RJC

RASĀYAN *J. Chem.*
Vol. 16 | No. 2 |735-739| April - June | 2023
ISSN: 0974-1496 | e-ISSN: 0976-0083 | CODEN: RJCABP
http://www.rasayanjournal.com
http://www.rasayanjournal.co.in

EVALUATION OF MULTIDIMENSIONAL BIOLOGICAL ACTIVITIES OF SYNTHESISED COMPLEXES OF Fe(II), Co(II), Ni(II) and Cu(II) USING SCHIFF BASE LIGANDS

Sapna✉ and Neelam Kumari
Department of Chemistry, Meerut College, CCS University, Meerut-250003, Uttar Pradesh, India
✉Corresponding Author: sapna123raj@gmail.com

ABSTRACT

Schiff base ligands are chemical compounds having diverse biological activities like industrial, agriculture and pharmaceutical. The current work discusses the evaluation of the biological properties of different synthesized mononuclear Fe(II), Co(II), Ni(II) and Cu(II) complexes. The complexes were synthesized using a condensation reaction which demonstrated the appearance of White, Cream, Black and Green. Biological activities for synthesized metal complexes were assessed against *S. aureus, B. cereus, E. coli and P. aeruginosa* and by comparing the zones of inhibition it can be depicted that metal complexes are fairly more effective inhibitors of gram-positive bacteria. Furthermore the antioxidant potential of these complexes was also evaluated and it concluded that copper complexes showed promising antioxidant activity which is higher in association with Ni(II), Fe(II), and Co(II). Hence, these metal complexes were biologically active and further studies are required.

Keywords: Schiff bases, Metal Complexes, Condensation, Antibacterial, Antioxidant.
RASĀYAN *J. Chem.*, Vol. 16, No. 2, 2023

INTRODUCTION

If we talk about coordination chemistry, Schiff bases are considered to be widespread ligands which are generally bidentate, tridentate, tetradentate or polydentate ligands. They are classified on the basis of the number of donor atoms present, such as Nitrogen (N), Oxygen (O) and Sulphur (S). These Schiff base ligands are expanded enormously to combine with metal ions and produce very stable complexes. Their applications are ranging from chemical areas to biological chemistry.[1] These compounds have similarities with naturally occurring biological substances due to their flexibility and presence of imine moiety (-N=CH-) which take part in transformation and re-examination reactions in a biological system.[2] The reaction mechanism used for the synthesis of these complexes involve in vivo binding or variation in activation energy however, ligands in metal ions can reduce or increase the reduction-oxidation potentials of a reaction, affecting the reaction process.[3] However, Schiff base ligands were synthesized using the condensation method which is the core of macrocyclic chemistry. Template reaction participated in the preparation of macrocyclic ligands in absence of metal ions and also in isolating the macrocyclic complexes. Transition metals played a role as a templating agent.[4] Apart from biological compounds, these metal complexes also played a vital role in Industrial, agriculture and pharmaceutical chemistry.[5] They are used as biological catalysts for the synthesis of various biopolymers as well as in the birth control and food packaging industries.[5] However, Schiff bases are less potent in comparison to metal complexes[6] because metal ions enhance the activity of different biologically active compounds. In recent years, transition metal complexes are reported for their vast contribution to the area of medicine and pharmaceutical. These complexes showed activity such as antibacterial, anticancer, antiphrastic, antiviral, antifungal and anti-HIV.[7] Previous works showed not only the inhibition of a broad range of bacteria but also determine the MIC value for the same.[8] This biological activity was sustained along with SEM study [Pd (L)(Cl)] possess the bactericidal activity and bacteriostatic activity.[9] The semi-synthetic penicillin-type antibiotic also affects the growth of positive and negative bacteria by preventing cell wall formation.[10] Schiff base ligands having two azo groups and their complexes are synthesized which also showed antimicrobial activity.[11] The compound [CuLphen] showed antimicrobial activity[12] and Cu(II) complexes with semicarbazones and thiosemicarbazones are also reported.[3] The metal complexes

http://doi.org/10.31788/RJC.2023.1628309

containing Schiff bases were also previously accessed for their radical scavenging and antioxidant properties in comparison to water-soluble L-ascorbic acid as a standard compound.[3,13] In light of the above-discussed specifics, it can be concluded that metal ligands can be a potent source for exhibiting different biological activities. This work deals with the formation of four metal complexes by condensation method and the compounds have been analyzed for various antibacterial activities followed by the DPPH radical scavenging activity of these compounds.

