



ISSN Print: 2394-7500
 ISSN Online: 2394-5869
 Impact Factor: 5.2
 IJAR 2020; 6(9): 35-38
www.allresearchjournal.com
 Received: 25-07-2020
 Accepted: 30-08-2020

Dr. Santosh Upadhyay
 R.S. Chemistry Department,
 BRABU, Muzaffarpur, Bihar,
 India

Syntheses, spectral characterization of Ni ions with Schiff base containing aliphatic and aromatic hydrazide moieties

Dr. Santosh Upadhyay

Abstract

C₂H₅OH solution of 3-ketobutanehydrazide and salicylhydrazide in equimolar ratio forms the corresponding Schiff base LH₃ and reacts with Ni(II) ions to forms [Ni(LH)(MeOH)₃].

Keywords: Syntheses, spectral characterization, Ni ions, aromatic hydrazide moieties

Introduction

Aroyl hydrazones and their coordination compounds are known to possess the biological activities and inhibit many enzymatic reactions in the cell. Owing to their biological activities such as antifungal, antibacterial, antimycobacterial, antitumor, anti inflammatory, anti-HIV, leishmanicidal, trypanocidal, inhibitor of anthrax lethal factor, antidiabetic, antimalarial, and antipyretic, there has been an increasing interest towards the studies of the coordination compounds of the Schiff bases containing the hydrazone moiety during the past few decades [1-12]. The coordination compounds containing hydrazone moiety have been reported to act as analytical reagents, such as polymer coatings, fluorescent materials [13, 14], enzymes inhibitors, antifungal/antibacterial agents [15, 16], and corrosion inhibitors [17]. A perusal of the literature reveals that much work has been carried out towards the coordination compounds of Schiff bases containing salicylhydrazide moiety [18-27]; however, no work seems to be reported on the coordination compounds of Schiff base derived from 3-ketobutanehydrazide and salicylhydrazide. Novel noncytotoxic salicylhydrazide-containing 1N inhibitors have been developed through substructure database search methods [28]. The developmental progress of the salicylhydrazide class of 1N inhibitors was halted due to cytotoxicity issues. The salicyloylhydrazide moiety has been reported to be the minimally required substructure for 1N inhibitory potency of the compounds [29]. The salicylhydrazides have also been proposed to inhibit 1N catalytic activity through chelation of the active site Mg²⁺, and they exhibit cytotoxicity in the nano molar range. The replacement of one of the two phenols in N, N-bis-salicylhydrazide with an optimally substituted heterocyclic group (heavily substituted triazole groups) renders a novel class of noncytotoxic salicylhydrazides, greatly enhancing the therapeutic potential of this class of 1N inhibitors. Keeping in view the above importance of the compounds possessing hydrazone moiety, we thought it worthwhile to synthesize and characterize the Schiff base, LH₃ (1) with Ni(II), ions.

Experimental

Materials: Nickel (II) acetate tetrahydrate, ethyl acetoacetate, methyl salicylate [Loba Chemie], hydrazine hydrate [Fisher Scientific], ammonium molybdate tetrahydrate, hexadecaqua octahydroxotetrazirconium(IV) chloride [BDH], DMSO, DMF, MeOH, EtOH, 1,4-dioxane, and THF [Ranbaxy] were used as received for the syntheses. Bis (acetylacetonato) dioxomolybdenum(VI) and hexadecaqua octahydroxotetrazirconium (IV) acetate were synthesized according to the literature procedures [30, 31].

Analytical and Physical Measurements: The estimation of metal contents, spectral studies (IR, reflectance, ¹H NMR, ESR), and the magnetic susceptibility measurements were carried out by the methods reported earlier [32]. The melting points of the compounds were

