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DI-IMINE LINKAGE BASED METAL COMPLEXES: SYNTHESIS, CHARACTERIZATION AND THEIR BIOLOGICAL APPLICATIONS

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ABSTRACT:

Two novel Ni(II) and Cd(II) Schiff base metal complexes were synthesized by condensing the prepared Schiff base in a 1:1 molar ratio, using ethanol as a solvent under controlled conditions. The progress of the reactions and the purity of the synthesized compounds were monitored by thin-layer chromatography (TLC). The obtained Schiff bases were characterized by solubility tests, melting point determination, FT-IR spectroscopy, and elemental analysis. The compounds were found to be partially soluble in most organic solvents while remaining insoluble in water. The antimicrobial potential of the synthesized metal complexes was evaluated by the agar well diffusion method on agar medium against selected Gram-positive and Gram-negative bacterial strains, Bacillus subtilis, Staphylococcus aureus, Proteus vulgaris, and Escherichia coli, along with the fungal strain Candida albicans, at100 mg/ml concentrations. The results revealed that the Schiff base metal complexes exhibited variable inhibitory activity against the tested microorganisms, indicating their promising antimicrobial properties.

KEYWORDS: Schiff base ligand, Metal complexes containing $NiCl_2$, $CdCl_2$ salt, Antimicrobial Activities.

I.INTRODUCTION:

Schiff bases are formed from primary amines and carbonyl (C=O) compounds, which can be either aldehydes or ketones. Their ease of preparation and metal complexation has garnered interest in chemists, as they exhibit physiological and pharmacological activities. Recently, these compounds have been classified as imines or azomethines, where the carbonyl group (C=O) is replaced by the nitrogen of the imine group, resulting in a carbon-nitrogen double bond (C=N) as the functional group. They are generally the condensed products of reactions involving primary amines and carbonyl groups. The nitrogen atom is bonded to an aryl or alkyl group rather than hydrogen, which contributes to the stability of the Schiff base as an imine. Schiff bases play a significant role in coordination chemistry and are capable of forming stable complexes with most transition metals, thereby enhancing their pharmacological efficacy, including anticancer, antimicrobial, antifungal properties. A wide array of biological activities, such as anti-inflammatory, and antipyretic effects, cytotoxic effect has attracted the interest of the pharmaceutical and medical fields in Schiff base complexes. They are the important molecules that have been widely studied in the industrial and biomedical field. [1-4] In organic chemistry Schiff bases are most widely used as pigments and dyes, catalysts, intermediate in organic synthesis, and as a polymer stabilizer. Apart from exhibiting medicinal properties, Schiff base compounds also play an important role as ligands in co-ordination chemistry. They are typically macro-cyclic or macro-acyclic polydentate ligands containing both nitrogen and oxygen donor atoms. Schiff bases possess some potential characteristics such as synthetic flexibility, magnetic properties, co-ordination capability and therapeutic effects. They act as a pathway for synthesis of many compounds containing carbon nitrogen bonds [5-6]. They also exhibit broad array of applications in various fields like, food industry, dye industry, catalysis, chemosensors, intermediates in organic synthesis, in material chemistry for production of photoactive solar energy as well as in agrochemicals.

In this research work, transition metal complexes of synthesized Schiff bases from2,2'-[butane-1,4-diylbis(oxy)] dibenzaldehyde with semithiocarbazide and 4-amino antipyrine was prepared. The resultant Schiff bases were complexed with lead (II) and Zinc (II) metal complexes were synthesized and identified using physicochemical and spectral analysis. The metal complexes were further studied for their antifungal and antibacterial evaluations

II. MATERIALS AND METHODS

The chemicals applied for production of ligands and complexes were of analytical grade of HIMEDIA Sigma -Aldrich and Merck and these were used without being cleansed. Thermo Scientific's NICOLET 6700 FT-IR infrared spectrometer was used to capture the IR spectrum data while using KBr as a supporting substance in the range of 400-4000cm. synthetic complexes have been characterized in terms of their physical characteristics. The course of reaction was monitored by using TLC method by identifying spot in iodine chamber. C, H, and N elemental analysis was done using CHNS micro analyzer.
Antibacterial studies of synthesized metal compounds have been checked using agar well diffusion method for Gram positive and Gram-negative bacteria.

