

Synthesis, Characterization and Biological Applications of Transition Metal Complexes of [no] Donor Schiff Bases

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Abstract

Ten novel transition metal complexes of N,O donor ligands have been synthesized by the reaction of ligands with metal acetates in 2:1 molar ratio. These reactions were carried out under reflux in methanol for 3-6 hours. The ligands and their transition metal complexes were characterized on the basis of physical properties, elemental analysis, Infrared spectroscopy, Magnetic susceptibility, Ultraviolet and Atomic absorption spectroscopy and ¹H-¹³C NMR spectroscopy. The FT- IR spectra of the complexes indicated that ligands behaved in bidentate manner coordinating via the nitrogen and oxygen. ¹H-NMR and ¹³C-NMR data of the ligands in pure and complex form confirmed the formation of the complexes. Other analytical techniques demonstrated that transition metal complexes of Cu, Ni, Co and Zn are four coordinated and those of Mn are six coordinated. Furthermore, antibacterial activities have been discussed.

Keywords: Transition metal complexes; NO donor schiff bases; Spectral characterization and biological activity

Introduction

The preparation and study of inorganic compounds containing biologically important ligands is made easier, because certain metal ions are active in many biological processes; species of low molecular weight are, hence, sought that reproduce, as far as possible, the structural properties and the reactivity of naturally occurring complexes of these ions in such processes. The fact that copper together with magnesium, calcium, iron, zinc, chromium, vanadium, and manganese are essential metallic elements and display great biological activity when associated with certain metal-protein complexes, participating in oxygen transport, electronic transfer reactions, or the storage of ions [1] has produced enormous curiosity in the study of systems containing these metals [2].

Schiff bases have a vital position in metal coordination chemistry even almost a century since their discovery. Due to their simplicity in preparation, diverse properties, medicinal, biochemical and industrial applications, the keen interest in the study of these compounds arose in the recent years. A number of metal coordination complexes of Schiff bases have been suggested as antibacterial, antifungal, cytotoxic, anti-inflammatory and Cytostatic agents. [3-6] In order to widen the scope of investigations on the coordination behavior of various donor ligands including Schiff base towards organo metallics, we carried out the investigations and established their bioactivities. [3,4,7-10] As an extension of this research, herein, we report the synthesis, characterization and bactericidal activity of some Schiff base metal complexes.

Materials and Instrumentation

All the chemical reagents used were of analytical grade. 2,3-Dihydroxybenzaldehyde, 3-Chloroaniline, 3-Trifluoromethylaniline and metal salts were obtained from Aldrich (U.S.A) chemicals and E.Merck (Germany). All the solvents which were used were of spectroscopic grade and were obtained from E.Merck (Germany) and Fluka Ltd. Melting points were determined in a capillary tube using electrothermal melting point apparatus Mitamura Riken Kogyo (Japan)

model MPD. Infrared spectra were measured as KBr pellets on a FT-IR spectrometer Bio-Rad Excalibur (USA) model FTs 300 MX in a frequency range of 4000-400 cm⁻¹. The electronic absorption spectra of the ligands and complexes were recorded using DMSO as solvent on a UV-visible Spectrophotometer M/s Shimadzu 1600. The elemental analysis was performed on an Elemental analyzer LECO Corporation (USA) CHNS-932. ¹H- NMR and ¹³C-NMR spectrum of ligands and their metal complexes were recorded using a FT-NMR spectrometer Bruker (Germany) 300 MHz.

Synthesis

Synthesis of ligands

The ligands were synthesized by the reported methods [11].

General procedure for synthesis of transition metal complexes

Transition metal complexes were prepared by mixing the corresponding ligands with transition metals Cu(CH₃COO)₂·2H₂O, Co(CH₃COO)₂·4H₂O, Ni(CH₃COO)₂·4H₂O, Mn (CH₃COO)₂·4H₂O and Zn (CH₃COO)₂·2H₂O.

