

SYNTHESIS, CHARACTERIZATION, AND CHELATING PROPERTIES OF 4-NITROBENZOYLSEMICARBAZONE-1-PHENYL-3-METHYL-2-PYRAZOLIN-5-ONE (NBMP-SC)

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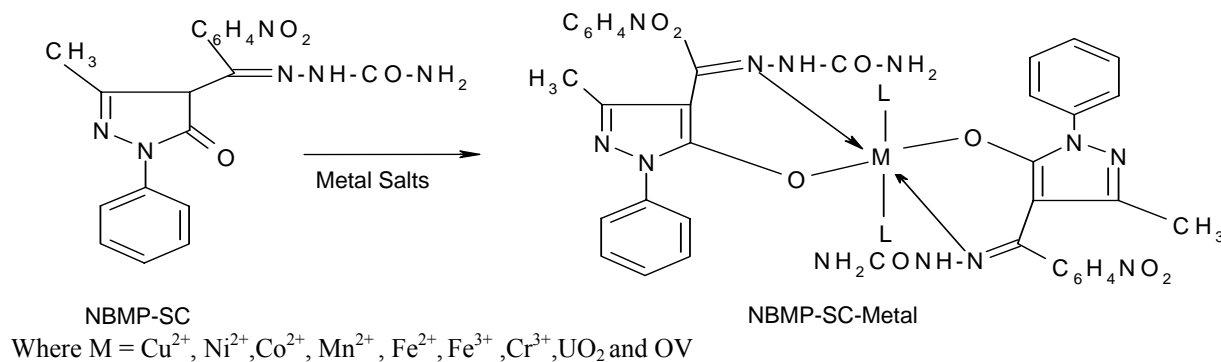
ABSTRACT

4-Nitrobenzoylsemicarbazone-1-phenyl-3-methyl-2-pyrazolin-5-one (NBMP-SC) was prepared and its metal chelates of Cu^{2+} , Ni^{2+} , Co^{2+} , Mn^{2+} , Fe^{2+} , Fe^{3+} , Cr^{3+} , UO_2 and OV were prepared. The ligands and its chelates were characterized by elemental analysis, Metal: ligand (M:L) stoichiometry, IR-electronic spectral studies and magnetic properties. The compounds also were screened for their antimicrobial activity.

Keywords: 4-Nitrobenzoylsemicarbazone-1-phenyl-3-methyl-2-pyrazolin-5-one (NBMP-SC), Spectral studies, Magnetic moment, Metal complexes, Antifungal activity.

INTRODUCTION

Number of 1-phenyl-2-pyrazolin-5-one derivatives has been studied for their metal complexation study²⁻⁴. Recently the thiosemicarbazone derivatives of 4-Nitrobenzoyl-1-phenyl-3-methyl-2-pyrazolin-5-one have been prepared from our laboratory⁵ and studied their metal complexation properties. As the semicarbazones derivatives of 4-Nitrobenzoyl-1-phenyl-3-methyl-2-pyrazolin-5-one (NBMP-SC)⁶⁻⁸ have been reported so far for their metal complexation. Hence, the present communications comprised the work in connection with the metal complexation study (NBMP-SC) shown in Scheme-1.



Scheme-1

EXPERIMENTAL

All the chemicals used in the present work were of pure grade. For the preparation of the metal chelates of the Cu^{2+} , Ni^{2+} , Co^{2+} , Mn^{2+} , Fe^{3+} , Cr^{3+} , UO_2 and OV metal nitrates were used. The $\text{FeSO}_4(\text{NH}_4)\text{SO}_4 \cdot \text{H}_2\text{O}$ was used in the preparation of the Fe^{2+} chelates respectively.