Synthesis of dialdehyde intermediate- *2, 2'- [butane-1, 4-diylbis (oxy)] dibenzaldehyde*

As already described in literature [7], In DMF solvent, a 40-50 ml solution of salicylaldehyde (0.2 mol, 24.4 g) was added drop wise to the solution of 1,4-dibromobutane (0.1 mol, 21.592 gm) followed by addition of anhydrous K_2CO_3 (0.1 mol, 13.8 g). Resulting mixture was then refluxed for about 4 hours. After refluxing, mixture was stirred at room temperature for 4 hour and then cooled to obtained crude product. Crude product was then recrystallized from 1-butanol, wash with distilled water then filter and dried.

Synthesis of Ligand. (L1 and L2)

According with the methodology presented in literature [7], The new Schiff bases were synthesized by the portion-wise addition of 0.2 mol of semithiocarbazide or 4-amino antipyrine in DMF solvent to a dimethyl formamide solution of the 0.1 mol of dialdehyde compound (A) and mixture enriched by a few drops of concentrated hydrochloric acid. The reaction mixture was refluxed for 4-5 h, after which it was allowed to cool to room temperature, leading to the formation of a precipitate. The resulting solid was filtered and washed several times with cold water to remove unreacted materials and acidic contaminants. The crude product was recrystallized from a DMF: ethyl alcohol (9:1) solvent system to afford yellow crystalline material. The purified precipitate was further washed successively with water followed by ethanol and then dried in a desiccator for 24 h to obtain the corresponding Schiff base in pure form.

Synthesis of Complexes

To the stirred solution of ligand in ethanol (60 ml), was added drop wise 2 mmol of M (II) chloride salt, where M = $NiCl_2.6H_2O$ and $CdCl_2.2H_2O$ dissolved in ethanol (40 ml). After the addition was completed, the reaction mixture was then refluxed for 2 hours with stirring. Then, the former mixture was transfer for distillation to reduce the volume of solvent. The coloured solid metal complexes were separated, filtered and washed with cold methanol. The desired product dried in air (Fig.1).