Synthesis

To a solution of HL¹ or HL² in methanol (20 ml) a solution of metal salts in 15 ml methanol in 2:1 molar ratio was added drop wise. The reaction mixture was refluxed for 3-6 hours at 60°C. The precipitates were formed. The product was filtered and washed with commercial

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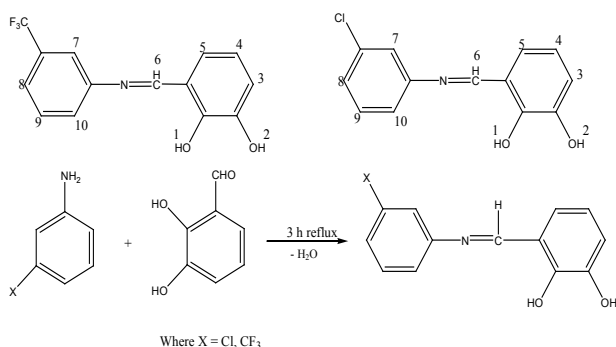
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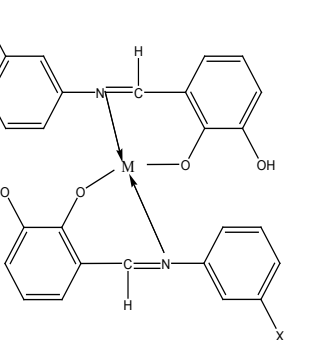
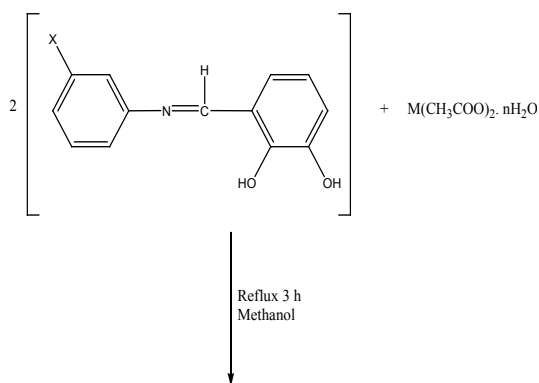
methanol. The resulting product was air dried. Solids products obtained were recrystallized in suitable solvents.

Results and Discussion

The reactions of Schiff bases with transition metal salts were quite facile and were completed in 3 to 8 hours, the water form during the reaction as byproduct was removed using Dean Stark funnel (Scheme 1 and 2).



Scheme 1 Structure of ligands



Scheme 2 Proposed structure of metal complexes

The complexes are air-stable, hygroscopic, with higher melting points, soluble in organic solvents. The results of the elemental analysis and some physical characteristics of the obtained compounds are quite satisfactory (Table 1).

Infrared spectroscopy

The common region for infrared analysis in organo transition chemistry is 4000-200 cm⁻¹. IR spectra of all the compounds have

been recorded using KBr pellets in the range 4000-400 cm⁻¹. The characteristic absorption bands are listed in Table 2. The important absorption frequencies are ν (OH), ν (M-O), ν (M-N) and ν (-C=N).

Assignment of different vibration bands have been made by the comparison of ligand spectra with that of transition metal complexes. In the spectra of the ligands a strong band at 3300 and 3450 cm⁻¹ was assigned to -OH stretching vibration. After complex formation this band was still observed in case of Mn complexes only, supporting the fact that water molecule is present as water of coordination.

A strong band appeared in the range of 1600-1625 cm⁻¹ in the free ligand, was attributed to the -C=N stretching vibration. In complexes the -C=N stretching vibration shifted to lower frequencies as compared to the free ligand. This shift indicated donation of the nitrogen lone pair of electron of the azomethine group to the metal atom [3,12].

In the low frequency region, the band observed in the complexes in the region of 500-550 cm⁻¹ and 400-470cm⁻¹ is attributed to (M-N) and ν (M-O) respectively [7]. The IR data suggested that the metal was bonded to the Schiff base (Table 2).

UV-Visible spectroscopy

UV-Visible studies were made in DMSO. From the values of λ_{\max} obtained it was found that $n \rightarrow \pi^*$ and $\pi \rightarrow \pi^*$ transitions are observed which are due to chromophoric groups (imine and aromatic ring) in the ligands. The spectra of the complexes showed red shift. All solutions were of 10⁻⁴ molar concentration; due to this dilute concentration no d-d transitions were observed [13]. The obtained values were compared to literature values and it was found that values for copper, nickel and cobalt were close to the values for four coordinated systems and for manganese the values were in the range of six coordinated system (Table 3).

Magnetic susceptibility

Magnetic susceptibility is quite useful technique for determining unpaired electrons in paramagnetic complexes which in turns help in suggesting structure of the complexes and the nature of ligand. Ligands were strong field ligands and this fact was supported by magnetic moment values for metals. The values indicated that ligand was strong field ligand as all electrons in nickel have been paired up. Value of magnetic moment for nickel is 0.72 B.M which indicated that there was no unpaired electron left after complex formation. Value should be higher if the electrons were unpaired. For other metals like copper, cobalt and manganese the values were in the range of 1.59-1.72 which was close to literature value for one unpaired electron [14]. So it was taken as evidence that all metals were in +2 oxidation state (Table 4).

