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Microwave Assisted Synthesis, Characterization and Biological Activity of Transition Metal Complexes of Schiff Base Ligand Derived from 2-Amino Benzimidazole with Isophthalaldehyde

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Abstract: ***A rapid, efficient, clean and environmentally synthesis of novel Schiff base ligand was also carried out which gave high in its yield within very short time. Newly synthesized Schiff base ligand by using microwave irradiation of 2-amino benzimidazole and Isophthalaldehyde. The newly synthesized compound has been characterized by elemental analysis, UV, IR, ^{1} H-NMR, LC-MS and Thermal study. This method provides several advantages such as environmental friendliness, simple work-up procedure, short reaction times, non-hazardous and excellent yield of products. The ligand and its metal complexes were screened for antibacterial activity against Staphylococcus Aureus, Escherichia Coli and Salmonella Typhi. The result indicated that the complexes exhibited excellent antibacterial activities.***

Keywords: Microwave irradiation, Schiff base, Metal Complexes, Antibacterial Activity.

I. INTRODUCTION

In recent years microwave-assisted synthesis is a branch of green chemistry. The applications of microwave irradiation are used for carrying out chemical transformations, which are pollution free, co-friendly, low cost and high yields together with simplicity in processing and handling [1-2].Recent advances in technology have now made microwave energy a more efficient means of heating reactions. Chemical transformation that took hours, or even days, to complete their organic reaction can now be accomplished in minutes [3-4]. Microwave irradiation is well known to promote the synthesis of variety of organic and inorganic compounds, where chemical reaction are accelerated because of selective absorption of microwave by polar molecules [5-7].Schiff bases are compounds that are containing azomethine group [-HC=N-] in their structure, formed by irradiation of a dynamic carbonyl compound with a primary amine [8-9]. Schiff bases have also been shown to show a big range of biological activities, including anti-inflammatory, antibacterial, antifungal, anti-proliferative, antimalarial, antiviral, and antipyretic pharmacological activities [10-11]. Azomethine or imine groups can be found in a variety of natural e.g. a cistrocladidine (antimalarial), natural-derived e.g. chitosan (antifungal), and non-natural compounds e.g. N-(Salicylidene)-2-hydroxyaniline (antibacterial). The imines group in such compounds has been shown to be significant to their biological activities [12-13]. Furthermore; the metal complexes of Schiff compounds have been of main attention for a lengthy time due to their capability to join oxygen to redox systems [14-15].In the present paper, we have described the coordination behavior of novel Schiff base derived from microwave irradiation of 2-amino benzimidazole and Isophthalaldehyde. Schiff bases have remarkable property of forming binuclear complexes and serve as excellent chelating ligands [16-19].

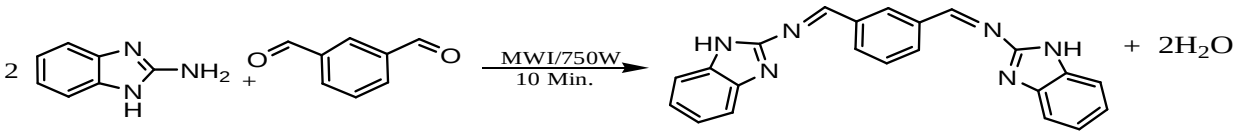
II. EXPERIMENTAL SECTION

A. Material and Method

The chemicals and solvents used in the chemical synthesis of Schiff's base were highest quality and were used without further purification. The entire chemicals were purchased from Sigma-Aldrich, Loba Chem. and Merck. Synthesis of compounds was carried out in microwave oven start E and TLC (Thin layer chromatographic) analyses were done on pre-coated aluminium plates (silica gel 60778, Fluka analytical).The visualization of TLC spots was performed under UV light. Melting points were determined in open capillary tubes on an Electro thermal SMP30 melting point apparatus (Stuart, UK). The 1H-NMR spectra were measured on ultra-shield Bruker 400 spectrometer using TMS as an internal standard. Finally, the infra-red spectra were measured in Varian FT-IR spectrophotometer 660.

B. Microwave Method for the Synthesis of the Schiff base Ligand

A mixture of 2.67gm (0.02mmol) 2-aminobenzimidazole with 1.34gm (0.01mmol) Isophthaladehyde were placed in flask and irradiated in a microwave oven for 10 minutes completion of the reaction was monitored by TLC. The reaction mixture was allowed to attain room temperature, the solid product washed with pet ether and recrystallized from ethanol. Bright yellow crystals obtained. (Yield: 91%).



