

Ligational Behavior of Synthesized New Hydrazones Towards Oxovanadium (IV) Complexes and Their Antituberculosis Aspects

Dr. Alok Chandrayan

Government Motilal Vigan Mahavidyalaya

Bhopal, India

drralokchandrayan@gmail.com

Dr. Alka Pradhan

Government Motilal Vigan Mahavidyalaya

Bhopal, India

Abstract- The synthesis of some oxovanadium (IV) complexes with bidentate ligands (new synthesized biologically active hydrazones) derived from 2-methyl-4-(N-cyanoethyl)-N-benzenesulphonyl-benzylidene-3-oxo-[N-(substituted-1-phenyl)propanamido] hydrazone were analyzed. The complexes prepared were of the type [VO.L₂] (where L= different new synthesized hydrazones). The characterization of these newly synthesized hydrazones and their metal complexes were done by IR, ¹H-NMR spectral studies and elemental analysis. The infrared data of these complexes revealed the bidentate nature of the ligands and coordination to imino nitrogen of the amido group and azomethinic-nitrogen atoms. The new products were synthesized and evaluated for anti-tuberculosis activity against *Mycobacterium tuberculosis* H₃₇R_v in L.J. medium. The biological screening data indicates that the metal chelates are more potent than the parent ligands.

I. INTRODUCTION

Hydrazone compounds obtained by the reaction of aromatic and heterocyclic hydrazides with mono- and di-aldehydes or ketones have revealed very versatile behavior in metal coordination¹. Many researchers have synthesized a number of new hydrazones because of their ease of synthesis².

Hydrazones play an important role in inorganic chemistry as they easily form stable complexes with most transition metal ions in the periodic table the development of the field of bioinorganic chemistry has increased the interest in hydrazone complexes, as they have been recognized that many of these complexes may serve as models for biologically important species. The remarkable biological activity of acid hydrazides R-CO-NH-NH₂, their corresponding hydrazones, R-CO-NH-N=CH-R' and the dependence of their mode of chelation with

transition metal ions present in the living system, have been of significant interest in the past³⁻⁶. The coordination compounds of aroylhydrazones have been reported to act as enzyme inhibitors⁷ and are useful due to their pharmacological application⁸⁻¹⁰. Isonicotinic acid hydrazide is a drug of proven therapeutic importance and used against a wide spectrum of bacterial ailments, as tuberculosis¹¹.

Hydrazones have been studied as a group of the most useful spectrophotometric reagents^{2, 12, 13}. Combining appropriate starting materials (carbonyl compounds and hydrazine), the sensitivity as an analytical reagent and / or solubility of the hydrazones could be improved and the donating environment could be changed. The shortcoming of hydrazones was their lack of selectivity² for metal ions. Much effort has been devoted to developing masking agents for use with hydrazones^{14, 15}.

High-performance liquid chromatography (HPLC) of metal chelates¹⁶ is a promising alternative approach for overcoming the lack of selectivity of the chelating reagents². hydrazone ligands and their complexes have been studied for their antifungal and antibacterial activity, as iron chelators in the treatment of anemias and as antiviral drugs¹.

The coordination chemistry of oxovanadium (IV) with multidentate ligands is important due to its growing application in catalysis¹⁷ and therapeutics¹⁸. Vanadium in traces has multiple biological roles, therapeutic value in small doses and toxic in excess. Vanadium containing compounds have their utility as insulin mimetic¹⁹ and antiamebic agent²⁰.

It is also suggested that vanadium could be considered as a representative of a new class of non-platinum metal antitumour agents²¹. In the present investigation we describe the synthesis

and characterization of some new hydrazones and their oxovanadium (IV) complexes.

Where **R = -Cl and -NO₂**

II. STRUCTURE OF NEW SYNTHESIZED HYDRAZONE

Ball Stick modal of new synthesized Hydrazone

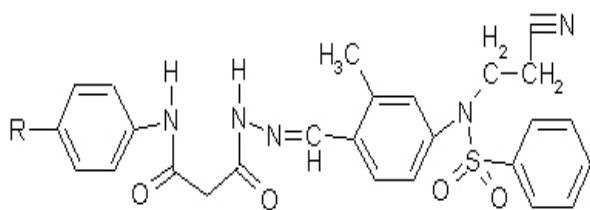
III. RESULTS AND DISCUSSION

All compounds gave satisfactory results for elemental analysis, IR and ¹H-NMR spectra. The physical and analytical data of synthesized new hydrazones and their metal complexes are presented in table-1.