Multinuclear NMR

H-NMR Data: ¹H-NMR spectra of all compounds had been recorded on 300 MHz NMR spectrometer. The characteristic resonance peaks in the ¹H NMR spectra of ligand were recorded in CDCl₃ and its metal complexes in DMSO. The expected resonance was assigned by intensity pattern and integration. The integration of spectra showed good agreement with the composition of the compounds. In both ligand (HL¹, HL²) hydroxyl proton showed signal at 13.23 ppm and 12.31 ppm respectively. These signals disappeared in all complexes due to the deprotonation of OH [15,16]. Both ligands HL¹, HL² showed a simple pattern for aromatic protons which is due to presence of only

Comp. No	Empirical formula (formula weight)	M.P. °C	Yield (%)	Colour	%C Calc. (Found)	%H Calc. (Found)	%N Calc. (Found)	%M Calc. (Found)
1	C ₁₄ H ₁₀ NO ₂ F ₃ (281)	134	87	Orange	57.78 (58.88)	2.95 (3.03)	4.48 (4.59)	—
2	C ₂₈ H ₁₈ N ₂ O ₄ F ₆ ·Cu(623)	>300	78	Green	53.51 (53.88)	2.75 (2.98)	4.38 (4.49)	9.77 (10.02)
3	C ₂₈ H ₁₈ N ₂ O ₄ F ₆ ·Co(618)	>310	81	Dark brown	53.30 (54.30)	2.35 (2.93)	4.27 (4.54)	8.91 (9.14)
4	C ₂₈ H ₁₈ N ₂ O ₄ F ₆ ·Ni(618)	>300	76	Dark brown	53.83 (54.20)	2.32 (2.90)	4.44 (4.52)	8.86 (9.03)
5	C ₂₈ H ₁₈ N ₂ O ₄ F ₆ ·Zn(625)	>320	65	Dark Mahron	52.91 (53.72)	2.77 (2.87)	4.23 (4.47)	8.67 (9.96)
6	C ₂₈ H ₁₈ N ₂ O ₄ F ₆ Mn·2H ₂ O(653)	>300	70	Light Mahron	51.42 (51.62)	3.23 (3.37)	4.08 (4.30)	7.56 (7.99)
7	C ₁₃ H ₁₀ ClNO ₂ (247)	145	85	Pinkish red	63.03 (62.56)	3.82 (3.91)	4.90 (5.03)	—
8	C ₂₆ H ₁₈ N ₂ O ₂ Cl ₂ ·Cu(556)	>300	78	Brown	55.06 (55.66)	2.93 (3.04)	4.83 (4.94)	10.80 (11.02)
9	C ₂₆ H ₁₈ N ₂ O ₂ Cl ₂ ·Co(551)	>310	81	Dark red	53.30 (54.30)	2.35 (2.93)	4.27 (4.54)	10.67 (10.88)
10	C ₂₆ H ₁₈ N ₂ O ₂ Cl ₂ ·Ni(551)	>300	76	Reddish	54.57 (55.03)	3.29 (3.44)	4.55 (4.60)	9.63 (10.03)
11	C ₂₆ H ₁₈ N ₂ O ₂ Cl ₂ ·Zn(558)	>330	65	Red	56.05 (56.39)	3.04 (3.13)	4.86 (4.93)	10.70 (10.96)
12	C ₂₆ H ₁₈ N ₂ O ₂ Cl ₂ ·Mn·2H ₂ O(587)	>330	70	Brick red	52.42 (52.62)	3.29 (3.37)	4.22 (4.30)	9.40 (9.89)

*In all other tables the formulation and number of the compounds are the same as given in this table.

Table1. Physical data of the ligands and their metal complexes

Codes	v O-H	v C=N	v M-O	v M-N
(1)	3316	1619	-	-
(2)	3404	1604	430	539
(3)	3430	1591	415	518
(4)	3455	1596	434	535
(5)	3435	1601	413	536
(6)	3440	1589	469	531
(7)	3439	1621	-	-
(8)	3343	1602	417	544
(9)	3440	1601	414	528
(10)	3415	1596	418	534
(11)	3428	1584	416	533
(12)	3413	1585	416	534

Table 2: Infrared spectra of the ligands and metal complexes.