Synthesis of 4-Nitrobenzoylsemicarbazone-1-phenyl-3-methyl-2-pyrazolin-5-one (NBMP-SC)

The ligand NBMP-SC was prepared in two steps described below:

Preparation of 4-Nitrobenzoyl-2-pyrazolin-5-one:

The 1-phenyl-3-methyl-2-pyrazolin-5-one (0.1mole, 17.4gm) was placed in a flask equipped with a stirrer, separating funnel, and reflux condenser. It was then dissolved in dioxane (85ml) by application of heat. To the reaction mixture, calcium hydroxide (0.2mole, 14.81gm) was added, followed by the dropwise addition of the Nitrobenzoyl chloride (0.1mole) at this stage, the mixture become a thick paste and its temperature also increased, as this being an exothermic reaction. The reaction mixture was then refluxed for half an hour. The resulting calcium complex was then decomposed by pouring it into the dilute hydrochloric acid (200ml, 2M). The resultant colored crystals were then collected on a Buchner-funnel and recrystallized from an acidified Methanol-Water mixture 20:40 (v/v).^{2,3}

Preparation of 4-Nitrobenzoylsemicarbazone-1-phenyl-3-methyl-2-pyrazolin-5-one (NBMP-SC):

Following procedure has been adopted in the preparation of semicarbazone of NBMP used in the present study. The semicarbazone was prepared by refluxing 1:1 mole 4-Nitrobenzoyl-2-pyrazolin-5-one and semicarbazide hydrochloride in methanol for 1hr. The semicarbazone of NBMP, thus obtained was filtered, recrystallised from methanol and designated as NBMP-SC. Yield was 72%. It m.p. was 230^oc (uncorrected).

Elemental Analysis:	C%	H%	N%
$C_{13}H_{15}N_5O_2$ (273.30)			
Calculated:	57.12	5.53	25.63
Found :	57.0	5.3	24.4
IR Features:	3380 cm^{-1}	N-H (m, br)	
	3300 cm^{-1}	C-H(m, br)	
	3052 cm^{-1}	C=N (w, br)	
	2957 cm^{-1}	C-H(w, sh)	
	1700 cm^{-1}	C=O(s, sh)	
	1640 cm^{-1}	C=N (w, br)	
	1630 cm^{-1}	C=N (m, br)	
	1219 cm^{-1}	O-H (m, sh)	
	965 cm^{-1}	N-N (m, sh)	
NMR: δ ppm (DMSO)	7.2-7.6 (6H)	Multiplet	Aromatic
	2.1-2.4 (1H)	Singlet	CH
	1.8-2.0 (3H)	Singlet	CH ₃

Synthesis of metal chelates of NBMP-SC:

All the metal chelates of NBMP-SC were prepared in the similar manner. The general procedure is as follows: The metal salt (0.01mole) was dissolved in a minimum amount of hot water (30ml). The hot ligand (0.021mole) solution in DMF (30ml) (The ligand solution for Cr⁺³ and Fe⁺³ was 0.031mole) was added dropwise with constant stirring. To the resulting mixture 2 grams of Sodium acetate was added and then the mixture was refluxed for 1hrs. The resulting mixture thus obtained was then concentrated to half of its original volume. The product was filtered and washed several times with hot water. The product was air-dried and then kept in desiccator. The yield of all chelates were almost quantitative.

Measurements

The elemental analysis for C, H, and N were carried out on elemental analyzer. IR spectra of NBMP-SC and its metal complexes were scanned on a Perkin-Elmer 983(USA) spectrophotometer KBr. Estimation of metal in each compound was carried out by gravimetric oxide method and EDTA titration as described by Flaschka¹. The vibrating sample magnetometer (VSM), model 7304(4-inch electromagnet VSM system), Lakeshore crytronics, Inc., USA, was used to characterize magnetic properties of metal chelates.

The diffused reflectance spectra of solid metal complexes were recorded on a Beckman-DK-2A spectrophotometer with a solid reflectance compound. The thermograms of the chelates were recorded on SDT-2960 simultaneous DSC-TGA. The electrical conductivity of all the complexes were measured in DMF using "conductivity Bridge 305" (systronics).

