

Efficient Bioassay Profile of Transition Metal Schiff Base Complexes

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Abstract- The 3d transition metal Mn (III) and Ir (III) complexes of prominent bioactive isonitroso schiff's base ligand p-Methoxy isonitrosoacetophenone (p-MINAP) derived from p-methoxy acetophenone have been synthesized. The complexes of formula Mn(p-MINAP)₃ and Ir(p-MINAP)₃ have characterized on the basis of elemental analysis, magnetic data, electronic spectra, Infrared Spectra, ¹H NMR Spectral data and antimicrobial activity. The paramagnetic and spectral features of the Mn(III) and Ir(III) complexes suggested octahedral geometry.

Key word: Octahedral geometry, magnetic susceptibility, IR, ¹H NMR and electronic spectra, p-MINAP.

INTRODUCTION

Schiff Bases for the first time were reported by H. Schiff in 1864 as a reaction of primary amines (R-NH₂) with aldehydes. Since then, the formation mechanism of azomethines, known as Schiff bases, and the properties of azomethines to form complexes have been widely investigated [1]. In recent years, many Schiff bases and their metal complexes have been synthesized and reported to exhibit biological activity [2–9]. The 3d transition metal complexes of bidentate oximes are capable of exhibiting a variety of structures owing to their potential ambidentate character. For many Co (II) and Ni (II) complexes obtained from isonitroso-β-diketones asymmetrical ring structures have been reported [10, 11]. Patel and coworkers [12] have proposed a symmetrical five member ring structure. The ligand p-Methoxy isonitrosoacetophenone (p-MINAP) has been used for few analytical applications [13, 14]. However, structural studies of the Mn(III) and Ir(III) complexes with (p-MINAP) have not been reported as such. It was therefore considered worthwhile to prepare and characterize them and report their structural features on the basis of magnetic data, electronic, IR spectral studies, ¹H NMR and Antimicrobial Activity.

EXPERIMENTAL SECTION

Chemicals:

The chemicals, reagents, solvents used were of analytical reagent grade. The novel isonitroso schiff's base ligand p-Methoxy isonitrosoacetophenone was prepared by the method described in the literature [15, 16]. The metal complexes are prepared as follows:-

Preparation of Mn(p-MINAP)₃ complex :-

1:3 stoichiometric ratios of Manganese acetate and (p-MINAP) were dissolved in minimum quantity of absolute alcohol and equal volume of distilled water. The Manganese acetate solution was added to the reagent solution drop wise with constant stirring. The pH of the resultant solution was adjusted to 6.3 –6.9 with HCl / NH₄OH. A Prussian blue colored complex thus formed was digested on water bath for 2 hours and then kept in vacuum for overnight; it was filtered, washed with distilled water & dried. It was recrystallized from chloroform and finally analyzed for Manganese, carbon, hydrogen and nitrogen.

Preparation of Ir (p-MINAP)₃ Complex:-

1:3 stoichiometric ratios of Iridium (III) chloride and (p-MINAP) were dissolved in minimum quantity of absolute alcohol and equal volume of distilled water. The Iridium chloride solution was added to the reagent solution drop wise with constant stirring. The pH of the resultant solution was adjusted to 4.5 to 5. Then the solution was kept in a boiling water bath for 35 minutes, a grey colored complex was separated. It was filtered, washed with distilled water, dried at 100°C for several hours. It was recrystallized from chloroform and finally analyzed for Iridium, carbon, hydrogen and nitrogen.

Physical Measurements:

Magnetic measurements of solid complexes were carried out from room temperature to liquid nitrogen temperature with Govy balance using mercury tetra-thiocyanato cobalt (II) as magnetic susceptibility

standard. Diamagnetic corrections were calculated by the method given in the literature. Visible and Ultraviolet spectra of the ligand and the complexes were recorded on a Schimat Zq Uv-2000 spectrophotometer. Infrared spectra of the ligand and the complexes were obtained on specord M 75 ir in KBr pellets. The conductance measurements were made in nitrobenzene solution.