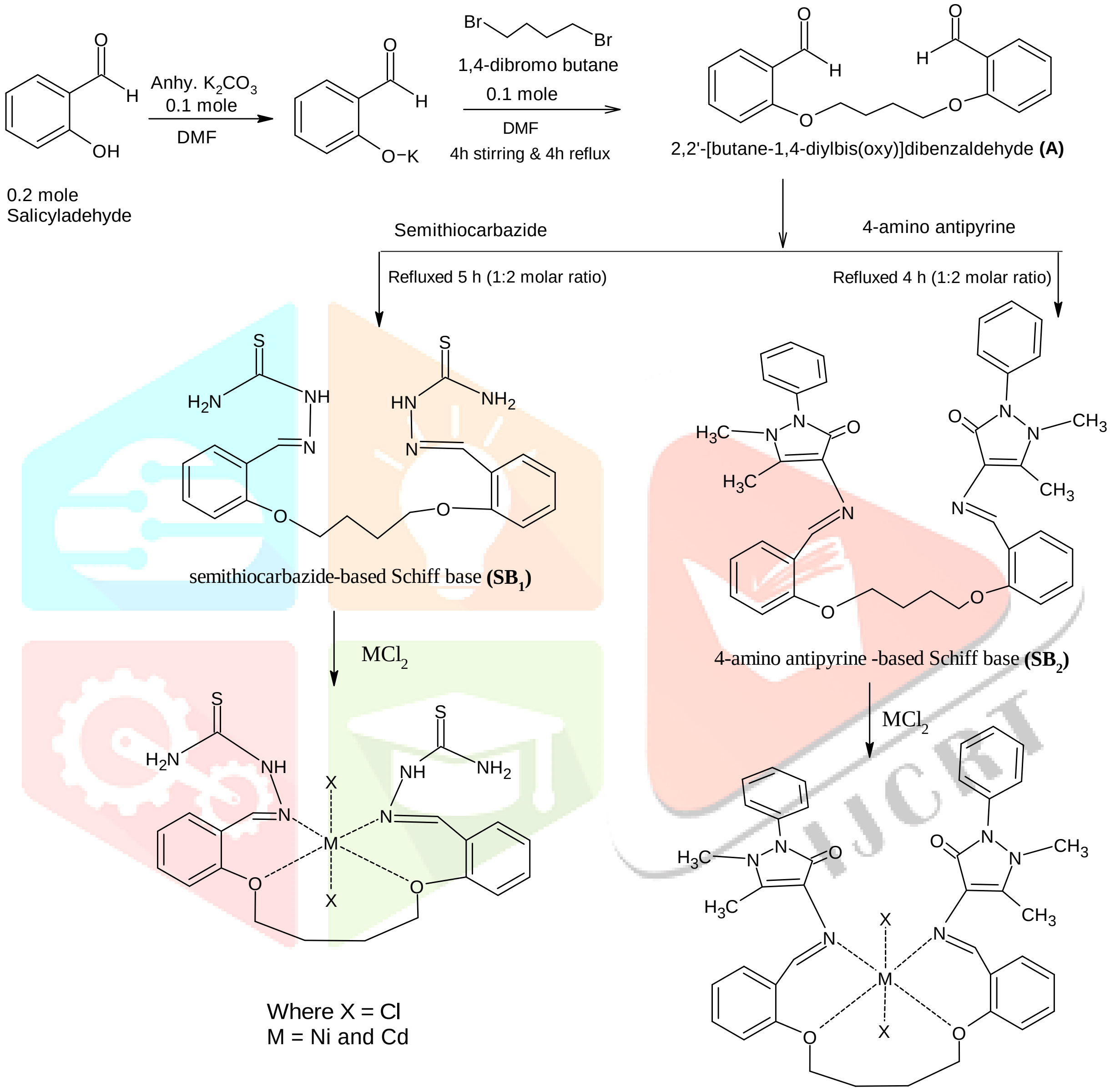

Figure 1 – Reaction Pathway

Characterization of [Ni(L_1) Cl_2)]

Colour: Greenish-Yellow, Yield 56%, Anal. Calc. for Ni(L_1)Cl_2): C, 41.83, H, 4.22, N, 14.64 Found; C, 41.87, H, 4.28, N, 14.68. FTIR Selected values (KBr, ν cm^{-1}), 3085 ν (Ar-CH), 2955, 2865 ν (Alf. -CH), 1625 ν (C=N), 1561, 1497 ν (Ar.-C=C), 1280, 1235 ν (Ar-0), 1354 ν (C=S), 820, 750 ν (o-substituted benzene).

Characterization of [Cd(L_1)Cl_2]

Colour: Pale Yellow, Yield 45%, Anal. Calc. for Cd(L_1)Cl_2: C, 38.25, H, 3.86, N, 13.38 Found; C, 38.29, H, 3.80, N, 13.32. FTIR Selected values (KBr, ν cm^{-1}), 3102 ν (Ar-CH), 2834, 2756 ν (Alf. -CH), 1610 ν (C=N), 1587, 1523 ν (Ar.-C=C), 1265, 1213 ν (Ar-0), 1352 ν (C=S), 810, 770 ν (o-substituted benzene).

Characterization of [Ni(L_2)Cl_2)]

Colour: Lime Green, Yield 61%, Anal. Calc. for Ni (L_2)Cl_2): C, 60.17, H, 5.06, N, 10.53 Found; C, 60.13, H, 5.10, N, 10.59. FTIR Selected values (KBr, ν cm^{-1}), 3265 ν (Ar-CH), 2939, 2875 ν (Alf. -CH), 1642 ν (C=N), 1583, 1445 ν (Ar.-C=C), 1209, 1196 ν (Ar-0), 825, 765 ν (o-substituted benzene).