Corresponding Author:
Dr. Santosh Upadhyay
 R.S. Chemistry Department,
 BRABU, Muzaffarpur, Bihar,
 India

determined on digital melting point apparatus (Stuart SMP-40). For the purification of KBHz, SHz and chromatographic separations were carried out using silica gel columns (160–200 mesh) of varying length. Thin-layer chromatography (TLC) was performed on commercial Merck plates coated with a 0.20mm layer of silica gel. The molar conductances of the coordination compounds in DMSO were carried out using Toshniwal conductivity bridge (Model CL01-02A) and a dip type cell calibrated with KCl solution. Carbon, hydrogen, and nitrogen contents of the compounds were determined on a FLASHEA1112 CHNS (O) analyzer. The IR spectra of complexes were recorded in KBr (4000–250 cm^{-1}) on a Fourier Transform Infrared spectrometer (Model RZX, Perkin Elmer). The reflectance spectra were recorded on a Hitachi-330UV-vis-NIR spectrophotometer. ^1H NMR spectra of 3-ketobutanehydrazide and complex compound were recorded on an Avance-II (Bruker) FT NMR spectrometer at 400MHz using DMSO as a solvent and TMS as an internal standard.

Synthesis and Characterization

Synthesis of 3-Ketobutanehydrazide (KBHz) Hydrazine hydrate (4.50 g, 100mmol) was added slowly with continuous stirring to an ice-cooled EtOH solution (30mL) of ethyl acetoacetate (15.0 g, 100mmol) during a period of 0.5 h. The reaction mixture was refluxed on a water bath for 2 h. The white compound separated out was suction filtered, washed with EtOH and recrystallised from EtOH, and dried in vacuo over silica gel at room temperature. The progress of the reaction was monitored on TLC using hexane and Et₂O (1: 1 v/v) as eluent. Color: white. M. p. = 186°C. Yield: 10.5 g (90%). Anal. Calcd. for C₄H₈N₂O₂: C, 41.30; H, 6.91; N, 24.05; Found: C, 41.25; H, 6.95; N, 24.15. IR bands (cm^{-1}): 3299 $\nu(\text{OH})$ (intramolecular H-bond), 2898 $\nu(\text{N-H})$ (intramolecular H-bond), 1678 $\nu(\text{C=O})$ (keto), 1619 $\delta(\text{NH}_2)$, and 1042 $\nu(\text{N-N})$ (hydrazide). ^1H NMR (400MHz; DMSO-d₆; δ , ppm): 1.28 (s, 3H, -CH₃), 2.59 (s, 2H, -CH₂), 5.25 (br, 2H, -NH₂) and 7.80 (br, 1H, -CONH).

Synthesis of 1. 3-Ketobutanehydrazide (11.8 g, 100 mmol) and salicylhydrazide (15.0 g, 100mmol) were refluxed in EtOH (50 mL) on a water bath for 2 h. The excess of solvent was distilled off, and the yellow compound separated out was allowed to stand at room temperature. The compound was suction filtered, washed with EtOH and recrystallized from EtOH, and dried as mentioned above. The progress of the reaction was monitored on TLC using hexane and Et₂O (1 :1v/v) as eluent. Color: yellow. M. p. = 108°C. Yield: 22.8 g (90%). Anal. Calcd. for C₁₁H₁₄N₄O₃: C, 52.0; H, 5.65; N, 22.30; Found: C, 52.70; H, 5.70; N, 22.45. IR bands (cm^{-1}): 3267 $\nu(\text{OH})$ (intramolecular H-bond), 2720 $\nu(\text{N-H})$ (intramolecular H-bond), 1618 $\nu(\text{C=N})$ (azomethine), 1533 $\nu(\text{C-O})$, 1238 $\nu(\text{C-O})$ (enol) and 1013

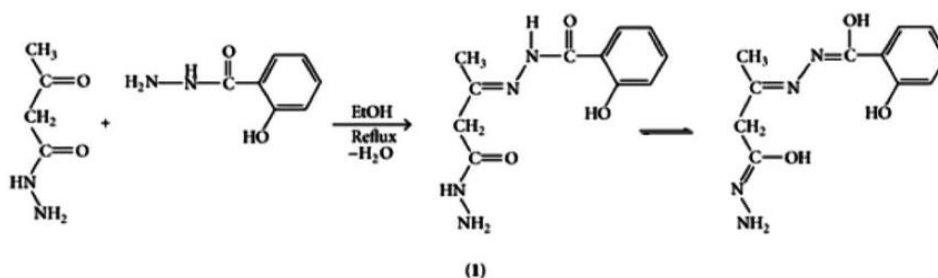
$\nu(\text{N-N})$. ^1H NMR (400MHz; DMSO-d₆; δ , ppm): 2.14 (s, 3H, -CH₃), 2.56 (s, 2H, -CH₂), 5.24 (d, 2H, -NH₂), 6.84–7.80 (m, 4H, -ArH), 8.0 (s, 1H, -N=COH) (adjacent to aliphatic moiety), 9.9 (br, 1H, -OH) (phenolic), 12.25 (s, 1H, -N=COH) (adjacent to aromatic moiety).