RESULTS AND DISCUSSION

Data Analysis and some properties of the complexes are reported in Table 1. On the basis of analytical data Mn (III) and Ir (III) complexes can be represented as $M(p\text{-MINAP})_3$. The complexes are colored and have good thermal stability. They are insoluble in water and dilute alkaline solution suggesting absence of a free oxime group due to removal of oximino proton during Complex formation. This is supported the infrared spectral studies. The molar conductance value of complexes in nitrobenzene shows that these are non-electrolytic in nature [17].

Magnetic Measurements:

The result of magnetic susceptibility measurements in a variable temperature data suggest that the Mn(III) and Ir(III) complexes may be paramagnetic with Octahedral geometries[18,19]. These suggestions are in agreement with spectral observation

Electronic Spectra:

The electronic spectral data for ligand field transition are summarized in Table 2. The complexes show a group of three or more bands in the 45.64 kK range which can be assigned as π - π^* or ligand metal transitions. The electronic spectral of (p-MINAP) in methanol shows an intense band at 46.75kK. It splits into two strong bands at 42.19kK and 41.69 kK. These can be explained by presuming that the symmetric

electron system cloud of (p-MINAP).They may be assigned to π - π^* transitions. The electronic spectrum of Mn(III)complex (Table 2) was consistent with a very broad intense band in the 51.85 kK region and band in the 42.56kK range. A shoulder also appears in the 46.61kK region. This region screened by the intense charge transfer band exhibited the broad maxima at 54.26 kK[20, 22].

Infrared Spectra:

I.R. spectra ($4000\text{-}400\text{ cm}^{-1}$) of the complexes are practically identical. The frequencies of some significant band of the free ligand and those of the metal complexes are reported in Table 4. The observed frequencies of different groups in the metal complexes have been assigned on the basis of literature data. The $\nu\text{-O-H}$ of the oxime group observed at 3317 cm^{-1} in (p-MINAP) is absent in the spectra of the complexes suggesting replacement of the oxime proton by the metal ion during complexation [23].The peak observed near 1710, 1595.68, 1610.11 cm^{-1} in spectrum of p-MINAP, $\text{Mn}(p\text{-MINAP})_2$ and $\text{Ir}(p\text{-MINAP})_2$ respectively, may be assigned to the perturbed $\nu\text{C=O}$ and/or $\nu\text{C=N}$ stretching vibration involving bonding through oxygen, and nitrogen donor atoms. A band appears in the range 1300-1200 cm^{-1} is reported that N-oxide ($\text{N}\rightarrow\text{O}$) stretching mode in aromatic ring compounds [24]. The bands at 1230.57, 1225.98 cm^{-1} in $\text{Mn}(p\text{-MINAP})_3$ and $\text{Ir}(p\text{-MINAP})_3$ respectively are attributed to the N-O stretching in the ligand[25].

It is significant to note that for metal complexes reported to have coordination only through the oxime oxygen or nitrogen atoms only. One medium to strong band at around 1050 or 1200-1250 cm^{-1} is found leading to a symmetrical six member ring structure [26] or asymmetrical five member ring structure.

Table –1 Analytical Data, Color and μ_{eff} . at room temperature

Complex	Colour	% C	% H	% N	% M	μ_{eff} .
p-MINAP	Brown	60.30 (60.33)	5.16 (5.06)	7.75 (7.82)	----	----
$\text{Mn}(p\text{-MINAP})_3$	Prussian Blue	52.29 (52.31)	4.37 (4.35)	6.75 (6.77)	13.25 (13.29)	Paramagnetic
$\text{Ir}(p\text{-MINAP})_3$	Grey	39.28 (39.25)	3.27 (3.25)	5.02 (5.08)	17.48 (17.49)	Paramagnetic