Characterization of [Cd(L_2)Cl_2)]

Colour: Pale Yellow, Yield 45%, Anal. Calc. for Cd (L_2)Cl_2): C, 56.38, H, 4.74, N, 9.86 Found; C, 56.33, H, 4.78, N, 9.83. FTIR Selected values (KBr, ν cm^{-1}), 3167 ν (Ar-CH), 2897, 2721 ν (Alf. -CH), 1621 ν (C=N), 1553, 1478 ν (Ar.-C=C), 1227, 1178 ν (Ar-0), 798, 746 ν (o-substituted benzene).

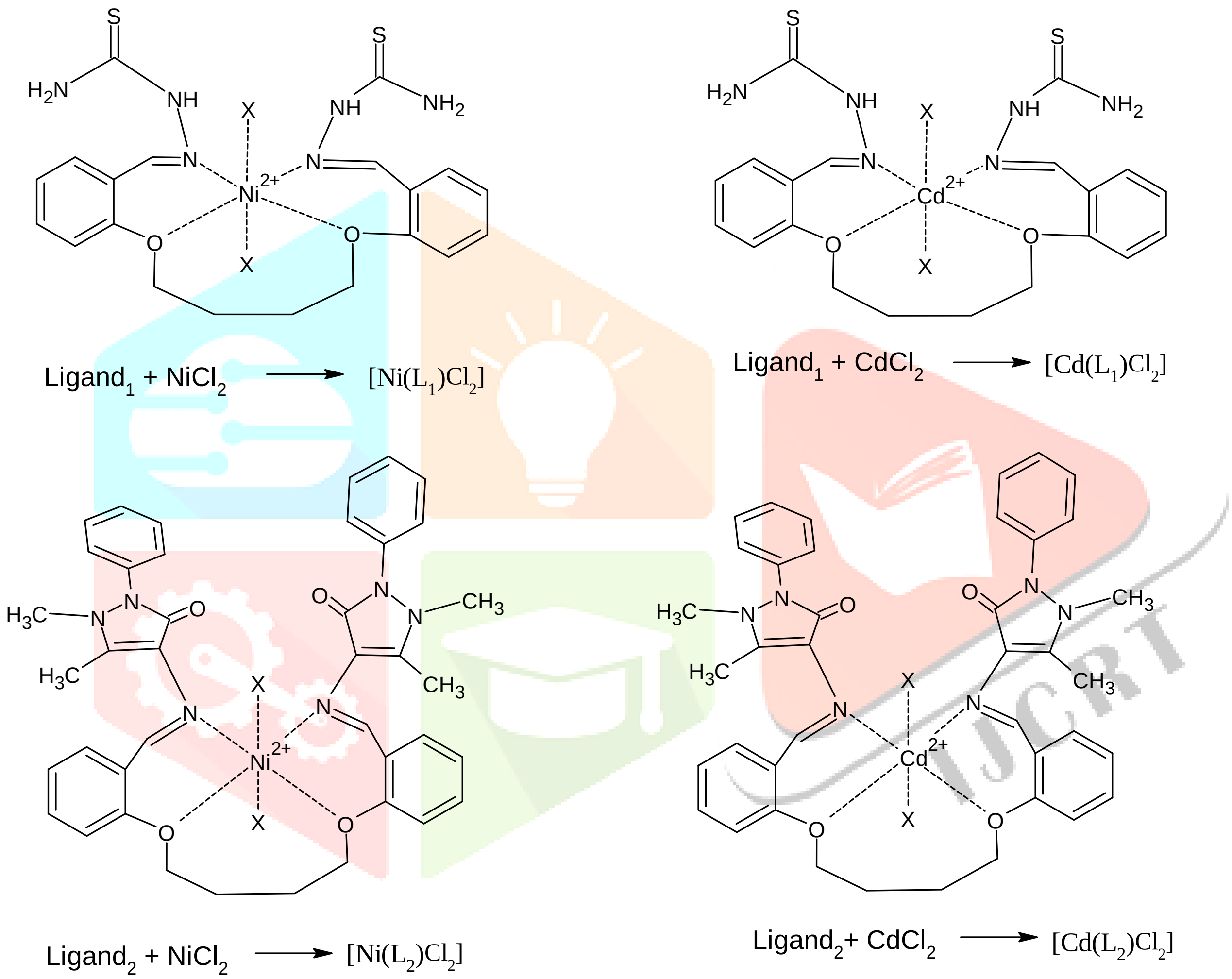

Figure 2- Proposed structure of metal complexes (X = Cl)