2-Aminobenzimidazole Isophthalaldehyde

(27E)-N-((3-((Z)-(1H-benzo[d]imidazol-2-ylimino)methyl) phenyl)methylene)-1H-benzo[d]imidazol-2-amine

C. Microwave Method for the Synthesis of Metal Complexes

Schiff base ligand and the metal salts were mixed in a 2:2 (metal: ligand) ratio in grinder. The reaction mixture was then irradiated in a microwave oven 60 Second. The solid complex precipitated was filtered, washed thoroughly with dry ether. The progress of the reaction and purity of the product was monitored by TLC using silica gel G (yield: 84-92%).

III. RESULT AND DISSCUSION

As a result of the study, an efficient, solvent free and microwave assisted synthesis of novel tetra- dentate Schiff base ligand (27E)-N-((3-((Z)-(1H-benzo[d] imidazol-2-ylimino) methyl) phenyl) methylene) -1H-benzo[d] imidazol-2-amine which gives excellent yield with very shorter reaction time. In the microwave method, homogeneity of the reaction mixture was increased by the rotation of reaction platform tray. The conformation of results was also checked by repeating of synthesis process. The Schiff base ligand with metal chloride or metal nitrate salts in 2:2 molar ratio gave 8 complexes. The microwave irradiation method was completed within 30 Sec-10 Minutes and yield 82-95%.The synthesized new metal complexes are coloured, crystalline, non-hygroscopic, and the complexes are insoluble in common organic solvents but soluble in DMSO and DMF.

A. Elemental Analysis

The Elemental analysis and physical properties of novel ligand is summarized in Table I

TABLE I

Molecular Formula	Mol. Wt.	Colour	M.P.℃	Time (Min.)	Yield (%)	(C H N) Elemental Analysis Found (calcd.) %		
						C	H	N
$C_{22}H_{16}N_6$	364	Bright Yellow	82	10	91	65.28 (72.53)	4.54 (4.40)	20.03 (23.07)

B. Physical Properties

The detail of physical properties of the ligand and its complexes are summarized in Table II.

Table II

Sr.No.	Formula of complex	Colour	M.P.℃	Time (Sec.)	Yield %
1	$[Mn_2(C_{22}H_{16}N_6)_2(H_2O)_4]$	Light Green	105	150 Sec	86
2	$[Fe_2(C_{22}H_{16}N_6)_2(H_2O)_4]$	Brown	146	20Sec	88
3	$[Co_2(C_{22}H_{16}N_6)_2(H_2O)_4]$	Dark Brown	120	30 Sec	89
4	$[Ni_2(C_{22}H_{16}N_6)_2(H_2O)_4]$	Light Green	208	40 Sec	95
5	$[Cu_2(C_{22}H_{16}N_6)_2(H_2O)_4]$	Bluish	142	30 Sec	84
6	$[Zn_2(C_{22}H_{16}N_6)_2(H_2O)_4]$	Yellow	109	30 Sec	87
7	$[Cd_2(C_{22}H_{16}N_6)_2(H_2O)_4]$	Dark Yellow	76	60 Sec	94
8	$[Ag_2(C_{22}H_{16}N_6)_2(H_2O)_4]$	Bright Yellow	139	90 Sec	92

C. IR Spectra

The IR spectra of the ligand and Ni (II), Ag(I) Complexes were showed stick bands following table no.3 .The IR spectra of novel ligand showed strong absorption band at 1701 cm^{-1} which was assigned to the azomethine group (C=N). In metal complexes this band undergoes a shift to higher frequencies and observed at (1703- 1720 cm^{-1}) [20-22], it may be due to increasing bond order of the C=N double bond on coordination with the metal ions as a result of electron donating of the other attached groups or due to the strain that occurred on the coordinating site on coordination [23].

The bands observed at 3379 cm^{-1} was assigned (N-H) stretching vibration of benzimidazole moiety. The ligand coordination is substantiated by new band appearing at the ranges (430-474 cm^{-1}) for the complexes, these are mainly attributed to υ (M-N) (Zeyrek *et al*., 2005) [24-26]. The IR spectra of Ni (II) and Ag (I) complexes show a strong band in the 3300-3600 cm^{-1} region, indicating the presence of coordinated water in these complexes [27-28]. The presence of coordinated water was further confirmed by the appearance of a non-ligand band in the 891-896 cm^{-1} region assignable to the rocking mode of water [29-30]. Selected IR frequencies of novel ligand and its metal complexes are summarized in Table III.