Table 2: Electronic Spectral data of complexes

Complex	Absorption spectra in methanol (nm)	Wave No kK
$\text{Mn}(p\text{-MINAP})_3$	211	51.85
	238	42.56
	259	46.61

Ir(p-MINAP) ₃	207	44.95
	238	41.26
	259	39.89

Table 3: Infrared Spectral Frequencies (4000 to 400 cm⁻¹) of ligand and metal complexes

Ligands (p-MINAP)	Mn(p-MINAP) ₃	Ir(p-MINAP) ₃	Assignment of group
3018.70	3024.72	3088.70	Aromatic C-H
3317.39	-----	-----	OH of =N-OH
1710.51	-----	-----	-C=O
1610.11	1595.68	1610.11	-C=N
2840.23	2860.32	2840.23	-OCH ₃
1440.12	1447.68	1413.12	=C-H
-----	1230.57	1225.98	=N→O
766	790.30	788.34	Para Substituent
-----	660.68	658.41	M-N

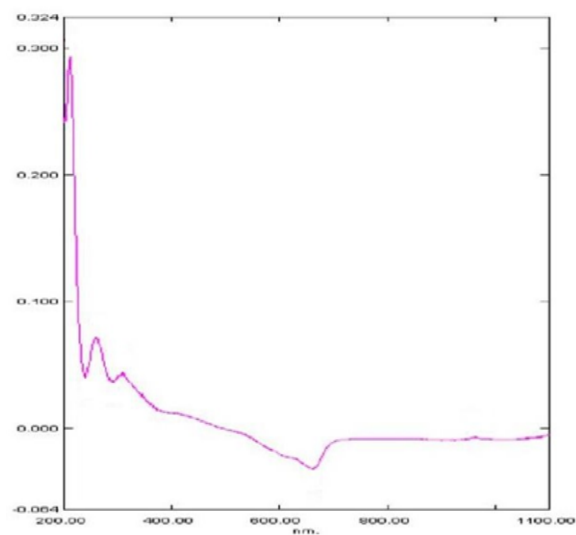


Fig. 1: Electronic Absorption Spectra of Prominent Bioactive ligand p-methoxy isonitroso acetophenone (p-MINAP)

¹H NMR Spectra

NMR Spectra of p-MINAP, Mn(p-MINAP)₃ and Ir(p-MINAP)₃ in DMSO solution exhibit peaks due to -CH group, -OCH₃ group & C_a and C_b of aromatic ring protons & does not show any proton signal due to =N-OH group. This suggest that their complexes have been formed by the replacement of the proton of the =N-OH group by the metal ion. It is interesting to note that the peaks due to -OCH₃ protons in Mn(p-MINAP)₃ and Ir(p-MINAP)₃ appear at similar value

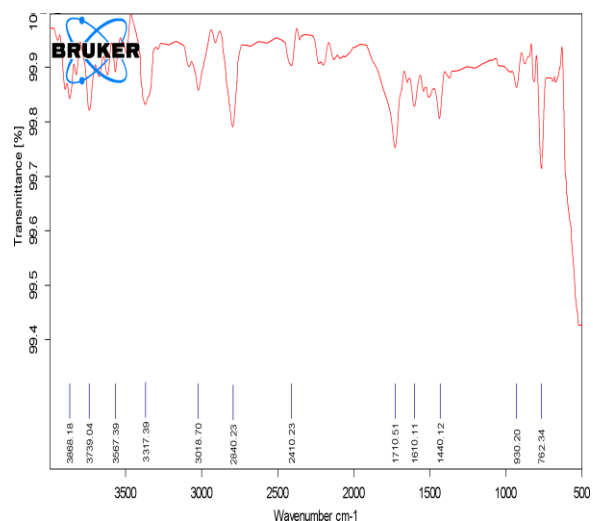


Fig. 2: Infrared Spectra of Prominent Bioactive ligand p-methoxy isonitroso acetophenone (p-MINAP)

compared to that of -OCH₃ proton in the bioactive ligand p-MINAP. Further signals of aromatic ring protons in these complexes occur at higher field side with respect to that of aromatic ring signal in P-MINAP. The donor atom is closest to the metal ion which involved in the formation of metal ligand bond. Nuclear magnetic resonance signals observed in bioactive ligand p-methoxy isonitroso acetophenone (p-MINAP) and its metal complexes are shown in Table 4.