Antimicrobial Activity:

The agar well diffusion method was used to evaluate the synthesized Schiff base metal complexes in vitro antibacterial and antifungal properties against the fungal strain Candida albicans, Gram-positive bacteria (Bacillus subtilis and Staphylococcus aureus), and Gram-negative bacteria (Proteus vulgaris and Escherichia coli). Mueller-Hinton Agar and Nutrient agar were used for preparation of bacterial and fungal cultures. The bacterial cultural were inoculated overnight at 38^0C for 48 hours. Inoculated medium containing grown culture of 100 µL was added to the medium and mixed well to get a uniform distribution. Final concentration of 100 µg was achieved by impregnating sterile holes with DMSO solutions of the test compounds. DMSO disc was used as negative control. Small holes are punched into the agar, after incubation, clear zone (zones of inhibition) around the wells indicates antimicrobial activity. The size of zone correlates to the potency of substance. Size of zone inhibition diameter was determined in terms of mm [9].

III.RESULT AND DISCUSSION

The prepared Schiff bases (SB_1, and SB_2) were prepared by condensation of dicarbonyl intermediate with semithiocarbazide and 4-amino antipyrine in molar ratio (1:2) in dimethyl formamide (DMF). The reactions proceeded forming Schiff bases metal complexes in good yield. Former complexes are sparingly soluble in most of the common organic solvents but completely insoluble in water. All prepared complexes are non-hygroscopic solids, stable in air and possess high melting points. The structures of the prepared compounds were supported by IR spectral studies and elemental analyses. Analysis of physical and analytical parameters indicates proposed composition of synthesized Schiff base metal complexes.

Elemental Analysis:

The findings of the elemental assessment are presented in Table 1. The elemental evaluation of newly prepared Schiff base metal complexes displayed a strong correlation with the calculated theoretical percentage analysis for each complex. The molar conductance measurements were verified, and the results suggest that, the metal complexes possess a non- electrolyte characteristic.

Table 1. Physical and Analytical data of newly synthesized metal complexes

Complexes	Colour	M.P (^{0}C)	Mol. wt in gm	% Metal	% Carbon (Found)	% Hydrogen (Found)	% Nitrogen (Found)	Molar Conductance (Scm^{2}mol^{-1})
$[Ni(L_1)\ Cl_2)]$	Greenish-Yellow	212-214	574.23	10.22	41.83 (41.87)	4.22 (4.28)	14.64 (14.68)	12.2
$[Cd(L_1)\ Cl_2)]$	Light Yellow	206-208	627.95	17.90	38.25 (38.29)	3.86 (3.80)	13.38 (13.32)	12.09
$[Ni(L_2)Cl_2)]$	Lime Green	238-240	798.39	7.35	60.17 (60.13)	5.06 (5.10)	10.53 (10.59)	11.03
$[Cd(L_2)Cl_2)]$	Pale yellow	224-226	852.12	13.19	56.38 (56.33)	4.74 (4.78)	9.86 (9.83)	11.08

FTIR Spectral Analysis:

