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Research Article

A NOVEL Mn(II) METAL COMPLEXES OF N, O DONOR METHYL SUBSTITUTED SALICYLOYL PYRAZOLE OXIMES: SYNTHESIS, SPECTRAL STUDIES AND ANTIMICROBIAL EVALUATION

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ABSTRACT

A series of four novel Schiff base methyl substituted salicyloylpyrazoleoxime and their Mn(II) complexes were synthesized and characterized by elemental analysis and thermal analysis, UV-Visible, IR, NMR spectroscopy. The elemental analysis data suggest that the Schiff base Mn(II) complexes have 1:2 (M:L) stoichiometry. The molar conductivity data show them to be non-electrolytes. Based on analytical and spectral data, four-coordinate geometry was assigned for all complexes. The electronic absorption spectra suggest the square planer geometry for the complexes. The ligand salicyloylpyrazoleoximes and their Mn(II) complexes were tested against gram positive bacteria *Bacillus subtilis, Staphylococcus aureus, Actinomycetes* and gram negative bacteria *Klebsiella, Pseudomonas aeruginosa*. The most of the ligands and metal complexes possess moderate antimicrobial activity.

Keywords: Synthesis, Salicyloylpyrazoleoxime, Spectroscopy, Non-electrolytes, Antimicrobial.

1. INTRODUCTION

Hydroxyoximes are flexible Schiff base ligands associated with hydroxyl group in addition to imine functionality. It is used as complexing agent and easy to make coordinate bond with bivalent metal through oxygen atom of phenol by deprotonation and through Nitrogen atom of imine group. The oximes are prominently used in isolation, separation and extraction of various metal ions [1-5]. The coordination chemistry of oxime and their metal complexes is remarkable because of these species exhibits variety of reactivity modes. They have been widely studied in variety of biochemical [6, 7] and analytical applications [8, 9].

Recently, pyrazoleoxime and their derivatives have attracted significant interest in chemical and medicinal research. The oxime group attached to the pyrazole ring is very good donor group because of its potential to facilitate different coordination modes. Also it is well known that Nitrogen atom of oxime group include in bond formation with metal atom and O atom forms bridge between two organic molecules through hydrogen bond. A pyrazoleoxime ligand contains two different bridging functions [10, 11]. A number of pyrazole derivatives show biological activity as antipyretic [12], antimicrobial [13] and antitumor activity [14]. Pyrazole derivatives are also used in agriculture as pesticides [15].

Among the transition metals, manganese is an essential metal in micronutrients of living organisms because it plays an important role in enzyme catalyzed reaction. The prospective use of manganese (II) complexes as a catalytic scavenger for H_2O_2 against oxidative stress [16-19]. Bipyridine and phenanthroline Mn(II) complexes shows antifungal activity in comparison with the antifungal drug ketoconazole [20]. Manganese (II) complex derived from Schiff base ligand 1,4-diaminobutane and pyridoxal hydrochloride exhibit prominent anticancer activity against breast cancer [21]. The Schiff base complexes using vitamin B6 with Mn(II) was found to and apoptosis inducer in human cancer cell [22].

The aim of the study of chelating ligands associated with oxime group invents from the fact that these types of ligands gives coloured complexes with transition metal ion and showing exciting properties. Transition metal complexes with oxime ligands have attracted much interest because they exhibit excellent coordination ability. Knowledge of their coordination towards metal ion will lead to better understanding of the structure,