EXPERIMENTAL

Chemicals

Present work uses different transition metals like cobalt(II) acetate tetrahydrate, nickel(II) acetate tetrahydrate, copper(II) acetate monohydrate, iron(II) acetate dehydrate, salicylaldehyde, 2-Methyl-3-semicarbazide and 2-Methyl-3-thiosemicarbazide. The solvents such as ethanol and methanol were also used. The highest purity and analytical reagent [AR] grade chemicals were employed and they were all procured by Sigma-Aldrich.

Synthesis of Schiff Base

For the preparation of the Schiff base, the method suggested by Kailas et al., 2016[14] opted for some modifications. The Schiff base ligands have been prepared through the condensation process of salicylaldehyde with 2-Methyl-3-semicarbazide and 2-Methyl-3-thiosemicarbazide in a 2:1 ratio.

Schiff Base Metal (II) Complexes: Synthesis

Metal complexes were synthesized by the amalgamation of methanolic solution of Schiff base ligand with appropriate metal salts in equal volume i.e. 1:1. The above-prepared mixture was recirculated in a water bath for 8–12 hrs till the final volume become 15ml, followed by addition of 15mL of ether. Now, this preparation was cooled to 0^0C which causes the precipitation in the reaction mixture. After the end of the process, through filtering and ether washing, the precipitated product was recovered and chloroform was used for recrystallization using a vacuum evaporator.[15]

Antimicrobial Activity Process

Bacillus cereus, Pseudomonas aeruginosa, Staphylococcus aureus and *Escherichia coli* were used as indicator organisms for assessing the bioactive potential of metal complexes. For enumerating the antibacterial effect of metal ligands agar well diffusion method was employed which uses Muller Hinton agar medium which provides proper nutrition to test pathogens[16]. MHA plates were prepared on which 100 microliter of test bacteria was swabbed and left for drying followed by making the wells in the plates using the cork borer. In these wells, 100 mg/ml concentration of each complex was used and upon completion of the incubation (24-48 h at 35°C) inhibition zone was recorded. A stock solution of metal ligands was prepared using DMSO. Ampicillin and DMSO alone were employed as the positive and negative controls respectively for comparison of the inhibition zone produced by the metal compounds. To minimize the error each experiment was performed thrice.

Antioxidant Activity

The method described by Kizilkaya et al., 2020[17] was used for in vitro evaluation of the radical scavenging activity. DPPH was used to estimate the scavenging effect of Schiff metal(II) complexes. DPPH solution was treated with the complexes of Schiff bases with transition metal(II). A spectrophotometer was used to measure the reaction's absorbance at 517 nm after it had taken place for 30 seconds at room temperature. The standard equation has been used to calculate the DPPH scavenging activity.

RESULTS AND DISCUSSION

Synthesis

In existing work, Schiff base ligands were synthesized using the condensation method. Salicylaldehyde with 2-Methyl-3-semicarbazide and 2-Methyl-3-thiosemicarbazide was condensed in a 2:1 ratio. The structure proposed for Schiff base ligands is given in below Fig.-1. Some of the characteristics of synthesized complexes were concise in Table-1. All the synthesized complexes were solids, non-

hygroscopic, bright colors and unreactive with air at ambient temperature, soluble in several organic solvents like DMSO.

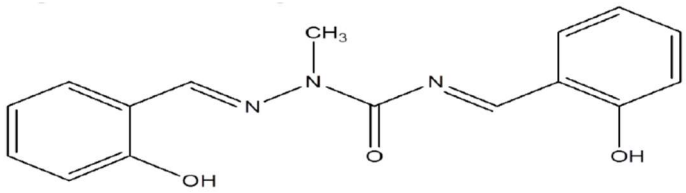

Fig.-1: 1,4-bis(2-hydroxy benzylidene)-2-methyl Semicarbazide

Table-1: Physical Data of all Complexes.