Table 1: Analytical Data of Synthesized hydrazones and their Metal Complexes

Compounds	Mol. Formula (Mol. Wt.)	M.P (°C)	Colour (yield %)	Elemental Analysis (%) Calculated/ Found)			
				C	H	N	M
MCPH	C ₂₆ H ₂₄ N ₅ O ₄ SCl (538.03)	207	Brown (71)	58.04 (58.00)	04.50 (04.48)	13.02 (13.00)	- -
MNPH	C ₂₆ H ₂₄ N ₆ O ₆ S (548.58)	212	Yellow (75)	56.93 (56.87)	04.41 (04.35)	15.32 (15.28)	- -
[VO(IV)- (MCPH)₂]	VO(IV)- (C ₅₂ H ₄₈ N ₁₀ O ₈ S ₂ Cl ₂) (1143.00)	223	Light Blue (68)	54.59 (54.50)	04.19 (04.11)	12.24 (12.19)	04.45 (04.38)
[VO(IV)- (MNPH)₂]	VO(IV)- (C ₅₂ H ₄₈ N ₁₂ O ₁₂ S ₂) (1164.10)	230	Dark Blue (70)	53.60 (53.55)	04.12 (04.08)	14.43 (14.37)	04.37 (04.30)

Infrared Spectra: Comparative study of the IR of hydrazones



and metal complexes are helpful in evaluating the results.

Spectral interpretation of new hydrazones show characteristic bands i.e. ν (N-H) stretching: 3320-3060 cm^{-1} , ν (C=O) stretching: 1750-1650 cm^{-1} and azomethine nitrogen: 1640-1610 cm^{-1} .

A strong band around 1630 cm^{-1} indicates the formation of new hydrazone because this band appears due to condensation of hydrazide with aldehyde, when these hydrazones chelate with metals, the normal frequency of ν (C=O) stretching band is shifted towards lower frequency region.

The lowering by 10-30 cm^{-1} in ν (C=N) azomethine nitrogen band frequency around 1700-1600 cm^{-1} suggests the coordination of hydrazone ligand to the metal ion through

imino nitrogen of the amido group and azomethine nitrogen. Some new bands present in far infrared region (690-650 cm^{-1} & 980-900 cm^{-1}) shows the formation of some new [ν (V-N) and ν (V-O)] bands in the spectra of metal complexes.

In all the complexes of VO²⁺, the V = O (oxovanadium) stretching frequency occurs in the range 975-960 cm^{-1} . These values are in the range observed for monomeric VO²⁺ complexes²². The $d\pi$ - $p\pi$ orbital overlap involved in a multiple bond. This strong multiple bonding with the oxygen appears to be responsible for the trans influence of the oxo ligand, which disfavors attachment of a ligand trans to O²³.

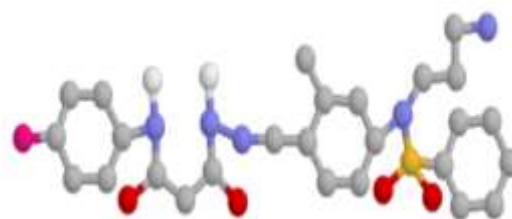


Table 2: Infrared absorption frequencies (cm⁻¹) of Hydrazones and their Metal Complexes

Compounds	ν (NH)	ν (C=N)	ν (V=O)	ν (V-N)
MCPH	3230 m	1620 s	-	-
MNPH	3225 m	1627 s	-	-
[VO(IV)-(MCPH) ₂]	3210 m	1600 s	975 m	665 m
[VO(IV)-(MNPH) ₂]	3210 m	1605 s	978 m	673 m

¹H-NMR Spectra: The ¹H-NMR spectra of new synthesized hydrazones MCPH and MNPH were recorded (Table-3). The spectra in comparison to the corresponding hydrazide, show the disappearance of NH₂ group signal, while that of the NH protons are shown low field to the range δ 8.90–11.80 ppm for the imino proton present in ligands²⁴ (hydrazones).