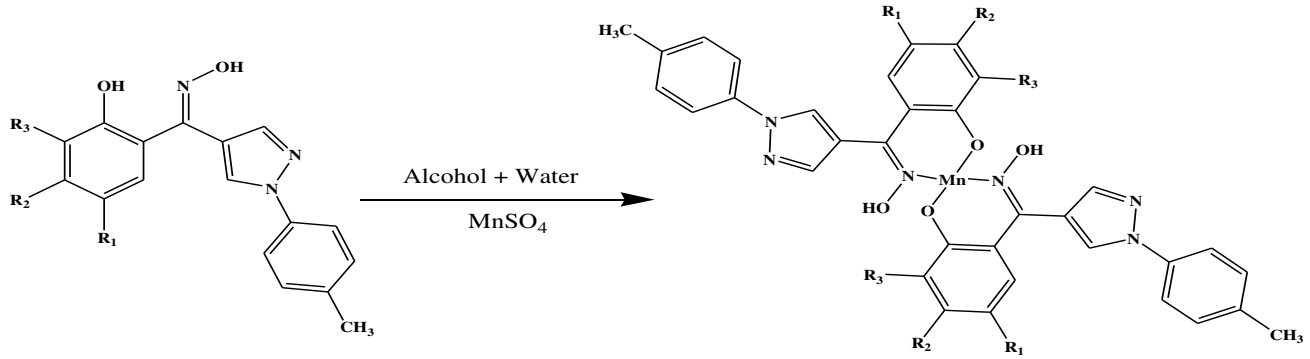
reactivity and stability of chelate complexes [23, 24]. Motivated by the aforementioned findings of hydroxyl oximes, pyrazoleoximes and manganese (II) complexes, we conceived our aim to synthesize Mn(II) complexes with pyrazoleoximes. In this paper we describe the synthesis, spectral analysis and microbial activities of novel Mn(II) complexes with salicyloylpyrazoleoximes.

2. MATERIAL AND METHODS

All the solvents, reagents and chemicals used in this work were of research grade and purified before use. Distilled water and distilled ethanol always used. The melting points were determined by open capillary method and uncorrected. Solution conductivity of complexes were measured using (Elico CM-180) conductivity meter in 1 $\times 10^{-3}$ M solution in DMF. UV-Visible spectra recorded in the range 190-700nm on Schimadzu double beam spectrometer (UV-1800) and IR spectra in the range 350-4000 cm^{-1} on Schimadzu FT IR instrument. The thermal analysis of the complexes was performed at Department of chemistry, New Arts, Commerce and Science college, Ahmednagar (MS). The percentage of metal in complexes were determined by volumetric method [25]. The procedure used for synthesis of ligand [26] and complexes was reported in earlier research [27].

2.1. General procedure for synthesis of Metal Complex

One equivalent of Manganese sulphate (0.001 mole) was dissolved in distilled water and acidified by conc. hydrochloric acid. The acidic solution of metal sulphate was warmed slightly on hot water bath. It was further treated with alcoholic ligand solution (2 equivalents). The ligand solution was added slowly drop after drop in the acidic metal solution. Little excess of ligand solution was added to ensure the complete complexation. The above mixed solution was then treated with alcoholic ammonia to make it alkaline. The solution was then digested on boiling water bath. The coloured complex precipitated out in alkaline medium. The resultant product was filtered, washed first with slight hot distilled water followed by ethyl alcohol to remove excess of ligand. The coloured precipitates of complexes were dried under ambient conditions.



Scheme 1: Synthetic route for Synthesis of Mn(II) Complexes of Methyl substituted Salicyloylpyrazoleoxime

3. RESULT AND DISCUSSION

The Mn(II) complexes with bidentate Schiff bases ligand methyl substituted salicyloylpyrazoleoximes were synthesized by the stoichiometric reaction of manganese sulphate and ligands in a 1:2 (M:L) molar ratio. The synthesized metal complexes were characterized by several physical, analytical and spectroscopic methods. The proposed formula for complexes (ML2) was supported by elemental analysis. The synthesized complexes are coloured which are different from colour of ligand supports the formation complexes. The melting points of metal complexes are different and higher than that of free ligands is also an evidence for complexation. The synthesized complexes are powder, non-hygroscopic and stable at room temperature. All the complexes are soluble in DMF, DMSO but insoluble in water and other organic solvents like acetone, chloroform, ethyl alcohol and carbon tetrachloride. The solubility behavior and analytical data of the complexes suggest that all the synthesized complexes are monomers. The low molar conductivity values for complexes indicates that the complexes are non-electrolyte and covalent in nature [28, 29]. This non-electrolyte nature of complexes supports chelating structure in complexes. The Physical, Analytical and molar conductance values are represented in Table 1.

3.1. IR spectrum

The free ligand shows broad band in the region 3130-3170 cm^{-1} due to hydrogen bonded ν(O-H) stretching frequency and absorption in the region 3220-3430 cm^{-1} assignable to free ν(O-H) stretching frequency. The absorption frequency in the range 3220- 3430 cm^{-1} which is assignable to free hydroxyl group, which was vanished upon metal complexation, suggest deprotonation and formation of metal oxygen bond of phenolic group. The hydroxyl stretching frequency in the region 3130- 3170 cm^{-1} was also shifted up to 30 cm^{-1} indicative of the coordination of nitrogen atom and presence of inter molecular hydrogen bonding between ligands to stabilize the complex [30].