TABLE III

Sr. No	Compound	υ (N-H)	υ (C=N)	υ Ar (C=C)	υ (H2O)Molecule	υ (M-N)
1	Schiff base Ligand	3379	1701	1452	-	-
2	Ni (II) Complex	3360	1720	1510	3643,891	430,474
3	Ag (I) Complex	3342	1703	1462	3382,896	439,470

D. NMR Spectra

The ^{1}H-NMR Spectrum for Schiff base ligand in DMSO at room temperature showed the following a peak at 8.14 ppm azomethine (S,1H,-CH=N-), peak at 7.5-7.9 ppm (m,4H aromatic proton),a peak at 6.08 ppm (S,1H, -N-H Benzimidazole ring) [31-34]

E. Mass Spectral Studies

The mass spectrum of the Schiff base ligand showed the molecular ion peak at m/z 365 (M+1) that correspond to the molecular weight of the Schiff base ligand i.e.364.

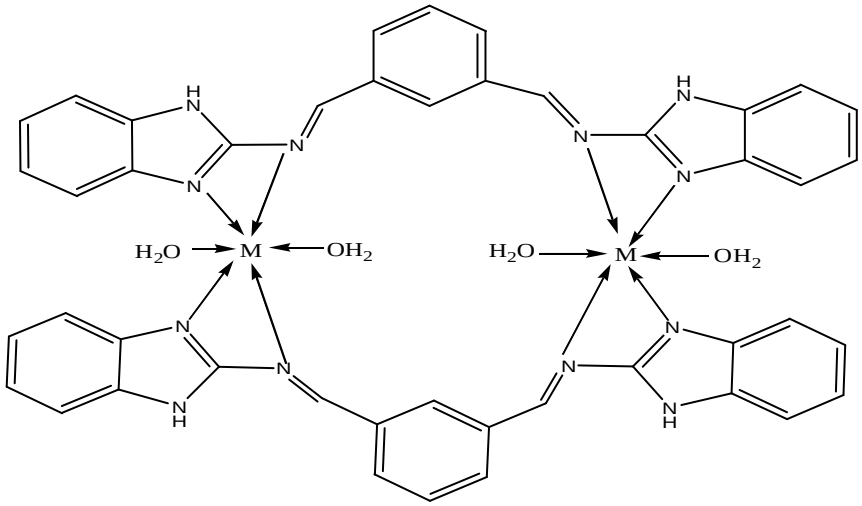
F. Electronic Spectra

The electronic spectral data of transition metal complexes were recorded in DMSO Solvent at room temperature. The band position of absorption band maxima assignment is presented in given below. The Ni (II) complex indicated three transition bands 44445, 48077, 49751 cm-1 corresponding to $^{3}A_2g \rightarrow {}^{3}T_2g$ (F) (υ_1), $^{3}A_2g \rightarrow 3\ T_1g$ (F) (υ_2), $^{3}A_2g \rightarrow {}^{3}T_1g$ (p) (υ_3),transition respectively. This suggests that octahedral geometry of Ni (II) Complex [35-36].

Ag (I) complex showed transition bands 44,445cm^{-1} corresponding to $^{2}Eg \rightarrow {}^{2}T_2g$. The band at 46512 cm^{-1} is due to charge transfer associated to coordination of ligand to Ag (I). This suggests that octahedral geometry of Ag (I) Complex [37-38].Electronic spectral data and geometries of metal complexes are presented in Table IV.

TABLE IV

Sr.No.	Complex	Frequency υ (cm^{-1})	Assignment	Geometry
1	$[Ni_2(C_{22}H_{16}N_6)_2(H_2O)_4]$	44,445 cm^{-1}	$^{3}A_{2g} \rightarrow {}^{3}T_{2g}$ (F) (υ_1)	Octahedral
		48,077 cm^{-1}	$^{3}A_{2g} \rightarrow {}^{3}T_{1g}$ (F) (υ_2	
		49,751 cm^{-1}	$^{3}A_{2g} \rightarrow {}^{3}T_{1g}$ (p) (υ_3)	
2	$[Ag_2(C_{22}H_{16}N_6)_2(H_2O)_4]$	44,445cm^{-1}	$^{2}E_g \rightarrow {}^{2}T_{2g}$	Octahedral
		46,512cm^{-1}	Charge transfer	



The Proposed structure of Schiff base metal complexes of Mn (II),Fe(III),Co(II), Ni(II),Cu(II), Zn(II), Cd (II), Ag(I).