The proton of azomethine group (CH = N) sharp peak is observed at δ 8.50–8.80 ppm. Further two signals observed at

δ 3.60–3.90 ppm are assigned to methylene protons²⁵. The multiplet due to aromatic protons appears in the δ 7.03–8.30 ppm region. The appearance of two doublets in the region δ 11.11–12.96 ppm coupled with signals at δ 3.60–3.90 ppm suggests enolization of hydrazones involving active methylene group with keto-enol equilibrium in the solution. Thus, the signal at δ 3.60 ppm may be attributed to methylene (-CH₂-) and that at δ 3.90 ppm to methane proton (=CH-).

The bonding of ligand to metal is further supported by ¹H-NMR spectral studies and NMR spectra (Table 3) recorded for [VO-(MCPH)₂] and [VO-(MNPH)₂]. The signals in the δ 11–13 ppm region are medium, broad and shifted upfield by about 0.38–0.45 ppm in the complex as compared to that in the free hydrazone in which they are relatively intense indicating that they arise due to secondary (imino)–NH protons²⁵. This suggests coordination of the imino nitrogen (amido group) atoms to the metal center. In the spectrum of oxovanadium complex of hydrazones (MCPH and MNPH) position of δ –CH=N- signal shifts down field by 0.49–0.65 ppm suggesting coordination of azomethine nitrogen atoms to the metal center.²⁵.

Table 3: ¹H-NMR Spectral data of hydrazones and their metal complexes

Compounds	-N-H	-CH=N-	-CH ₂ -	Ar-H
MCPH	11.2 (1H,m)	8.5 (1H,s)	3.6 (2H,m)	7.10-8.00 (12H,m)
MNPH	11.5 (1H,m)	8.7 (1H,s)	3.8 (2H,m)	7.15-8.10 (12H,m)
[VO(IV)-(MCPH) ₂]	11.6(1H, m, bro.)	7.9 (1H,s)	3.5 (2H,m)	7.05-7.90 (12H,m)
[VO(IV)-(MNPH) ₂]	11.9 (1H,m, bro.)	8.1 (1H,s)	3.7 (2H,m)	7.09-8.00 (12H,m)

IV. ANTITUBERCULOSIS ACTION

A close study of table 4 reveals that all the four synthesized new compounds screened for their antitubercular effect against *M. tuberculosis*, the compound Iia was found to show remarkable effect (MIC 100 μ g/ml).

Moreover, the compounds Ia and Iib exhibited a moderate activity (MIC 250 μ g/ml). However, the compound having codes as Ib showed mild activity (MIC 500 μ g/ml).

In the present study small number of isolates (n = 04) were tested for their antitubercular susceptibility.

It would be appropriate to study the same impact of the synthesized new compounds on a still larger number of isolates obtained from variety of clinical samples, so as to study the spectrum of effectivity of these compounds.

With the increasing number of multi-drug resistance of *M. tuberculosis*, it is desirable to start anti-tubercular therapy only after sensitivity assay to determine the most suitable drug against particular isolate infecting to patient. Moreover, with increasing prevalence of tuberculosis, there is a need of regular development of newer and newer anti tubercular drugs for the effective management of tuberculosis in patients, thus here lies the importance of the investigated compounds of organic origin.

V. CONCLUSION

In this paper coordination chemistry of a newly synthesized hydrazone ligands, obtained from the reaction of 3-oxo-[N-(substituted -1-phenyl) propanamido] hydrazide and 2-methyl-4-(N-cyanoethyl)-N-benzenesulphonyl benzaldehyde

, is described . Oxovanadium (IV) complexes have been synthesized using the above newly hydrazone ligands and characterized on the basis of analytical, IR ¹H-NMR spectral data. The observation of newly hydrazone ligand to the metal ion through imino nitrogen of the amido group and azomethine nitrogen and acts as a bidentate ligand. In all the synthesized metal complexes of vanadium metal attached oxygen atom to monomeric (VO²⁺) form because of the dπ-pπ orbital overlap involved in a multiple bond. This strong multiple bonding with the oxygen appears to be responsible for the trans-influence of the oxo-ligand, which disfavors attachment of a ligand trans to oxygen.