The absorption frequency due to azomethine linkage was observed in the range 1540- 1550 cm^{-1} due to ν(C=N) and 1240- 1295 cm^{-1} due to ν(N-O) in the spectra of free ligands. The small shifting of these bands towards lower value in stretching frequency of azomethine group is also strong evidence for the coordination of nitrogen atom with metal ion [31, 32]. The absorption peaks due to ν(C-O) observed in the 960-995 cm^{-1} region. The spectra of free ligand showed hypsochromic shift in the spectra of the complexes. This supports bonding of the metal ions to the phenolic -OH after deprotonation [33]. The shift equally confirms the participation of oxygen in the C-O-M bond [34].

The further convincing evidence of the coordination of phenolic -OH group and oxime nitrogen was verified by arrival of new weak bands in the range 560- 530 cm^{-1} and 450- 475 cm^{-1} which is assigned to ν(M-O) and ν(M-N) respectively [35, 36]. These bands are only perceived in the spectra of manganese complexes not in free ligand. Thus all the IR data the metal ion is bonded to salicyloylpyrazole ligand through phenolic oxygen and imino nitrogen atoms [37].

The important peaks in FTIR spectra of synthesized free ligands and their manganese metal complexes are presented in Table 2.

Table 1: Physical and analytical data of Mn(II) complexes.

Complex (M. Formula)	Substituents R_1	R_2	R_3	Colour	M. P. (^{0}C)	% Yield	Found (Calcd.) % M	C	H	N	Molar conductance ($ohm^{-1}cm^2mol^{-1}$)
Mn-1 ($C_{34}H_{26}Cl_2MnN_6O_4$)	Cl	H	H	Dark Brown	252-254	78	7.59 (7.75)	57.46 (57.64)	3.94 (3.70)	11.75 (11.86)	28.9
Mn-2 ($C_{36}H_{32}MnN_6O_4$)	CH_3	H	H	Dark Brown	232-134	94	8.44 (8.23)	64.59 (64.77)	4.76 (4.83)	12.88 (12.59)	15.3
Mn-3 ($C_{34}H_{26}Br_2MnN_6O_4$)	Br	H	H	Dark Brown	212-214	89	6.76 (6.89)	51.56 (51.22)	3.44 (3.29)	10.66 (10.54)	22.7
Mn-4 ($C_{36}H_{30}Cl_2MnN_6O_4$)	Cl	CH_3	H	Dark Brown	>300	81	7.63 (7.46)	58.87 (58.71)	4.35 (4.11)	11.69 (11.41)	43.4
Mn-5 ($C_{34}H_{24}Cl_4MnN_6O_4$)	Cl	H	Cl	Dark Brown	208-210	86	7.29 (7.07)	52.33 (52.53)	3.35 (3.11)	10.75 (10.81)	26.1

Table 2: The significant peaks in FTIR spectra of free ligand and its Mn(II) complexes

Compound \ Frequency	ν_{O-H}	$\nu_{C=N}$	ν_{N-O}	ν_{C-O}	ν_{M-O}	ν_{M-N}
HL1	3364, 3160	1541	1295	985	-	-
Mn-1	3145	1543	1275	960	553	459
HL2	3244, 3165	1548	1276	962	-	-
Mn-2	3141	1516	1242	953	546	458
HL3	3223, 3157	1548	1274	991	-	-
Mn-3	3138	1541	1261	957	560	458
HL4	3430, 3165	1549	1253	985	-	-
Mn-4	3163	1553	1247	931	553	449
HL5	3264, 3159	1551	1247	971	-	-
Mn-5	3135	1518	1235	953	557	459

3.2. ^{1}H NMR spectra

^{1}H NMR spectra of selected compounds was recorded in DMSO-d_6 as solvent and TMS as internal standard in the range 0- 16 δppm. However due to presence of metal ion, proton resonance was not effected and gave broad peaks indicating the formation of metal complexes [38].