G. Differential Scanning Calorimetry (DSC) analyses of Metal Complexes

The DSC analyses of Ni (II) and Ag (I) metal complexes were conducted from room temperature to 360℃. The DSC curves obtained under dynamic nitrogen atmosphere with flow rate of 80 ml min^{-1} and heating rate of 10 ℃ min^{-1}. The thermal data obtained from the thermogram of each metal complex is summarized in Table V.

The DSC analysis of Ni (II) complex: The Ni (II) complex undergo decomposition in three stages as per the data obtained from thermogram. The peak data may be explained as follows. The first stage occurred in temperature range of 193.94℃ to 206.53 ℃with peak temperature 189.83℃. This corresponds to dehydration process with loss of coordinated water molecules. The second stage occurred in temperature range of 231.04 ℃ to 277.83 ℃ with peak temperature 256.92℃. These endothermic peak values correspond to partial decomposition of the ligand. The third stage occurred in temperature range of 296.060C to 314.12℃ with peak temperature 298.56℃, these endothermic peak values shows decomposition of ligand and formation of Stable NiO. These three peak areas gave value of ΔH = -19.88Joules/g, ΔH= 259.62 Joules/g, ΔH =19.2 Joules/g respectively [39-40].

The DSC analysis of Ag (I) complex: The Ag (I) complex underwent decomposition in three stages as per the data obtained from thermogram. The peak data may be explained as follows. The first stage occurred in temperature range of 159.170C to 190.46 0C with peak temperature 175.57℃. This corresponds to dehydration process with loss of coordinated water molecules. The second stage occurred in temperature range of 224.86℃ to 222.82℃ with peak temperature 207.81℃. These endothermic peak values correspond to partial decomposition of the ligand. The third stage occurred in temperature range of 277.72℃ to 344.320C with peak temperature 319.37℃, these endothermic peak values shows decomposition of ligand and formation of stable AgO. These three peak areas gave value of ΔH = 105.96 Joules/g, ΔH = -8.22 Joules/g, ΔH = 90.00 Joules/g respectively [41].

TABLE V

Complex	Onset Temp.in ℃	Peak Temp.in ℃	End set Temp.in ℃	Transition Enthalpy (ΔH) Joules/g	Sample Mass in mg
$[Ni_2(C_{22}H_{16}N_6)_2(H_2O)_4]$	193.94	189.83	206.53	-19.88J/g	2.20
	231.04	256.92	277.83	259.65J/g	
	296.06	298.56	314.12	19.28J/g	
$[Ag_2(C_{22}H_{16}N_6)_2(H_2O)_4]$	159.17	175.57	190.46	105.96J/g	3.92
	224.86	207.81	222.82	-8.22 J/g	
	277.72	319.37	344.32	90.00J/g	

H. Antimicrobial Activity

The synthesized Schiff base ligands and its metal complexes was shows against selected bacteria Escherichia coli Staphylococcus aureus and Salmonella Typhi were grown overnight at 37 ℃ temperature [42]. Determination of minimum inhibitory concentrations (MIC) by Micro Broth Dilution Method was evaluated against test bacteria for the concentration ranging between 0.4µg/ml to 100µg/ml.DMSO and compared with antibiotics viz. Streptomycin [43- 44].The Synthesized metal complexes of Fe (III), Co(II), Cu(II) and Cd(II) was observed very good activity against Escherichia Coli as compared to novel ligand and Ni (II) Cu(II) and Ag (I) complexes showed excellent activity against Staphylococcus Aureus bacteria as compared to novel ligand, Mn (II) and Zn (II) complex showed excellent activity against Salmonella Typhi bacteria. The novel Schiff base ligand exhibited low bacterial activity as compared to their metal complexes. All metal complexes showed very good antibacterial activity. Antibacterial activity of novel ligand and their metal complexes are summarized in table VI.