Results and Discussion

The nucleophilic addition reaction between 3-ketobutanehydrazide and salicylhydrazide in equimolar ratio in EtOH followed by the elimination of one water molecule results in the formation of the Schiff base, LH3 (1) (Scheme 1). A MeOH solution of 1 reacts with a MeOH solution of Ni(II), ions and forms the corresponding coordination compounds, 2–7 (Scheme 2). The coordination compounds are insoluble in H₂O, EtOH, dioxane, and THF, but they were soluble in DMF and DMSO. Their molar conductance data (3.5–11.8 $\Omega^{-1} \text{cm}^2 \text{mol}^{-1}$ in DMSO) reveal their non electrolytic nature. They are stable up to 250°C and get decomposed above this temperature. Attempts to obtain single crystal suitable for X-ray determination were unsuccessful. The structures of the synthesized ligand and metal complexes (Schemes 1 and 2) were established with the help of elemental analyses data, IR and NMR spectra.

Infrared Spectral Studies: The IR spectra of KBHz and compound 1 were recorded in KBr. The $\nu(\text{C=N})$ (azomethine) stretch of 1 shifts to lower energy by 7–24 cm^{-1} indicating coordination through its azomethine N atom [38]. The $\nu(\text{C-O})$ stretch of 1 occurring at 1532 cm^{-1} remains unaltered indicating the noninvolvement of phenolic O atom towards coordination [39]. The $\nu(\text{C-O})$ (enolic) stretch of the Schiff base shifts from 1238 cm^{-1} to higher energy by 8–18 cm^{-1} in Ni coordination through its enolic O atom [39]. Thus, 1 behaves as a dibasic tridentate ONO donor ligand in Ni coordinating through its azomethine N and both enolic O atoms. The involvement of enolic O and azomethine N atoms towards coordination is further supported by the appearance of new nonligand bands between 570–590 and 478–480 cm^{-1} due to the $\nu(\text{M-O})$ and $\nu(\text{M-N})$ vibrations in Ni complexes. These bands are in the expected order of increasing energy: $\nu(\text{M-N}) < \nu(\text{M-O})$ [40] as expected due to the greater dipole moment change in the M–O vibration, greater electronegativity of the O atom than N atom, and shorter M–O bond length than the M–N bond length [41].

Reflectance Spectral Studies: Ni shows three bands at 9250, 15360, and 24095 cm^{-1} due to the $^3\text{A}_{2g}(\text{F}) \rightarrow ^3\text{T}_{2g}(\text{F})$ (ν_1), $^3\text{A}_{2g}(\text{F}) \rightarrow ^3\text{T}_{1g}(\text{F})$ (ν_2) and $^3\text{A}_{2g}(\text{F}) \rightarrow ^3\text{T}_{1g}(\text{P})$ (ν_3) transitions, respectively, suggesting an octahedral geometry around the metal ion [46]. Using the free ion value of $B = 1030 \text{cm}^{-1}$, the values of spectral parameters in Ni are as follows: $10Dq = 9252 \text{cm}^{-1}$, $B = 743.64 \text{cm}^{-1}$, $\beta = 0.72$, $\beta^0 = 29\%$ and $\text{CFSE} = -132.79 \text{kJmol}^{-1}$