3.3. Thermal Analysis

The TG curve for manganese complexes did not show considerable weight loss up to 200°C, signifying that absence of lattice water and water of crystallization. The metal complexes showed decomposition temperature above 200°C also indicates that they are thermally quite stable, suggesting strong metal-ligand bonding. The decomposition of manganese complexes was started beyond 200°C, which may be due to the weight loss of organic ligands by evolution of gaseous products. Further increase in temperature, decomposition completed leading to formation of stable residue of manganese oxides in the temperature range 600-800°C.

The TG spectra of Mn-1 and Mn-5 complexes are presented in Figures-1. Mn-1 complex showed two step and Mn-5 complexes showed single step decompositions with formation for stable metal oxide as (Mn_2O_3). The observed stable residue for Mn-1 complex is 10.78% (Cal-11.08%) and for Mn-5 complex is 9.86% (Cal-10.10 %).

3.4. Electronic Absorption Spectra

3.4.1. Electronic absorption spectral study of ligands

The UV-Visible spectra of salicyloylpyrazoleoxime ligands were recorded to a known concentration (1 x 10^{-4}M) in DMF solution over a range 200- 700 nm. In the present investigation the absorption spectra of ligands exhibit two strong bands in the region 260- 340 nm, which are assigned to n→π* and π→π* transitions [39]. The observed λ_{max} values for all ligands are found to be nearly same. The λ_{max} values for synthesized ligands are summarized in table and spectra are represented in following Figs. 2 and 3.