TABLE VI

Sr.No.	Compounds	Minimal inhibition Concentration (µg/ml)		
		E.Coli	S.Aureus	S.Typhi
1	Ligand	125	250	500
2	Mn(II) Complex	125	250	50
3	Fe(III)) Complex	100	250	125
4	Co(II)) Complex	100	250	100
5	Ni(II)) Complex	125	100	200
6	Cu(II)) Complex	100	100	250
7	Zn(II)) Complex	250	500	100
8	Cd (II)) Complex	100	125	125
9	Ag (I)) Complex	125	62.5	250

IV. CONCLUSION

In the present work, Microwave synthesis of Novel Schiff base ligand (27E)-N-((3-((Z)-(1H-benzo[d] imidazol-2 ylimino) methyl)phenyl) methylene)-1H-benzo[d] imidazol-2-amine and its metal complexes which gives excellent yield with very shorter reaction time, Microwave assisted synthesis can be used to reduce the time and increase the yield of reaction. In conclusion, we have described here an efficient and environmentally benign synthesis of Schiff base ligands and its metal complexes under microwave irradiation using solvent free. Further, this method is simple, mild and eco-friendly from green chemistry point of view.

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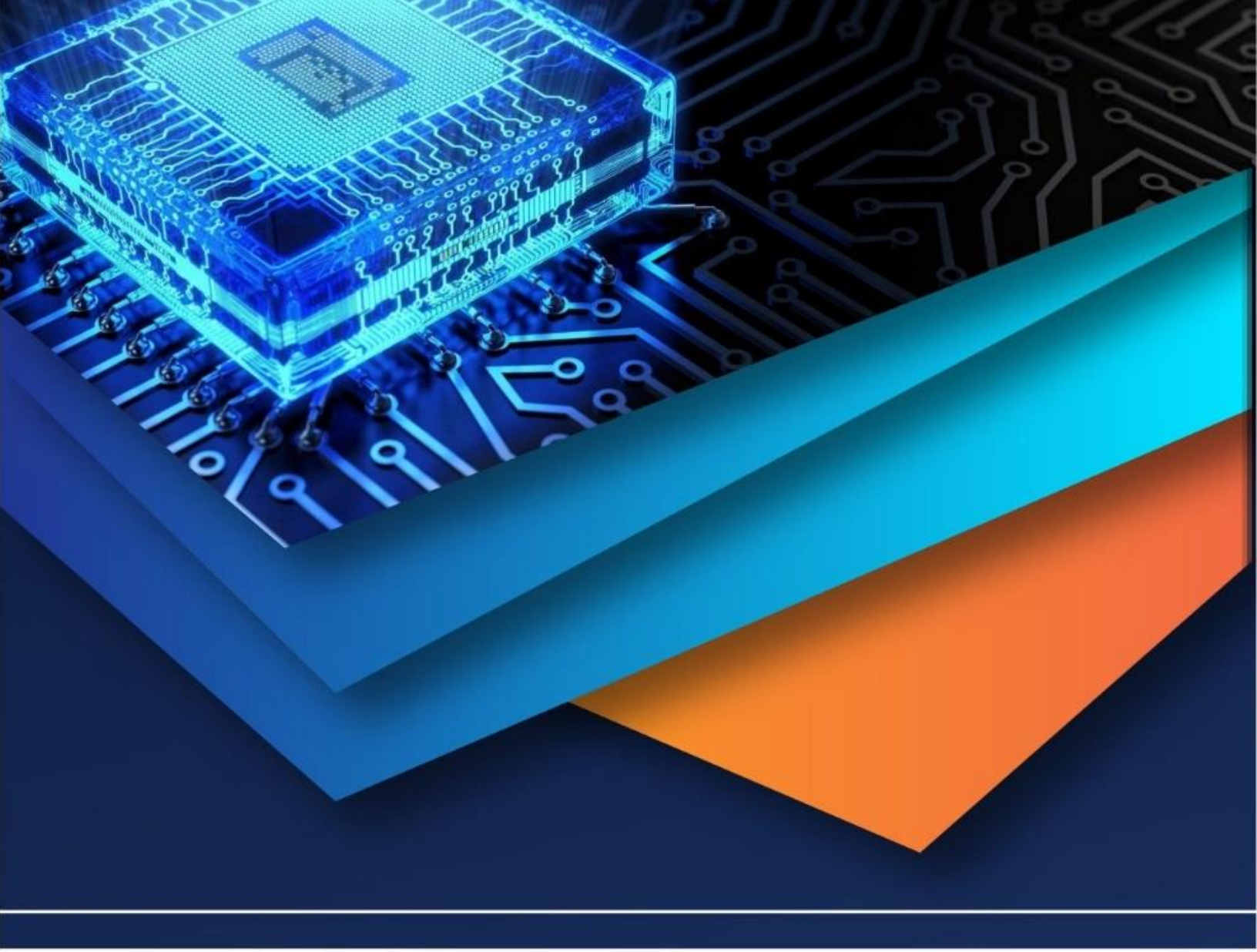

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