Compound	Wavelength (λ)	Absorption (A)	Type of transitions
(1)	354, 230	1.50, 0.50	n-π* and π-π*
(2)	440,234	1.67, 0.55	n-π* and - π*
(3)	477,236	1.75, 0.751	n-π* and π- π*
(4)	412,265	1.65, 0.67	n-π* and - π*
(5)	383,245	1.57, 0.852	n-π* and π- π*
(6)	404,247	1.64, 0.573	n-π* and π- π*
(7)	365,276	1.571,0.541	n-π* and π- π*
(8)	450,260	1.75, 0.511	n-π* and π- π*
(9)	414,287	1.62, 0.43	n-π* and - π*
(10)	386,290	1.58, 0.47	n-π* and - π*
(11)	411,276	1.60, 0.852	n-π* and π- π*
(12)	432,268	1.73, 0.573	n-π* and π- π*

Table 3: UV spectral data of ligands and its Synthesized Transition Metal Complexes.

Codes	μ (B.M) (Found)	μ (B.M) (Literature values)	Unpaired electrons
(2)	1.60	1.73	1
(3)	1.67	1.73	1
(4)	0.72	-	0
(6)	1.59	1.73	1
(8)	1.63	1.73	1
(9)	1.70	1.73	1
(10)	0.41	-	0
(12)	1.61	1.73	1

Table 4: Magnetic susceptibility of Synthesized Transition Metal Complexes.

H-NO	(1)	(5)	(7)	(11)
1	13.23(s)[2H]	-	12.31(s)[2H]	-
2	13.23(s)[2H]	12.67(s)[2H]	12.31(s)[2H]	12.75(s)[2H]
3	6.87-7.58(m)[7H]	6.90-7.78(m)[14H]	6.60-7.7.80(m)[7H]	6.80-7.54(m)[14H]
4	6.87-7.58(m)[7H]	6.90-7.78(m)[14H]	6.60-7.7.80(m)[7H]	6.80-7.54(m)[14H]
5	6.87-7.58(m)[7H]	6.90-7.78(m)[14H]	6.60-7.7.80(m)[7H]	6.80-7.54(m)[14H]
6	8.63(s)[1H]	8.99(s)[2H]	8.86(s)[1H]	8.94(s)[2H]
7	6.87-7.58(m)[7H]	6.90-7.78(m)[14H]	6.60-7.80(m)[7H]	6.80-7.54(m)[14H]
8	6.87-7.58(m)[7H]	6.90-7.78(m)[14H]	6.60-7.80(m)[7H]	6.80-7.54(m)[14H]
9	6.87-7.58(m)[7H]	6.90-7.78(m)[14H]	6.60-7.80(m)[7H]	6.80-7.54(m)[14H]
10	6.87-7.58(m)[7H]	6.90-7.78(m)[14H]	6.60-7.80(m)[7H]	6.80-7.54(m)[14H]

Table 5: ¹H NMR spectral data of ligands and its Synthesized Transition Metal Complexes.

C.NO	(1)	(5)	(7)	(11)
C1	148.57	149.51	148.93	149.66
C2	145.04	145.81	145.07	146.10
C3	118.43	118.43	118.23	119.39
C4	123.40	123.41	121.25	121.39
C5	123.50	123.55	123.29	123.38
C6	119.51	119.85	118.39	119.80
C7	164.00	166.21	163.45	164.72
C8	148.73	149.83	149.17	150.85
C9	121.99	122.66	119.63	120.17
C10	132.20	131.35	135.15	134.34
C11	123.55	123.40	127.02	126.96
C12	131.33	131.35	130.52	130.80
C13	130.11	130.92	119.38	119.59
C14	123.86	123.92	-	-

Table 6: ¹³C NMR spectral data of ligands and its Synthesized Transition Metal Complexes.

seven protons in this region. These protons do not show any significant change. As ligand to metal ratio was 2:1, therefore, signals for 14 protons were observed after complex formation. The azomethanic protons of the ligands gave signal at 8.63 and 8.86 for HL¹ and HL² respectively. The downfield shift of both the signals to 8.99 and 8.94 suggests the bonding of N to the metal (Table 5).

C NMR Data: The ¹³C NMR spectral data of ligand and its metal complexes were recorded in DMSO. The C1 attached to OH group shifted to a lower field region in complexes, indicating participation

of the C-O group in coordination to transition metal to form C-O-M bonds. The resonances due to the aromatic C-atoms did not shift significantly on bonding to transition metals. The azomethinic C-7 showed a down field shift due to shifting of electron density from nitrogen to metal supporting the formation of N-M bond (Table 6).