Antifungal activity

The fungicidal activity of all the compounds was studied at 1000 ppm concentration in vitro plant pathogenic organisms listed in Table-3. The antifungal activities of all the samples were measured by cup plate method. Each of the plant pathogenic strains on potato dextrose agar (PDA) medium. Such a PDA medium contained potato 200 gms, dextrose 20gms, agar 20gms and water 1 litre. 5 days old cultures were employed. The compounds to be tested were suspended (1000ppm) in a PDA medium and autoclaved at 120° C for 15 min. at 15 atm pressure. These medium were poured into sterile Petri plate and the organisms were inoculated after cooling the Petri plate. The percentage inhibition for fungi was calculated after 5 days using the formula given below:

$$\text{Percentage of inhibition} = \frac{100(X-Y)}{X}$$

Where, X: Area of colony in control plate

Y: Area of colony in test plate

The fungicidal activity all compounds are shown in Table-3.

RESULTS AND DISCUSSION

The parent ligand NBMP-SC was amorphous powdered, soluble in various solvents like dioxane, DMSO, and DMF. The results of elemental analysis of the ligands are reported in a Table-1.8 They are consistent with the predicted structure as Scheme-1. The ligand was synthesized as shown in Scheme-1. Examination of IR spectrum of NBMP-SC reveals that a broad band of N-H is observed at 3380cm⁻¹ as well as 1640 cm⁻¹ C=N (azomethine), 1700 cm⁻¹ (C=O). The NMR data also confirm the structure of NBMP-SC. The metal complexes of NBMP-SC with the metal ions Cu²⁺, Ni²⁺, Co²⁺, Mn²⁺, Fe²⁺, Fe³⁺ and Cr³⁺ vary in colours. On the basis of the proposed structure as shown in Scheme-1, the molecular formula of the NBMP-SC ligand is C₁₃H₁₅N₅O₂ (273.30) which upon complex ion coordinates with one central metal atom at four coordinates sites and with one water molecules. Therefore the general molecular formula of the resulting metal complex is [C₁₃H₁₅N₅O₂]₂.M.H₂O for divalent metal ions. This has been confirmed by results of elemental analysis of all the metal chelates and their parent ligand. The data of elemental analysis reported in Table-1 are in arrangement with the calculated values of C, H and N based on the above mentioned molecular formula of parent ligand as well as metal complex. The electrical conductivity of these complexes in acetonitrile indicates that the complexes are essentially non-electrolytes.

IR spectra of metal complexes reveal that all the spectra are identical in all respects. The comparison of IR spectrum of the parent ligand NBMP-SC with that of its each metal complex has revealed certain characteristics differences.

One of the significant differences to be expected between the IR spectrum of the parent ligand and its metal complex is the presence of more broadened bands in the region of 3450-3100cm⁻¹ for the metal complex as the oxygen of the O-H, nitrogen of N-H of ligands forms a coordination band with the metal ions. It is gratifying to note that the ligand band at 965cm⁻¹ assigned to ν (N-N), shifts to 990-1000cm⁻¹ on complexation leading further support to the involvement of nitrogen of azomethine moiety in the complex formation. The ligand band at 1700cm⁻¹ show an absorption due to O-H in the region 1250-1210cm⁻¹. This peak is either missing or shows a significance lowering of intensity in the chelates. A strong band 960cm⁻¹ in a vanadyl complex may be assigned to νC=O. A peak 900cm⁻¹ in the uranyl complexes may be assigned to asymmetric stretching of O=U=O moiety^{9,22,23}.