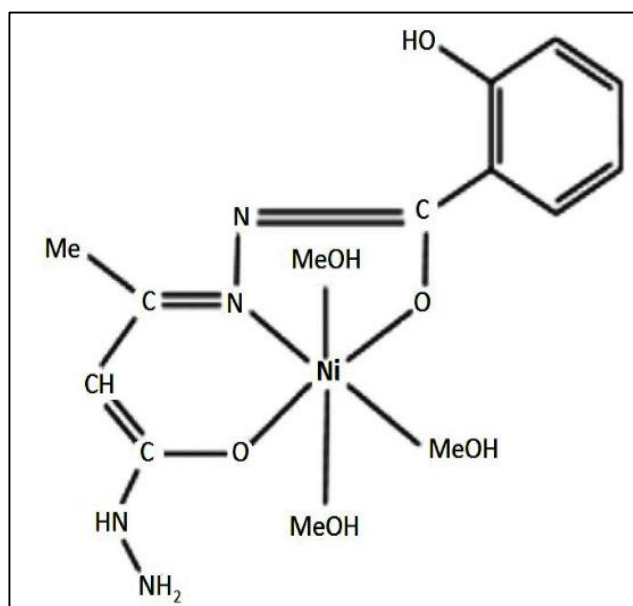
Scheme 1



¹H NMR Studies: The ¹H NMR spectra of KBHz, 1 and 4–7 were recorded in DMSO-d₆. The chemical shifts (δ) are expressed in ppm downfield from TMS [47]. The Schiff base (1) exhibits a singlet at δ 2.14 ppm due to the methyl protons, a singlet at δ 2.56 ppm due to the methylene proton, a doublet at δ 5.24 ppm due to the –NH₂ protons, a broad signal at δ 9.87 ppm due to the phenolic proton, a multiplet at δ 6.84–7.80 ppm due to the aromatic protons, a singlet at δ 8.01 ppm due to –N=COH (adjacent to aliphatic moiety) proton, and a singlet at δ 12.24 ppm due to –N=COH (adjacent to aromatic moiety) proton. The absence of the resonance signals at δ 8.01 ppm and δ 12.24 ppm due to the enolic protons (adjacent to aliphatic and aromatic moieties resp.) in 4–7 indicates the deprotonation of the enolic protons followed by the involvement of both enolic O atoms towards coordination.

Magnetic Measurements

The magnetic moments of Ni is 3.17 B.M. This value lie in the normal range reported for the majority of magnetically dilute octahedral compound of Ni(II) ions [46].



Scheme 2

Conclusions

On the basis of the analytical data, valence requirements, conductance, spectral studies, and magnetic susceptibility measurements, it is proposed that 1 acts as a monobasic tridentate ONO donor ligand in Ni coordinating through its azomethine N and both enolic O atoms which is paramagnetic.

References

1. Shah S, Vyas R, Mehta RH. "Synthesis, characterization and antibacterial activities of some new Schiff base compounds," *Journal of Indian Chemical Society*. 1992; 69(9):590-596.
2. Pandeya SN, Sriram D, Nath G, Clercq ED. "Synthesis, antibacterial, antifungal and anti-HIV activities of Schiff and Mannich bases derived from isatin derivatives and N-[4-(4-chlorophenyl)thiazol-2-yl]