Biological activity

The antibacterial activity of Schiff base and metal complexes against *Staphylococcus aureus* strain was screened using agar well

Compound Codes	Zone of Inhibition (mm)	Zone of inhibition of Std. drug, mm
1	22.87	26
2	10.13	26
4	11.01	26
6	16.55	26
7	17.04	26
10	20.54	26
11	12.11	26

Table 7: Anti Bacterial activity of ligands and Metal Complexes.

diffusion method [17]. Imipenem was used as standard drug. The inhibition zones were measured in mm. The zone of inhibition of std. drug was 26 mm. The size of well was 6 mm (diameter) std. and wells were supplemented with DMSO and reference antibacterial drugs. The concentration of test sample was 1 mg/ml of DMSO. The plates were incubated at 37°C for 24 hrs. The result indicated that both ligands showed significant activity. Whereas, Mn complex of HL¹ and Ni complex of HL² showed significant activity against standard drug (Table 7).

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References

1. Albertin G, Bordignon E, Orio A (1975) Five-coordinate copper (II) complexes. Synthesis and properties of [Cu(tren)L]²⁺ cations. *Inorg Chem* 14: 1411-1413.
2. Karlin KD, Zubieta J (1983) *Copper Coordination Chemistry: Biochemical and Inorganic Perspectives*, New York.
3. Rehman W, Badshah A, Khan S, Tuyet LTA (2009) Synthesis, characterization, antimicrobial and antitumor screening of some diorganotin(IV) complexes of 2-[(9H-Purin-6-ylimino)]-phenol. *Eur J Med Chem* 44: 3981-3985.
4. Rehman W, Baloch MK, Badshah A (2008) Synthesis, spectral characterization and bio-analysis of some organotin(IV) complexes *Eur J Med Chem* 43: 2380-2385.
5. Rosu T, Gulea A, Nicolae A, Georgescu R (2007) Complexes of 3d(n) metal ions with thiosemicarbazones: synthesis and antimicrobial activity. *Molecules* 12: 782-796.
6. Che C, Huang JS (2003) Metal complexes of chiral binaphthyl Schiff-base ligands and their application in stereoselective organic transformations. *Coord Chem Rev* 242: 97-113.
7. Rehman W, Saman F, Ahmad I (2008) Synthesis, Characterization, and Biological Study of Some Biologically Potent Schiff Base Transition Metal Complexes. *Russ J Coord Chem* 34: 678-682.
8. Rehman W, Muhammad B, Ali F, Atif S (2008) Syntheses, Spectral Studies and Bioanalyses of Some Triorganotin(IV) Complexes of Cephalexin. *Chinese J Struct Chem* 27: 846-852.
9. Rehman W, Badshah A, Khan S, Ahmad I (2009) Synthesis, Structural Investigations and Biological Screening of Diorganotin(IV) Complexes Derived from 5,5-Diethyl Sodium Barbitol. *Chinese J Struct Chem* 28: 419-426.
10. Rehman W, Rehman S, Muhammad B, Shah ST, Tauseef I, et al. (2009) Synthesis, Characterization and Anti-inflammatory Activity of Some Organotin(IV) Complexes. *Polish J Chem* 83: 2043-2049.
11. Shuja S, Ali S, Meetsma A, Broker GA, Tiekink ERT (2007) 3-[3-(Trifluoromethyl) phenyliminomethyl] benzene-1,2-diol. *Acta Cryst E* 63: o1781- o1782.
12. Sandhu GK, Kaur G (1990) Preparation, IR and ¹H NMR spectral studies of triorganotin(IV) complexes of *N*-benzoylglycine and *N*-benzoylglycylglycine. *J Organomet Chem* 388: 63-70.
13. Bagihalli GB, Patil SA (2010) Synthesis, physico-chemical investigations, and in vitro microbial, studies of VO(IV) complexes with novel ONON donor Schiff bases. *Main Group Chemistry* 8: 71-88.
14. Lebl T, Holecek J, Lycka A (1996) Infrared and ¹³C ¹⁵N and ¹¹⁹Sn NMR Spectral Studies of Some Tri- and Diorganotin (IV) Pyridinecarboxylates. *Sci pap Uni perducice* 2: 5-23.
15. Selvakumar PM, Suresh E, Subramanian PS (2007) Synthesis, spectral characterization and structural investigation on some 4-aminoantipyrine containing Schiff base Cu(II) complexes and their molecular association. *Polyhedron* 26: 749-756.
16. Stefano RD, Scopelliti M, Pellerito S, Fiore T, Vitturi R, et al. (2002) Organometallic complexes with biological molecules: XVII. Triorganotin(IV) complexes with amoxicillin and ampicillin. *J Inorg Biochem* 89: 279-292.
17. Rahman A, Choudhary MI, Thomsen WJ (2001) *Bio-assay Techniques for Drug Development*. Amsterdam: Harward Academic Press.