	Found	Cald	Found	Cald	Found	Cald	Found
$(\text{H}_1\text{L})_2\text{Cu}^{2+}$	68	66.40	66.3	4.01	3.9	15.49	15.4	7.03	7.1
$(\text{H}_1\text{L})_2\text{Co}^{2+}$	61	66.74	66.7	4.03	4.0	15.57	15.5	6.55	6.5
$(\text{H}_1\text{L})_2\text{Mn}^{2+}$	64	67.04	66.9	4.05	4.0	15.64	15.6	6.13	6.1
$(\text{H}_1\text{L})_2\text{Ni}^{2+}$	65	66.76	66.7	4.03	3.9	15.57	15.5	6.52	6.4
$(\text{H}_1\text{L})_2\text{Zn}^{2+}$	58	66.26	66.2	4.00	3.9	15.45	15.4	7.22	7.2

RESULTS AND DISCUSSION

The synthesis of 1-(4-((8-hydroxyquinolin-5-yl)diazanyl)phenyl)-2-(2-methyl-1H-benzo[d]imidazol-1-yl)ethanone (H_1L) was carried out by a simple coupling reaction of diazonium salt of 1-(4-aminophenyl)-2-(2-methyl-1H-benzo[d]imidazol-1-yl)ethanone (AMBE) and 8-hydroxyquinolinol (HQ). The resulted ligand was an amorphous reddish brown powder along with good yield. The C,H,N contents of ligand (**Table-1**) are consistent with the predicted structure (**Scheme-1**). The IR spectrum of ligand comprises the important bands were observed at 1630, 1575 cm^{-1} due to azo groups. The broad band for $-\text{OH}$ is appeared at around 3250 cm^{-1} . Also the bands for aromatic stretching and double conjugate are consist with their predicted structures. NMR spectrum of ligand shows peak at 2.34 ppm and 4.22 for CH_3 and $-\text{OH}$ respectively, rest of the aromatic protons are appeared in multiplicity at 6.8-8.1 δ . Furthermore, all CMR peaks are found at their respective position. Thus the structure of ligand is confirmed as shown in **Scheme-I**. The C,H,N contents and metal content for all metal chelates (**Table-2**) are also consistent with the predicted structure. The results show that the metal: ligand (M:L) ratio for all divalent metal chelate is 1:2.

TABLE-3: Spectral features and magnetic moment of DAPOHQ metal chelates

Metal Chelates	μ_{eff} (BM)	Electronic spectral data (cm^{-1})	Transition
$(\text{H}_1\text{L})_2\text{Cu}^{2+}$	1.92	23441 15870	Charge transfer ${}^2\text{B}_{1g} \rightarrow {}^2\text{A}_{1g}$
$(\text{H}_1\text{L})_2\text{Co}^{2+}$	4.72	24610 18925 8957	${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{2g}(\text{F})$ ${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{2g}$ ${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{2g}(\text{P})$
$(\text{H}_1\text{L})_2\text{Mn}^{2+}$	5.87	24014 18552 16230	${}^6\text{A}_{1g} \rightarrow {}^6\text{A}_{2g}$ ${}^6\text{A}_{1g} \rightarrow {}^4\text{T}_{2g}$ (4G) ${}^6\text{A}_{1g} \rightarrow {}^4\text{T}_{1g}(\text{PG})$
$(\text{H}_1\text{L})_2\text{Ni}^{2+}$	3.32	22589 15358	${}^3\text{A}_{1g} \rightarrow {}^3\text{T}_{1g}(\text{P})$ ${}^3\text{A}_{1g} \rightarrow {}^3\text{T}_{1g}(\text{F})$
$(\text{H}_1\text{L})_2\text{Zn}^{2+}$	Diamag.		-----