- thiosemicarbazide," *European Journal of Pharmaceutical Sciences*. 1999; 9(1):25-31
3. More PG, Bhavankar RB, Patter SC. "Synthesis and biological activity of Schiff bases of aminothiazoles," *Journal of Indian Chemical Society*. 2001; 78(9):474-475,
4. Leite ACL, de Lima RS, Moreira DR *et al.*, "Synthesis, docking and in vitro activity of thiosemicarbazones, aminoacylthiosemicarbazides and acyl-thiazolidone against *Trypanosoma cruzi*," *Bioorganic Medicinal Chemistry*. 2006; 14(11):3749-3757
5. Smalley TL, Peat AJ, Boucheron JA *et al.*, "Synthesis and evaluation of novel heterocyclic inhibitors of GSK-3," *Bioorganic Medicinal Chemistry Letters*. 2006; 16(8):2091-2094.
6. Gemma S, Kukreja G, Fattorusso C *et al.*, "Synthesis of N1-arylidene-N2-quinolyl-and N2-acrydinylhydrazones as potent antimalarial agents active against CQ-resistant *P. falciparum* strains," *Bioorganic Medicinal Chemistry Letters*. 2006; 16:5384-5388,
7. Nayyar A, Monga V, Malde A, Coutinho E, Jain R. "Synthesis, anti-tuberculosis activity and 3D-QSAR study of 4-(adamantan-1-yl)-2-substituted quinolines," *Bioorganic Medicinal Chemistry*. 2007; 15(2):626-640.
8. Hanna ML, Tarasow TM, Perkins J. "Mechanistic differences between in vitro assays for hydrazone-based small molecule inhibitors of anthrax lethal factor," *Bioorganic Medicinal Chemistry*. 2007; 35(1):50-58,
9. Visbal G, Marchan E, Maldonado A, Simoni Z, Navarro M. "Synthesis and characterization of platinum-sterol hydrazone complexes with biological activity against *Leishmania (L.) Mexicana*," *Journal of Inorganic Biochemistry*. 2008; 102(3):547-554,
10. Kumar P, Narasimhan B, Sharma D, Judge V, Narang R. "Hansch analysis of substituted benzoic acid benzylidene/furan-2-yl-methylene hydrazides as antimicrobial agents," *European Journal of Medicinal Chemistry*. 2009; 44:1853-1863,
11. Kumar D, Judge V, Narang R *et al.*, "Benzylidene/2-chlorobenzylidene hydrazides: synthesis, antimicrobial activity, QSAR studies and antiviral evaluation," *European Journal of Medicinal Chemistry*. 2010; 45:2806-2816,
12. Yaul GAR, Dhande VV, Bhadange SG, Aswar AS. "Synthesis, structural studies and biological activity of dioxomolybdenum (VI), dioxotungsten (VI), thorium(IV) and dioxouranium (VI) complexes with 2-hydroxy-5-methyl and 2-hydroxy-5-chloroacetophenone benzoylhydrazone," *Russian Journal of Inorganic Chemistry*. 2011; 56(4):549-554,
13. Martin DF, Janusonis GA, Martin BB. "Stabilities of bivalent metal complexes of some β-ketoimines," *Journal of American Chemical Society*. 1961; 83(1):73-75,
14. Bahnasawy RME, Tabl ASE, Shereafy EE, Kashar TI, Issa YM. "Mononuclear and binuclear copper(II) complexes of phenylhydrazoacetylacetone isonicotinoylhydrazone," *Polish Journal of Chemistry*. 1999; 73(12):1925-1936.
15. Campos A, Anaconda JR, Vallette MMC. "Synthesis and IR study of a zinc (II) complex containing a