Table-1: Analysis of NBMP-SC ligand and its metal chelates

Empirical Formula	Mol. Wt. Gm/mole	Yield (%)	Elemental Analysis							
			C%		H%		N%		M%	
			Cald	Found	Cald	Found	Cald	Found	Cald	Found
C ₁₃ H ₁₅ N ₅ O ₂	273	72	57.12	57.34	5.53	5.23	25.63	24.98	----	-----
C ₂₆ H ₂₉ N ₁₀ O ₄ Cu ²⁺ ·2H ₂ O	644.5	70	52.69	52.61	5.77	5.92	23.63	23.52	9.91	9.89
C ₂₆ H ₂₉ N ₁₀ O ₄ Ni ²⁺ ·2H ₂ O	639.7	65	48.69	48.84	5.34	5.08	22.84	22.26	9.16	9.52
C ₂₆ H ₂₉ N ₁₀ O ₄ Co ²⁺ ·2H ₂ O	639.9	70	48.76	48.80	5.34	4.96	21.84	21.93	9.19	9.15
C ₂₆ H ₂₉ N ₁₀ O ₄ Mn ²⁺ ·2H ₂ O	635.9	75	49.29	48.93	5.41	4.57	22.11	21.89	9.13	9.18
C ₂₆ H ₂₉ N ₁₀ O ₄ Fe ²⁺ ·2H ₂ O	639.8	65	48.90	49.20	5.36	4.81	21.94	21.88	8.74	8.51
C ₂₆ H ₂₉ N ₁₀ O ₄ Fe ⁺³ NO ₃ ·H ₂ O	683.8	75	45.75	45.55	4.73	4.44	22.58	22.84	9.17	10.15
C ₂₆ H ₂₉ N ₁₀ O ₄ Cr ⁺³ NO ₃ ·H ₂ O	682.0	75	46.01	45.77	4.75	4.21	22.18	21.14	7.66	7.80
C ₂₆ H ₂₉ N ₁₀ O ₄ OVH ₂ O	629.94	75	49.44	49.39	4.79	4.15	22.18	22.00	8.07	8.05
C ₂₆ H ₂₉ N ₁₀ O ₄ UO ₂	815.0	75	38.23	38.9	3.70	3.82	17.16	17.43	29.14	29.35

Table-2: Spectral features and magnetic moments of NBMP-SC metal chelates

Metal Chelates	μ_{eff} (BM)	Molar conductivity ohm ⁻¹ cm ² mole ⁻¹	Electronic spectral data (cm ⁻¹)	Transition
NBMP-SC-Cu ²⁺	1.89	9.13	13175 25642	Charge transfer ${}^2E_g \rightarrow {}^2T_{2g}$
NBMP-SC -Ni ²⁺	2.92	3.74	10351 17271 30487	${}^3A_{2g} \rightarrow {}^3T_{2g}$ ${}^3A_{2g} \rightarrow {}^3T_{1g}$ ${}^3A_{2g} \rightarrow {}^3T_{1g}(p)$
NBMP-SC -Co ²⁺	4.54	3.28	10528 19723 23866	${}^4A_{1g}(F) \rightarrow {}^4T_{2g}(F)$ ${}^4A_{1g}(F) \rightarrow {}^4A_{2g}$ ${}^4A_{1g}(F) \rightarrow {}^4T_{1g}(P)$
NBMP-SC -Mn ²⁺	6.04	4.45	23869 18349 16826	${}^6A_{1g} \rightarrow {}^6A_{2g}$ 4E_g ${}^6A_{1g} \rightarrow {}^4T_{2g}(4G)$ ${}^6A_{1g} \rightarrow {}^4T_{1g}(PG)$
NBMP-SC -Fe ²⁺	4.92	5.85	22657 16447	Charge transfer ${}^5T_{2g} \rightarrow {}^2E_g$
NBMP-SC-Fe ⁺³ -NO ₃	6.81	---	25641 19157 12903	${}^6A_{1g} \rightarrow {}^4T_{1g}$ ${}^6A_{1g} \rightarrow {}^4T_{2g}$ ${}^6A_{1g} \rightarrow {}^4A_{1g}, {}^4E_g$
NBMP-SC-Cr ⁺ -NO ₃	3.51	6.08	18587 23980 39289	${}^4A_{2g}(F) \rightarrow {}^4T_{2g}(F)$ ${}^4A_{2g}(F) \rightarrow {}^4T_{1g}(F)$ ${}^4A_{2g}(F) \rightarrow {}^4T_{1g}(P)$
NBMP-SC-OV	1.95	6.08	12336 17241 24937	$d_{xy} \rightarrow d_{xz}, d_{yz}$ $d_{xy} \rightarrow d_{x^2-y^2}$ $d_{xy} \rightarrow d_z$
NBMP-SC -8UO ₂	Diamag.	3.28		-----

Examination of data of the metal content in each compound revealed a 1:2 metal: ligand(M:L) stoichiometry in all of the complex of divalent metal ions and 1:3 for trivalent ions.