Table 4: Assignments of ¹H NMR Signals in p-MINAP & Metal Complexes

All Values in δ scale

Cmpounds	=NOH group	Aromatic Ring -C _a H group	Aromatic Ring -C _b H group	-CH Group	-OCH ₃ Group
p-MINAP	8.48	7.92	7.60	2.42	3.90
Mn(p-MINAP) ₃	---	7.90	7.66	2.44	3.90
Ir(p-MINAP) ₃	---	7.96	7.68	2.46	3.90

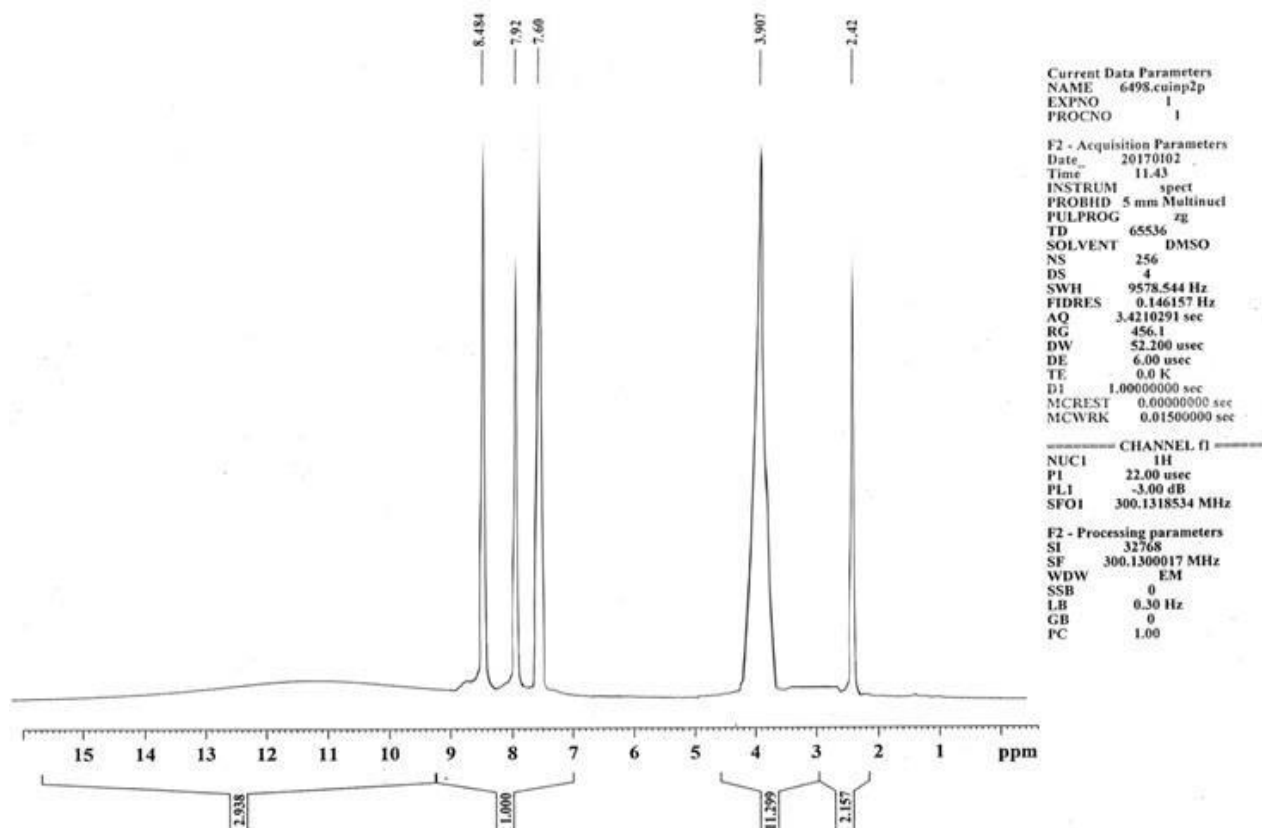


Fig. 3: ¹H NMR Spectra of Bioactive ligand p-methoxy isonitroso acetophenone (p-MINAP)

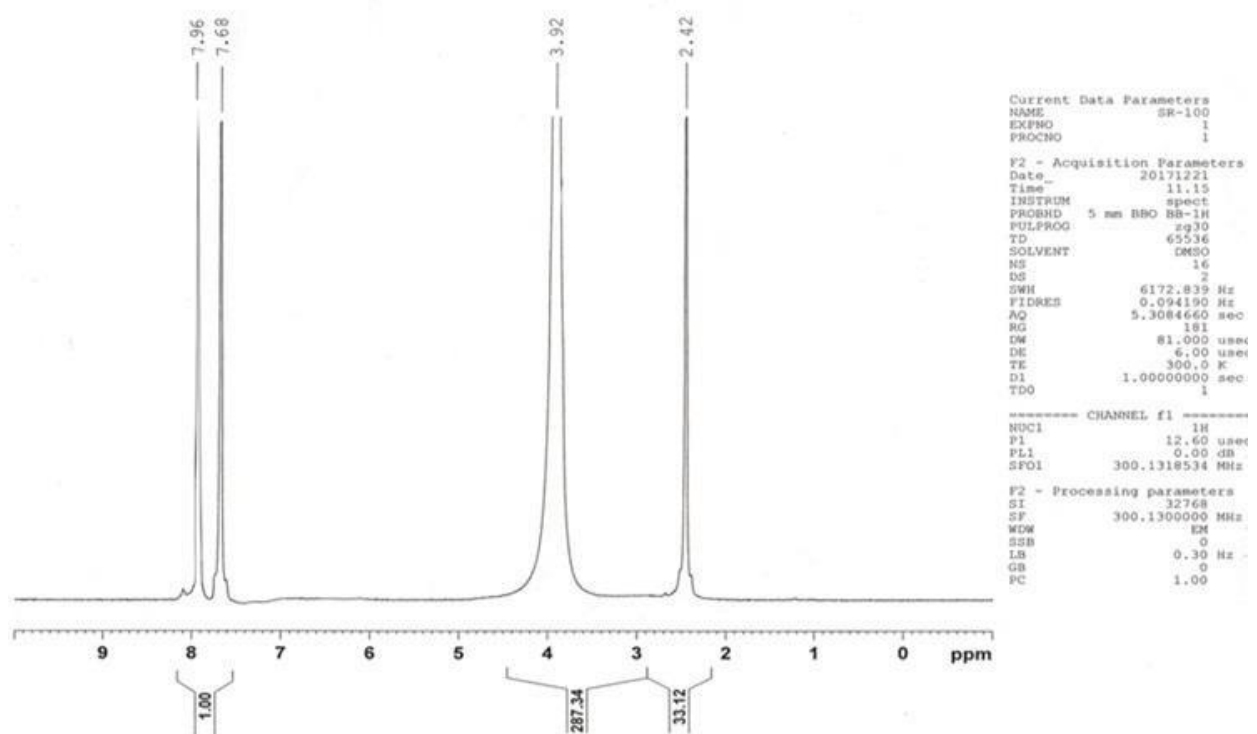


Fig. 4: ¹H NMR Spectra of Transition metal complex Ir(p-MINAP)₃

Antimicrobial Activity: -

Antibacterial activity of the synthetic 3d transition metal complexes of p-methoxy isonitroso Acetophenone was examined against *E. coli*, *S. aureus*, *P. aeruginosa*, *B. subtilis*, *B. cereus* and *K. pneumoniae*. Antifungal activity of the same compounds was evaluated against *C. albicans*, *A. niger* and *F. oxysporium*. Assays were performed in agar media with final concentration of 500 µg/ml. All the synthesized compounds are effective at this concentration of 500 µg/mL. The results showed that the ligand (p-MINAP) and synthesized complexes of p-MINAP exhibited poor to good antibacterial and antifungal activities against all the tested strains.