- tetradentate macrocyclic Schiff base ligand: antifungal properties,” *Main Group Metal Chemistry*. 1999; 22(5):283-288,
16. Verma M, Pandeya SN, Singh KN, Stables JP, “Anticonvulsant activity of Schiff bases of isatin derivatives,” *Acta Pharmaceutica*. 2004; 54(1):49-56,
 17. Fouda AS, Badr GE, El-Haddad MN. “The inhibition of C-steel corrosion in H₃PO₄ solution by some furfural hydrazone derivatives,” *Journal of the Korean Chemical Society*. 2008; 52(2):124-132,
 18. Narang KK, Aggarwal A. “Salicylaldehyde salicylhydrazone complexes of some transition metal ions,” *Inorganica Chimica Acta*. 1974; 9(L2):137-142,
 19. Syamal A, Kumar D. “Molybdenum complexes of bioinorganic interest: new dioxomolybdenum(VI) complexes of Schiff bases derived from salicylaldehydes and salicylhydrazide,” *Transition Metal Chemistry*. 1982; 7(3):118-121,
 20. Syamal A, Kumar D. “Spectral studies on new dioxouranium (VI) complexes of tridentate Schiff bases derived from salicylhydrazide & salicylaldehyde or substituted salicylaldehydes,” *Indian Journal of Pure and Applied Physics*. 1983; 21:87-91.
 21. Baligar RS, Revankar VK. “Coordination diversity of new mononucleating hydrazone in 3d metal complexes: synthesis, characterization and structural studies,” *Journal of Serbian Chemical Society*. 2006; 71(12):1301-1310,
 22. Yang QX, Gang LZ, Sheng LW, Liang ZH. “Synthesis, crystal structure and cytotoxic activity of a novel nickel(II) complex with Schiff base derived from salicylhydrazide,” *Chinese Journal of Structural Chemistry*. 2008; 27:707-711,
 23. Chowdhury DA, Uddin MN, Sarker MAH. “Synthesis and characterization of dioxouranium (VI) complexes of some aroylhydrazines and their Schiff bases with acetone,” *Chiang Mai Journal of Science*. 2008; 35:483-494,
 24. Luo W, Wang XT, Meng XG, Cheng GZ, Ji ZP. “Metal coordination architectures of N-acyl-salicylhydrazides: the effect of metal ions and steric repulsion of ligands to their structures of polynuclearmetal complexes,” *Polyhedron*. 2009; 28:300-306.
 25. Kumar D, Gupta PK, Kumar A, Dass D, Syamal A. “Syntheses, spectroscopic and magnetic properties of polystyreneanchored coordination compounds of tridentate ONO donor Schiff base,” *Journal of Coordination Chemistry*. 2011; 64(4):590-599,
 26. Shelke VA, Jadhav SM, Shankarwar SG, Munde AS, Chondhekar TK. “Synthesis, characterization, antibacterial and antifungal studies of some transition and rare earth metal complexes of N-benzylidene-2-hydroxybenzohydrazide,” *Bulletin Chemical Society of Ethiopa*. 2011; 25(3):381-391.
 27. Gerber TIA, Yumata NC, Betz R. “The reaction of salicylhydrazide with [ReOX₃(PPh₃)₂]. Influence of X on product formation,” *Inorganic Chemistry Communications*. 2012; 15:69-72
 28. Al-Mawsawi LQ, Dayam R, Taheri L, Witvrouw M, Debyser Z, Neamati N. “Discovery of novel non-cytotoxic salicylhydrazide containing HIV-1 integrase inhibitors,” *Bioorganic and Medicinal Chemistry Letters*. 2007; 17(23):6472-6475.
 29. Neamati N, Hong H, Owen JM *et al.*, “Salicylhydrazinecontaining inhibitors of HIV-1 integrase: implication for a selective chelation in the integrase active site,” *Journal of Medicinal Chemistry*. 1998; 41(17):3202-3209,
 30. Chen GJJ, McDonald JW, Newton WE. “Synthesis of Mo(IV) and Mo(V) complexes using oxo abstraction by phosphines. Mechanistic implications,” *Inorganic Chemistry*. 1976; 15(11):2612-2615
 31. Kumar D, Pandey V, Gupta A. “Studies on the coordination compounds of thiazolidin-4-one derived from salicylaldehyde-o-hydroxyphenylurea,” *International Journal of Chemical Sciences*. 2011; 9(3):1307-1318.
 32. Kumar D, Syamal A, Gupta A, Pandey V, Rani M. “Coordination compounds of Schiff base containing urea moiety, *Journal of Indian Chemical Society*. 2012; 89(6):745-752.
 33. Syamal A, Kumar D. “New oxozirconium(IV) complexes with the Schiff bases derived from salicylaldehyde, substituted salicylaldehydes and salicylhydrazide,” *Polish Journal of Chemistry*. 1981; 55:1747-1750
 34. Mishra AP, Purwar H, Jain RK. “Microwave synthesis, spectral, thermal and antimicrobial activities of Co(II), Ni(II)and Cu(II) metal complexes with Schiff base ligand,” *Biointerface Research in Applied Chemistry*. 2012; 2(2):291-299.
 35. Syamal A, Kale KS. “Magnetic properties of oxovanadium (IV) complexes of some β -diketones,” *Indian Journal of Chemistry*. 1979; 17A:518-520,
 36. Ferraro JR. *Low Frequency Vibrations of Inorganic and Coordination Compounds*, Plenum Press, New York, NY,USA, 1971.
 37. Kumar D, Syamal A, Gupta A, Rani M, Gupta PK. “Role of pH on the formation of the coordination compounds with the Schiff base derived from 3-formylsalicylic acid and 4-amino-2,3-dimethyl-1-phenyl-3- pyrazolin-5-one,” *Journal of the Indian Chemical Society*. 2010; 87(10):1185-1197.
 38. Kumar D, Syamal A, Jaipal, Gupta PK. “Coordination compounds of polystyrene-supported azo dye,” *Journal of the Indian Chemical Society*. 2007; 84(3):217-222.
 39. Silverstein RM, Bassler GC. *Spectrometric Identification of Organic Compounds*, Wiley Inter science, New York, NY, USA, 2nd edition, 1967.