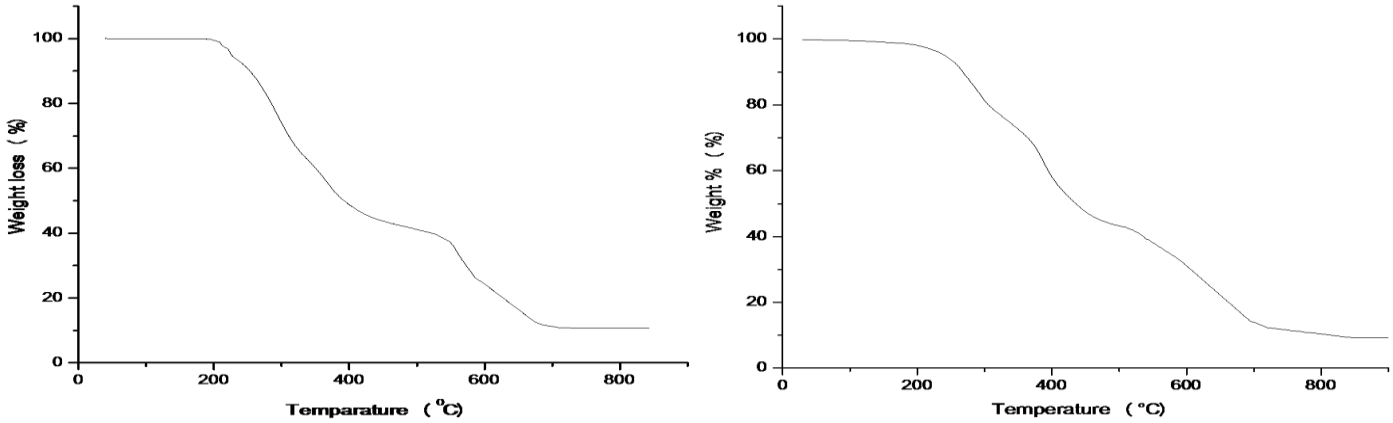


Fig. 1: TGA spectra of complex Mn-1 and Mn-5

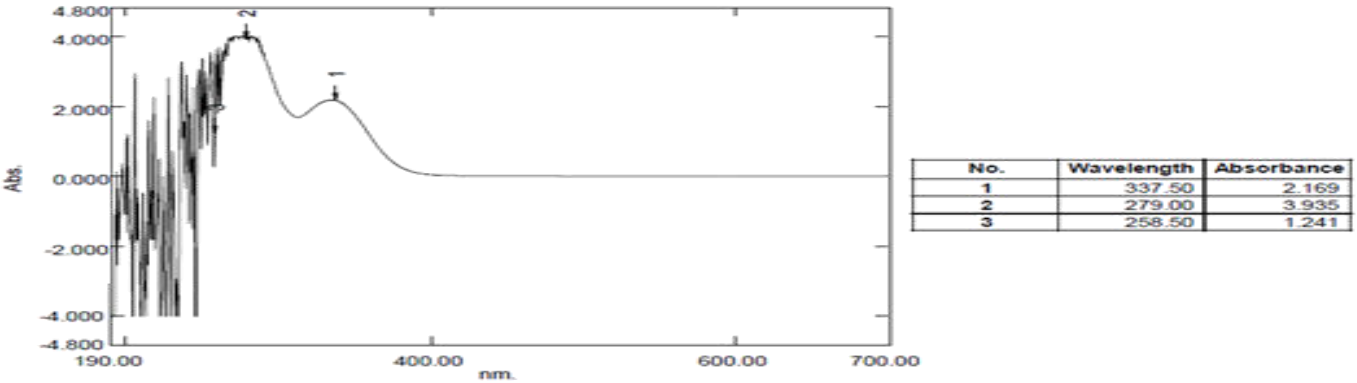
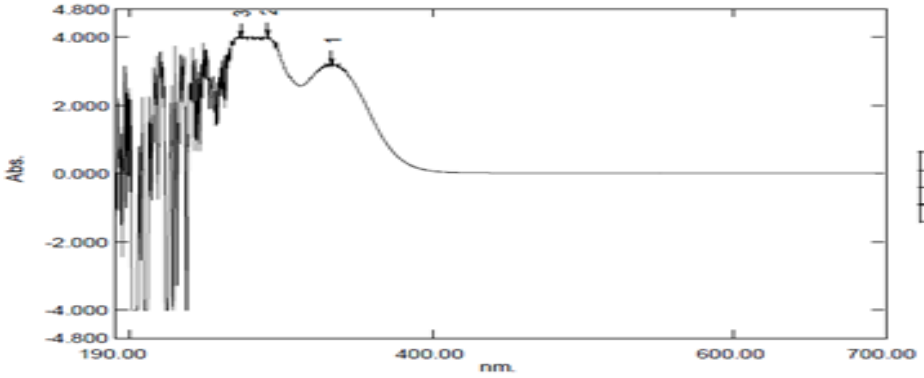


Fig. 2: Electronic absorption spectra of ligand (HL2)

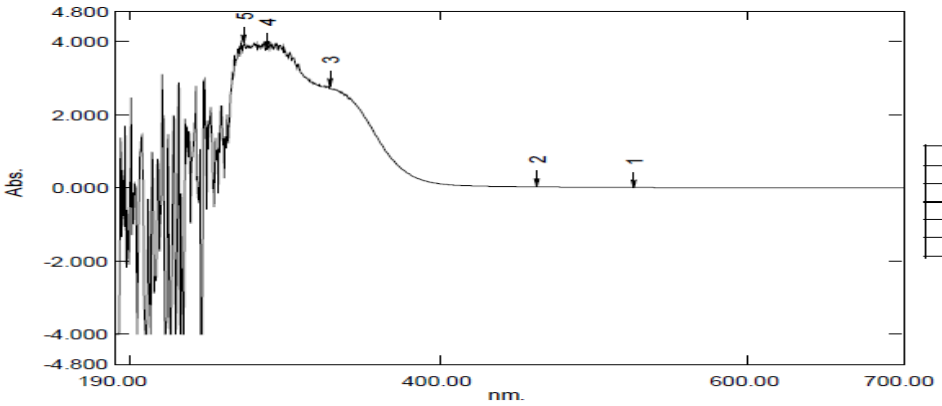
3.4.2. *Electronic absorption spectral study of complexes*

The electronic absorption spectra of manganese complexes showed two strong band in the region 280 nm and 330 nm due to π→π* and n→π* transitions. These bands are attributed to organic molecules and appeared to lower value than free ligands. Along with that in the absorption spectra of manganese complexes, a weak band observed in the region 450- 540 nm. These are associated with strong charge transfer bands and characteristics of square planar geometry for the complexes. The electronic absorption spectra of complexes Mn-2 and Mn-4 are presented in Figs. 4 and 5 and their λ_{max} values are summarized in Tables.