TABLE-4: Antibacterial activity of ligand and its metal chelates

Sample	Zone of inhibition (in mm)			
	Gram +ve		Gram -ve	
	<i>Bacillus subtilis</i>	<i>Staphylococcus aureus</i>	<i>Ps. aeruginosa</i>	<i>E. coli</i>
H_1L	19	13	22	13
$(\text{H}_1\text{L})_2\text{Cu}^{2+}$	21	19	25	20
$(\text{H}_1\text{L})_2\text{Co}^{2+}$	05	17	18	19
$(\text{H}_1\text{L})_2\text{Mn}^{2+}$	12	16	16	23
$(\text{H}_1\text{L})_2\text{Ni}^{2+}$	12	19	17	10
$(\text{H}_1\text{L})_2\text{Zn}^{2+}$	20	17	14	16

TABLE-5: Antifungal activity of ligand and its metal chelates

Sample	Zone of inhibition of fungus at 1000 ppm (%)			
	<i>Candida albicans</i>	<i>Fusarium oxysporium</i>	<i>Aspergillus niger</i>	<i>Rhizopus Nigricans</i>
H ₁ L	58	53	62	56
(H ₁ L) ₂ Cu ²⁺	79	76	80	73
(H ₁ L) ₂ Co ²⁺	66	71	74	65
(H ₁ L) ₂ Mn ²⁺	71	64	67	62
(H ₁ L) ₂ Ni ²⁺	62	58	69	64
(H ₁ L) ₂ Zn ²⁺	68	63	71	65

The infrared spectra of suggest the formation of transition metal chelates by the absence of band characteristic of free -OH group of parent H₁L. The other bands are found at the similar positions as appeared in the spectrum of parent- ligand. However, the band due to (M-O) band is found for all metal at their respective position.

Magnetic moments of metal chelates are given in **Table-3**. The electronic spectrum of Cu²⁺ chelates shows two broad bands around 15870 and 23441 cm⁻¹. The first band may be due to a ²B_{1g} → ¹A_{1g} transition, while the second band may be due to charge transfer. This diffusion suggests a distorted octahedral structure for the Cu²⁺ metal chelate. In addition, the higher value of the magnetic moment supports the geometry of Cu²⁺ metal chelate. The Co²⁺ metal chelate diffuse into three absorption bands first at 24610 cm⁻¹, second at 18925 cm⁻¹ and third at 8957 cm⁻¹ which can be assigned as ⁴T_{1g} → ²T_{2g}, ⁴T_{1g} → ⁴T_{1g}(P), ⁴T_{1g}(F) → ⁴T_{2g}(F) transitions, respectively. These absorption bands and the magnetic moment value confirm an octahedral geometry for the Co²⁺ metal chelate [27]. The spectrum of Mn²⁺ polymeric chelate shows three absorption bands at 16230 cm⁻¹, 18552 cm⁻¹ and 24014 cm⁻¹. These bands may be assigned to ⁶A_{1g} → ⁴T_{1g}(PG), ⁶A_{1g} → ⁴T_{2g}(G) and ⁶A_{1g} → ⁶A_{2g} ⁴E_g transitions, respectively. The high intensity of the bands suggests that they may have some charge transfer character. The magnetic moment is found to be lower than normal range. In the absence of low temperature measurement of magnetic moment it is difficult to attach any significance to this. The observed μ_{eff} value 5.87 is consistent with the expected spin only value for Mn²⁺ i.e. 5.92 [27]. In the Ni²⁺ complexes, μ_{eff} values are in the range 3.32 B.M. as expected for six coordinated Ni²⁺ species. Also the reflectance spectra of the this complex display two bands at 15358 cm⁻¹ and 22589 cm⁻¹, assignable to ³A_{1g} → ³T_{1g} (P) and ³A_{1g} → ³T_{1g} (P) respectively. The spectral bands are well within the range observed for octahedral distortion. Zn²⁺ complex is diamagnetic in nature and its electronic spectra do not furnish any characteristic d-d transitions.

The examination of antibacterial and antifungal activity of ligand and its metal chelates (**Table-4 and 5**) reveals that the ligand is moderately toxic against all strains, while all the chelates are more toxic than ligand. The substitution of phenyl rings does not more effect on the activity of chelates. In each series the Cu-chelates have much toxicity. This is expected because the copper salts are mostly used as fungicides. Most of the compounds inhibit the growth of the above organism, which cause decease in many plants.

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