The biological screening data of indicate that the metal chelates are more potent than the parent ligands.

VI. EXPERIMENTAL

Materials and Instrumentation: All reagents used were purchased from Merck and used as received. Melting points were taken in open capillary and are uncorrected. Elemental analyses, ¹H-NMR spectra were obtained on a Bruker FT-400 spectrometer using CDCl₃ as solvent and TMS as an internal standard. IR spectra were recorded on KBr disks, using a Jasco-410 FTIR spectrometer. All the hydrazides were prepared by the reaction of hydrazine hydrate with different esters.

3-oxo-[N-(4-chloro-1-phenyl) propanamido] hydrazide, 3-oxo-[N-(4-nitro-1-phenyl) propanamido] hydrazide²⁶ and 2-methyl-4-(N-cyanoethyl) -N-benzenesulphonyl benzaldehyde²⁷ were prepared by reported methods.

(A) Preparation of Hydrazones : Synthesis of 2-methyl-4-(N-cyanoethyl) -N-benzenesulphonyl benzylidene-3-oxo-[N-(4-chloro-1-phenyl) propanamido] hydrazone (MCPH) (Ia) : 3-oxo-[N-(4-chloro-1-phenyl) propanamido] hydrazide (0.227gm , 0.001mol) and 2-methyl-4- (N-cyanoethyl)-N-benzenesulphonyl benzaldehyde (0.328gm , 0.001mol) were dissolved in ethanol and added a drop of concentrated H₂SO₄ . Mixture was stirred for 5 min. The resulting solid was recrystallised from ethanol as brown crystals (71%).

(II) Synthesis of 2-methyl-4-(N-cyanoethyl) -N-benzenesulphonyl benzylidene-3-oxo-[N-(4-nitro-1-phenyl) propanamido] hydrazone (MNPH) (Ib) [yellow crystals (75%)] was prepared similarly.

(B) Preparation of the metal complexes of MCPH and MNPH :

To a hot solution of the respective metal salt [0.173gm vanadyl chloride (VOCl₂.2H₂O)] in methanol was added a sufficient amount of the MCPH (0.538 gm) or MNPH (0.548 gm) . The solution was mixed with a required stoichiometric amount of the respective ligand in hot methanol. The resulting mixture was refluxed for four hours and then concentrated to half of its volume. On cooling, a colored crystalline product was obtained

, which was filtered , washed with organic solvents and dried in a vacuum oven .

(C) Biological experiments:

A series of newly synthesized compounds have been tested for their anti-tubercular effect on *M. tuberculosis*²⁸⁻³⁰. Four different strains of *M.tuberculosis* isolated from various clinical specimens belonging to pulmonary and extra-pulmonary patients (sputum, pleural fluid, pus and lymph node aspirate). Standard strain of *M. tuberculosis* i.e. (H₃₇R_v) was used as control strain. All test compounds of varying concentration ranging from 1600 µg/ml – 50 µg/ml.

The L .J. Media containing different test compounds were brought at room temperature . 100 µl of seed culture was applied to each slant of L. J. Medium containing different test compounds. A fresh disposable loop was used for each slant. The cap was closed tightly and slants were incubated at 37±0.5⁰ C.

All the cultures, incubated at 37⁰C were observed initially twice in a week for a period of three weeks and later weekly for a total period of eight weeks for the growth of AFB. Results were noted according to the minimum effective concentration inhibiting the growth of AFB on the medium.

Table 4: MIC values of newly synthesized compounds

Code No.	Name of Compounds	MIC Values (µg/ml)
Ia	MCPH	250
Ib	MNPH	500
IIa	[VO(IV)-(MCPH) ₂]	100
IIb	[VO(IV)-(MNPH) ₂]	250

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