Complexes of Mn (p-MINAP)₃ and Ir(p-MINAP)₃ were shown maximum zone of inhibition and hence

were found to inhibit the growth of all tested strains of bacteria and fungi. It may be due to the more penetrating power of iron complexes to the cell wall of bacteria, which prevents the biosynthesis of peptidoglycan or may find better fit at the receptor site as compared to other compounds. Though the ligand exhibited antibacterial and antifungal activity against all the tested strains, its activity is less when compared with its metal complexes and hence suggested its unsuitability against all the strains. None of the synthesized complex showed more activity as compared to the standard drug.

Table.5: Antibacterial Activity Data of p-MINAP & Synthesized Complex

Compound	Bacteria along with zone of inhibition(mm)					
	<i>E. Coil</i>	<i>S. aureus</i>	<i>P. aeruginosa</i>	<i>B. Subtilis</i>	<i>B. cereus</i>	<i>K. penumoniae</i>
P-MINAP	10	12	11	10	13	12
Mn(P-MINAP) ₃	12	13	11	14	14	15
Ir(P-MINAP) ₃	12	13	10	12	10	09
Gentamycin	17	20	18	18	20	19

Table 6: Antifungal Activity Data of P-MINAP & Synthesized complex

Compound	Fungi along with zone of inhibition(mm)		
	<i>C. albicans</i>	<i>A. niger</i>	<i>Fusarium oxysporium</i>
P-MINAP	13	12	11
Mn(P-MINAP) ₃	17	16	15
Ir(P-MINAP) ₃	13	13	14
Miconazole	22	21	22

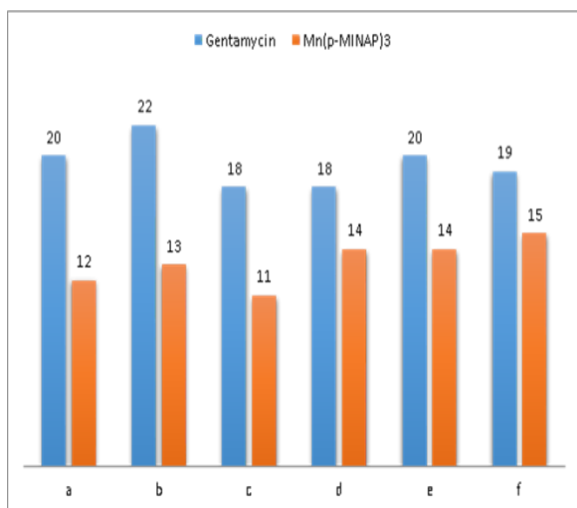


Fig. 5: Antibacterial activity of parent Gentamycin and Mn(III) complex of p-MINAP. *E.coli* (a), *S. aureus* (b), *P. aeruginosa* (c), *B. subtilis* (d), *B. cereus* (e), *K. pneumoniae* (f)