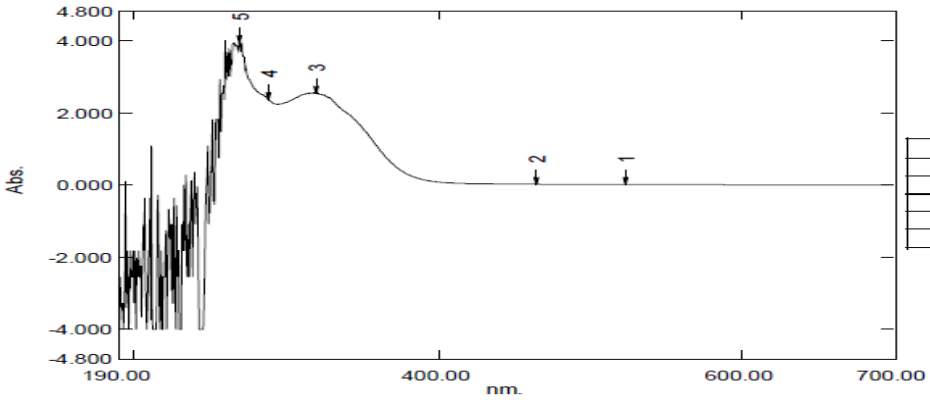
No.	Wavelength	Absorbance
1	334.00	3.139
2	291.20	3.977
3	273.00	3.973

Fig. 3: Electronic absorption spectra of ligand (HL4)



No.	Wavelength	Absorbance
1	526.00	0.008
2	463.00	0.022
3	329.00	2.759
4	288.00	3.769
5	274.00	3.952

Fig. 4: Electronic absorption spectra of complex (Mn-2)



No.	Wavelength	Absorbance
1	524.00	0.009
2	465.00	0.017
3	320.00	2.533
4	289.00	2.353
5	269.00	3.923

Fig. 5: Electronic absorption spectra of complex (Mn-4)

3.5. Antimicrobial evaluation

All the synthesized ligands and manganese complexes were tested against gram positive bacteria *Bacillus subtilis, Staphylococcus aureus, Actinomycetes* and gram negative bacteria *Klebsiella, Pseudomonas aeruginosa*. The newly synthesized compounds exhibited varying degree of inhibitory effect (low to moderate) on the growth of tested bacteria. The antibacterial data for synthesized ligand and complexes are presented in table 3 and fig. 6. However, antimicrobial screening of synthesized Schiff base metal complexes was found comparatively much more active than free ligands. The antimicrobial activity of metal complexes showed considerable zone of inhibition compared to that standard drugs. Most of the synthesized complexes showed antimicrobial activity against *Actinomycetes*and *Pseudomonas aeruginosa*. After coordination with metal ion, the compounds which are biologically inactive becomes active and biologically less active compounds becomes more active [40-42]. Such introduction and enhancement in the activity of metal complexes were explained on the basis of Overtone's concept [43] and Tweedy's chelation theory [44].

Table 3: Antimicrobial activity of salicyloylpyrazoleoxime and Mn(II) complexes.

Compound	Substituents				Bacteria				
					Gram-positive			Gram-negative	
	R_1	R_2	R_3	R	*Sa*	*Bs*	*Am*	*Ks*	*Pa*
HL1	Cl	H	H	CH_3	30	19	24	25	32
HL2	CH_3	H	H	CH_3	--	21	20	26	--
HL3	Br	H	H	CH_3	21	17	--	--	23
HL4	Cl	CH_3	H	CH_3	20	13	16	--	21
HL5	Cl	H	Cl	CH_3	--	17	--	24	--
Mn-1	Cl	H	H	CH_3	12	16	15	23	--
Mn-2	CH_3	H	H	CH_3	--	21	15	23	--
Mn-3	Br	H	H	CH_3	16	--	--	--	26
Mn-4	Cl	CH_3	H	CH_3	16	--	--	--	24
Mn-5	Cl	H	Cl	CH_3	15	20	16	20	27
Control	-	-	-	-	10	08	10	22	20
Penicillin	-	-	-	-	43	42	36	32	32