Compound	Color
Fe(II)+B	White
Co(II) +B	Cream
Ni(II) +B	Green
Cu(II) +B	Black

Antimicrobial Activity

The antimicrobial activity of any compound is defined as its ability to hamper the increase of pathogenic microbes by restricting some specific kind of biological mechanisms. In the present work, all metal ligands were found to be active against all the tested pathogens out of which Cu (II)+B showed comparable activity in comparison with the standard drugs against *S. aureus* and *B. cereus*. As per the obtained results, it can be concluded that all the metal complexes impart bioactivity against tested pathogens. Cu (II)+B showed more or less similar kind of results in comparison with the standard drug against *S. aureus* and *B. cereus*. These metal complexes may alter the cell permeability and lipophilicity of microbes which ultimately decreases the number of active cells. This alteration is mainly caused because of the existence of azomethine chromophore and OH- function forming a bond with dynamic centers of the cells membranes which ultimately increase the permeability[18] moreover another attribute towards antibacterial activity is blockage of protein synthesis caused due to lack of cell respiration which ultimately causing the death of organisms.[19] The maximum antibacterial activity was exhibited by Cu (II)+B against *B. cereus* (28mm) whereas Mn(II)+B showed a minimum zone of inhibition against *P. aeruginosa* (14mm). The test bacterial strains used in the present work showed a difference in susceptibility pattern because of differences in cellular makeup i.e., the difference in the amount of peptidoglycan and the presence or absence of an outer membrane.[20] The results for the antibacterial activity exhibited by metal complexes as well as standard drugs were summarized in Table-2.

Table-2: Antibacterial Properties of Compounds using Schiff Bases as Ligands

Compound	*E. coli*	*P. aeruginosa*	*S. aureus*	*B. cereus*
Fe(II)+B	15	14	24	26
Co(II) +B	16	18	23	26
Ni(II) +B	16	15	26	24
Cu(II) +B	18	16	25	28
DMSO	-	-	-	-
Ampicillin	13	16	29	28

Antioxidant Activity

The human body is a house of chemical reactions where different metabolic processes happened. During these processes reactive oxygen species (ROS) were produced degrading the structural components like nucleic acid, lipids and proteins causing diabetes, cancer, atherosclerosis, Alzheimer, Parkinson's, etc. Due to these above-discussed negative effects of ROS, DPPH scavenging potential of metal complexes were examined taking ascorbic acid as a standard.[21] The most active Schiff base metal-ligand was Cu(II) +B, which exhibits 45% scavenging activity whereas the minimum was shown by Co(II) +B (34%). The difference in the activity is due to the variation in hydrogen donation potential metal complexes which depict the order of Cu(II) > Ni(II) > Mn(II) > Co(II)[22]. By analyzing the above results it can be concluded that apart from all the metal complexes only the Copper(II) complex was found to be more potent in comparison to others.

Table-3: Antioxidant Activity of Compounds using Schiff Bases as Ligands

Compounds	% DPPH Scavenging Activity
Fe(II)+B	40
Co(II) +B	34
Ni(II) +B	42
Cu(II) +B	45
Ascorbic Acid	56

CONCLUSION

The present work encompasses not only the Schiff bases and synthesis of metal complexes but also exhibited their antibacterial activities which showed their potential towards gram-negative test bacterial strains. Moreover, the DPPH scavenging properties of all the synthesized complexes were also evaluated showing excellent free radical scavenging properties establishing potentiality as antioxidant agents. The above results established that synthesized metal complexes are not only good antibacterial agents but also act as potent agents for free radical scavenging.

ACKNOWLEDGMENTS

Authors are thankful to the authorities of their Institution for the cooperation and support.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

All the authors contributed significantly to this manuscript and participated in reviewing, editing and approving the final draft for publication. The research profile of the authors can be verified from their ORCID ids, given below:

Sapna https://orcid.org/0009-0005-4503-7266
Neelam Kumari https://orcid.org/0009-0002-0974-3233