Magnetic moment (μ_{eff}) of each of the metal complex is given in Table-2. Examination of these data reveals that all complexes of Zn^{+2} and UO_2^{+2} are diamagnetic while other are paramagnetic.

The diffuse electronic spectrum of $[\text{Cu}(\text{NBMP-SC})_2(\text{H}_2\text{O})_2]$ metal complex shows broad band at 15000cm^{-1} on a strong charge transfer band ¹⁰ at 25000cm^{-1} . the $[\text{Ni}(\text{HL})(\text{H}_2\text{O})_2]$ and $[\text{Cu}(\text{HL})(\text{H}_2\text{O})_2]$ complex gave two absorption bands respectively at 15601, 22996 and 15381, 22723 cm^{-1} corresponding to ${}^4\text{T}_{1g} \rightarrow {}^2\text{T}_{1g}$ and ${}^4\text{T}_{1g}(\text{p})$ transitions. thus absorption bands at the diffuse, reflectance spectra and the value of magnetic moments indicate and octahedral configuration for the $[\text{Ni}(\text{HL})(\text{H}_2\text{O})_2]$ and $[\text{Cu}(\text{HL})(\text{H}_2\text{O})_2]$ complex. The electronic spectra of Fe (III) chelates, the d-d transition appear mostly as weak bands ¹¹⁻¹⁴. The spectra show bands at 12000, 18000 and 25000cm^{-1} . These bands correspond to the ${}^6\text{A}_{1g} \rightarrow {}^4\text{T}_{1g}(\text{G})$, ${}^6\text{A}_{1g} \rightarrow {}^4\text{T}_{2g}(\text{G})$ and ${}^4\text{A}_{1g} \rightarrow {}^4\text{E}_g$, ${}^4\text{A}_{1g}(\text{G})$ transition respectively, in an octahedral stereochemistry ¹⁵⁻²¹.

Conductivities of all the complexes were measured in acetonitrile solvent, all the complexes were found to be non-electrolytic in nature of 1:1 type, and molar conductivity values were in the range of 3.28-22.22 $\text{ohm}^{-1}\text{cm}^2\text{mole}^{-1}$ in DMF.

The antifungal activity of all the compounds measured for various plant pathogens. Inspection of the result shown in Table-3 indicated that all compounds are good toxic for fungi. Out of all the compounds copper chelates is more toxic than other. These compounds almost inhibit the fungi about 70%. Hence, produced metal chelates can be employed as garden fungicides. Further work in these directions is in progress.

Table-3: Antifungal activity of NBMP_SC ligand and its metal chelates

SNBMPle	Zone of inhibition of fungus at 1000 ppm (%)						
	BT	N	RN	AN	AF	AA	AK
NBMP-SC	57	56	54	65	62	66	72
NBMP-SC - Cu^{2+}	85	74	76	85	80	80	84
NBMP-SC - Ni^{2+}	82	76	74	74	72	82	82
NBMP-SC - Co^{2+}	63	74	73	72	76	78	84
NBMP-SC - Mn^{2+}	78	73	71	76	81	79	85
NBMP-SC - Fe^{2+}	76	62	62	74	82	85	82
NBMP-SC - Fe^{3+}	82	85	87	82	84	74	83

BT= *Botrydeplala thiobromine* N= *Nigrospora Sp.* RN= *Rhisopus Nigricans*
AN= *Asperginus niger* AF= *Aeprogines funigalus* AA= anida Albicans
AK= *Andida krusegios candida grabrata*HO5

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