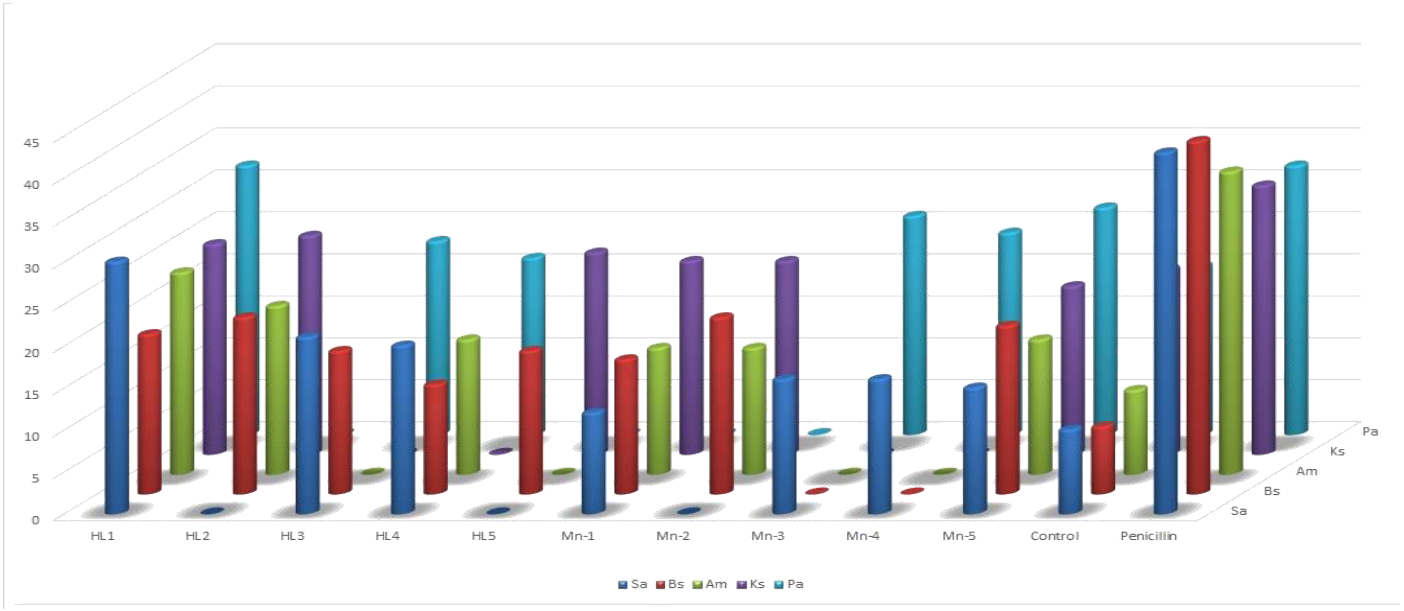


Fig. 6: Antimicrobial activity of salicyloylpyrazoleoxime and Mn(II) complexe

The dissimilarity in the activity of the different metal complexes against different bacteria depends either on the impermeability of the cells of the microbes or difference in the ribosomes in the microbial cells [45,

46]. The metal complexes may also be a vehicle for activation of the ligand as a cytotoxic agent. Moreover, complexation may lead to significant reduction of drug resistant [47]. Besides this other factor such as solubility, conductivity and dipole moment influenced by the presence of metal ions may also be the possible reason causing enhancement of the antimicrobial activity of chelate complex as compared to free Schiff base compounds [48]. The antimicrobial activity may also enhance due to involvement of formation of hydrogen bond through the azomethine group with the active centers of cell constituents, resulting in an interference with normal cell process [49].

Now it is clear that, these compounds possess antibacterial properties. Use of these compounds as antibacterial on therapeutic scale need to be further elaborated. In many cases the bacterial pathogens have acquired resistance against traditional compounds or drugs. Under such conditions, these new compounds can be tried as alternative compounds for the control of these pathogens. However, further studies in this direction are needed.

4. CONCLUSION

In this present study new salycyloylpyrazoleoxime and its manganese complexes are reported. The newly synthesized ligands and complexes are characterized by physical methods and elemental analysis. The formation of metal complexes confirmed by UV-Visible, IR and ^{1}H NMR spectroscopy. The spectral data suggest that the oxygen atom of phenol group and nitrogen atom of imine group are involved in coordination with metal ion. The formation of metal complexes is also confirmed by thermal methods of analysis. All the metal complexes are stable below 200°C and decomposes slowly after 200°C giving formation of corresponding metal oxide. The complexes are insoluble in water, alcohol and other organic solvents but good solubility in DMF and DMSO. The electronic absorption spectra suggest probable square planer geometry. The molar conductance values of these complexes suggest the non-electrolytic nature. The antibacterial study revealed that the most of the ligands and metal complexes possess moderate antimicrobial activity.

5. ACKNOWLEDGMENT

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