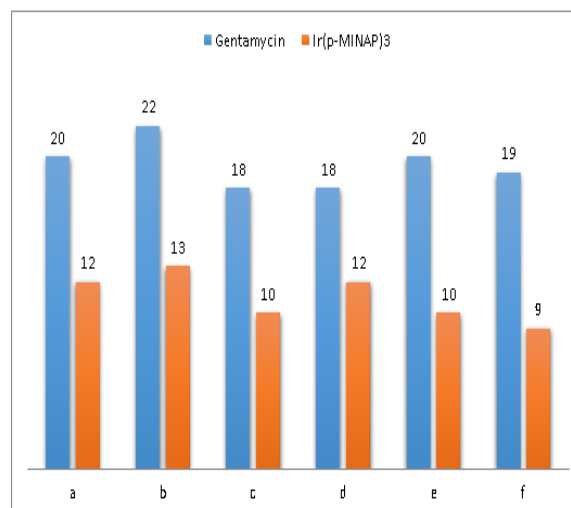


Fig. 6: Antibacterial activity of parent Gentamycin and Ir(III) complex of p-MINAP. *E.coli* (a), *S. aureus* (b), *P. aeruginosa* (c), *B. subtilis* (d), *B. cereus* (e), *K. pneumoniae* (f)

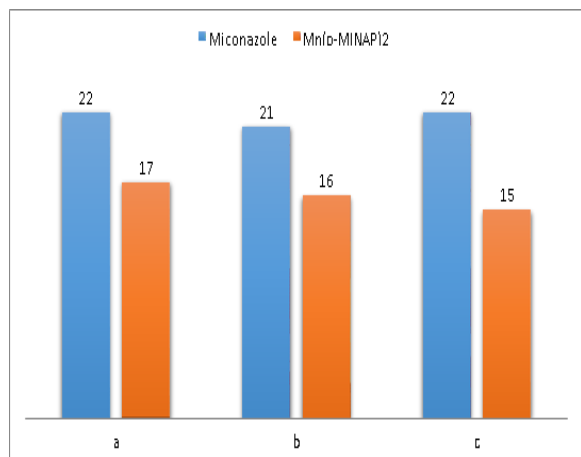


Fig. 7: Antifungal activity of parent Miconazole and Mn(III) complex of p-MINAP.

C. albicans (a), *A. niger* (b), *F. Oxysporium* (c)

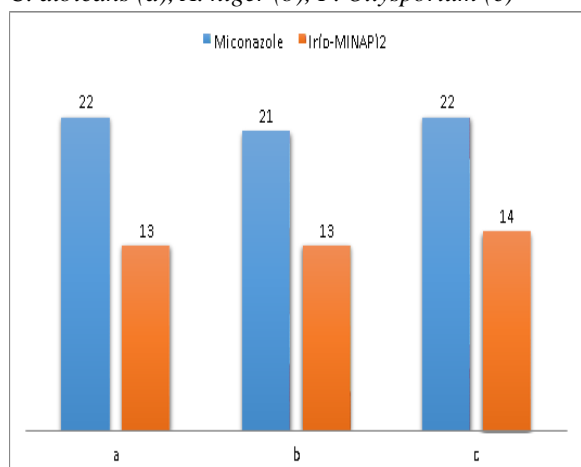


Fig. 8: Antifungal activity of parent Miconazole and Ir(II) complex of p-MINAP.

C. albicans (a), *A. niger* (b), *F. Oxysporium* (c)

CONCLUSION

On the basis of analytical data, Magnetic properties and spectral data, the novel isonitroso prominent bioactive ligand with transition metal ion composition was found to be 1: 3 and octahedral geometry has been assigned to transition metal complexes of Mn (III) and Ir(III).

Similarly, on the basis of Antimicrobial Activity it is proved that the complexes are prominent bioactive ligand.

Overall, this research study has successfully synthesized and characterized transition metal complexes with a novel isonitroso Schiff's base ligand. The complexes have shown promise as bioactive

compounds with potential applications in the field of antimicrobial agents.

Conflict of Interest:

Due to my original work there is no conflict of Interest

ACKNOWLEDGEMENT

The authors would like to thank all the support staff of the Department of Chemistry, Vidya Vikas Arts, Commerce & Science College, Samudrapur Dist-Wardha, Maharashtra, Faculty of Science and Technology, R. T. M. Nagpur University, Nagpur for all the support rendered during this study.

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