REFERENCES

1. A. Ali, M. Pervaiz, Z. Saeed, U. Younas, R. Bashir, S. M. Bukhari, F. Ali, S. Jelani, A. Rashid, and A. Adnan, *Inorganic Chemistry Communications,* **109903**, (2022), https://doi.org/10.1016/j.inoche.2022.109903
2. G. Valarmathy, R. Subbalakshmi, R. Selvameena and V. Gomathi, *Oriental Journal of Chemistry*, **29(1),** 315 (2013), https://doi.org/10.13005/ojc/290220
3. S. Goel, S. Chandra and S. D. Dwivedi, *Journal of Saudi Chemical Society.*, **20(6),** 651(2016), https://doi.org/10.1016/j.jscs.2013.07.005
4. H. A. El-Boraey and O. A. EL-Gammal, *Open Chemistry Journal,* **5(1),** (2018), https://doi.org/10.2174/1874842201805010051
5. C. Boulechfar, H. Ferkous, A. Delimi, A. Djedouani, A. Kahlouche, A. Boublia, A.S. Darwish, T. Lemaoui, R. Verma and Y. Benguerba, *Inorganic Chemistry Communications,* **150**, 110451(2023), https://doi.org/10.1016/j.inoche.2023.110451
6. G. G. Mohamed, *Spectrochimica Acta, Part A: Molecular and Biomolecular Spectroscopy*, **64(1),** 188(2006), https://doi.org/10.1016/j.saa.2005.05.044
7. M. S. Hossain, C. M. Zakaria, M. Kudrat-E-Zahan and B. Zaman, *Der Chemica Sinica,* **8(3)**, 380(2017)
8. H. Guguloth, *International Journal of Pharmacy and Biological Sciences*, **5(3),** 102(2015).

9. N. Bandyopadhyay, M. Zhu, L. Lu, D. Mitra, M. Das, P. Das, A. Samanta and J. P. Naskar, *European Journal of Medicinal Chemistry*, **89,** 59(2015).
10. N. K. Chaudhary and P. Mishra, *Bioinorganic Chemistry and Applications*, **2017,** 1(2017), https://doi.org/10.1155/2017/6927675
11. M. Orojloo, P. Zolgharnein, M. Solimannejad and S. Amani, *Inorganica Chimica Acta*, **467,** 227(2017), https://doi.org/10.1016/J.ICA.2017.08.016
12. A. A. Osowole, G. A. Kolawole and O. E. Fagade, *Synthesis and Reactivity in Inorganic, Metal-Organic, and Nano-Metal Chemistry,* **35(10)**, 829(2012).
13. S. A. Hosseini-Yazdi, A. Mirzaahmadi, A. A. Khandar, V. Eigner, M. Dušek, M. Mahdavi, S. Soltani, F. Lotfipour and J. White, *Polyhedron,* **124**, 156(2017).
14. K. H. Kailas, J. P. Sheetal, P. P. Anita and H. P. Apoorva, *World Journal of Pharmacy and Pharmaceutical Sciences,* **5(2),** 1055(2016).
15. M. Rajasekar, S. Sreedaran, R. Prabu, V. Narayanan, R. Jegadeesh, N. Raaman and A. Kalilur Rahiman, *Journal of Coordination Chemistry,* **63(1)**, 136(2010), https://doi.org/10.1080/00958970903296362
16. S. Magaldi, S. Mata-Essayag, C. H. De Capriles, C. Pérez, M. T. Colella, C. Olaizola and Y. Ontiveros, *International Journal of Infectious Diseases*, **8(1),** 39(2004), https://doi.org/10.1016/j.ijid.2003.03.002
17. H. Kizilkaya, B. Dag, T. Aral, N. Genc and R. Erenler, *Journal of the Chinese Chemical Society,* **67(9)**, 1696(2020), https://doi.org/10.1002/jccs.20200016
18. A. Marir, T. N. Mouas, B. Anak, E. Jeanneau, A. Djedouani, L. Aribi-Zouioueche and F. Rabilloud, *Journal of Molecular Structure,* **1217,** 128353(2020).
19. A. Sahraei, H. Kargar, M. Hakimi and M. N. Tahir, *Journal of Molecular Structure,* **1149**, 576(2017), https://doi.org/10.1016/J.MOLSTRUC.2017.08.022
20. G. Kumar, D. Kumar, S. Devi, R. Johari and C. P. Singh, *European Journal of Medicinal Chemistry,* **45(7)**, 3056(2010), https://doi.org/10.1016/j.ejmech.2010.03.036
21. A. Braca, C. Sortino, M. Politi, I. Morelli and J. Mendez, *Journal of Ethnopharmacology,* **79(3)**, 379(2002), https://doi.org/10.1016/s0378-8741(01)00413-5
22. J. A. Hernandez, A. Jiménez, P. Mullineaux and F. Sevilia, *Plant, Cell & Environment,* **23(8)**, 853 (2000), https://doi.org/10.1046/j.1365-3040.2000.00602.x

[RJC- 8309/2022]