The FTIR was used to analysed the formation of metal complexes showed potential groups having electron donor properties to form coordinate bond with metal ions. The coordination of azomethine nitrogen to metal ions indicates the observed changes in the IR spectral values of v (C = N) for the ligands, which display similar increasing trends with their respective complexes, ranging from a minimum value of 1610 cm^{-1} for $[Cd(L_1)\ Cl_2)]$ to a maximum value of 1625 cm^{-1}for $[Ni(L_1)\ Cl_2)]$ respectively [10]. Additionally, the characteristic IR spectra of ligand can be attributed to the absorptions for the aromatic (C=C) have been decreases at 1561, 1497cm^{-1} for $[Ni(L_1)\ Cl_2)]$and 1587, 1523 cm^{-1}for $[Cd(L_1)\ Cl_2)$ [12]. The presence of IR band at 3102 cm^{-1} for $[Ni(L_1)\ Cl_2)]$and 3265 cm^{-1} for $[Cd(L_1)\ Cl_2)]$ indicating presence of (Ar-CH) signals [11-13]. Similarly, the presence of two IR signals at 2955, 2865 cm^{-1}for $[Ni(L_1)\ Cl_2)$ and signal at 2834, 2756 cm^{-1}for $[Cd(L_1)\ Cl_2)$ attributed for the presence of (Alf. -CH) stretching vibrations. Other distinguishing bands for $[Ni(L_1)\ Cl_2)]$ in the range of 1280, 1235 cm-^{1} and 1265, 1213cm^{-1} for $[Cd(L_1)\ Cl_2)]$ appears due to (Ar-O) stretching respectively [13-14].

In $[Ni\ (L_2)Cl_2)]$ and $[Cd(L_2)Cl_2)]$ intense band appears at 1642cm-^{1} and 1621cm-^{1}was due to azomethine linkage. The lower value of azomethine linkage in metal complexes then ligand was due to coordination with metal. The signal appears at 3265 cm-^{1} and 3167 cm-^{1} in Ni and Cd-complex was due to (Ar-CH) stretching. Similarly, band arises at 1583, 1445 cm-^{1} in Ni complex and 1553, 1478 cm-^{1} in Cd complex are due to (Ar-C=C) stretching [14-16]. The bands in the spectra at 2939, 2875 cm-^{1} in Ni-complex and 2897, 2721 cm^{-1} in Cd-complex is attributed to the (Alf. -CH) group. Also, the band assigned to 1209, 1196 cm^{-1} for Ni-complex and 1227, 1178 cm^{-1} for Cd-complex was due to (Ar-O) stretching respectively [17-18].

Antimicrobial Activity

The antibacterial and antifungal efficacy of the synthesized Schiff base metal complexes was assessed against gram-negative bacteria, specifically Proteus vulgaris and Escherichia coli, as well as gram-positive bacteria, namely Bacillus subtilis and Staphylococcus aureus and Candida albicans is used fungi. An inhibitory effect of individual tested Schiff base metal complex indicating poor inhibition against P. vulgaris among the complexes under study. Solutions of the complexes were prepared at a concentration of 100 mg/ml using DMSO as the solvent. Each plate contained four wells, with each well holding 100 µL of the solution. Each wells contained one Schiff base meatal complex. DMSO served as a negative control, and the antibiotic chloramphenicol was utilized as a standard reference. The metal complexes demonstrated significant antibacterial activity against these bacterial strains. Among them, the cobalt and nickel complexes exhibited the moderate potency against all tested strains when compared to the standard chloramphenicol. The Ni complex having L_1 and L_2 ligand displayed particularly strong antimicrobial properties against B. subtillis, Staphylococcus aureus and E. coli as compared to cadmium complex. But Cd complex having L_2 ligand shows slightly higher activity for P. vulgaris then other complexes. Cd complex having L_1 ligand shows higher activity for fungi C. albicans. In general, the synthesized Schiff base complexes exhibited considerable antibacterial activity, with Ni and Cd metals emerging as the most promising candidate. These results suggest that these compounds could act as valuable frameworks for additional biological and pharmacological research. The inhibitory zone measurements for each complex are presented in the table below.

Table 2. Antibacterial and antifungal activities of the Schiff base metal complexes.

Complexes	Conc. (µg/disc)	Zone Inhibition Diameter (mm)				
		Gram +ve Bacteria		**Gram –ve Bacteria**		**Fungus**
		B. subtillis	**S. aureus**	**P. vulgaris**	**E. coli**	**C. albicans**
$[Ni(L_1) Cl_2)]$	100	12	16	09	10	09
$[Cd(L_1) Cl_2)]$	100	08	09	08	10	11
$[Ni(L_2)Cl_2)]$	100	10	15	08	12	10
$[Cd(L_2)Cl_2)]$	100	09	12	10	11	09
Chloramphenicol		20	21	22	23	Miconazole 22

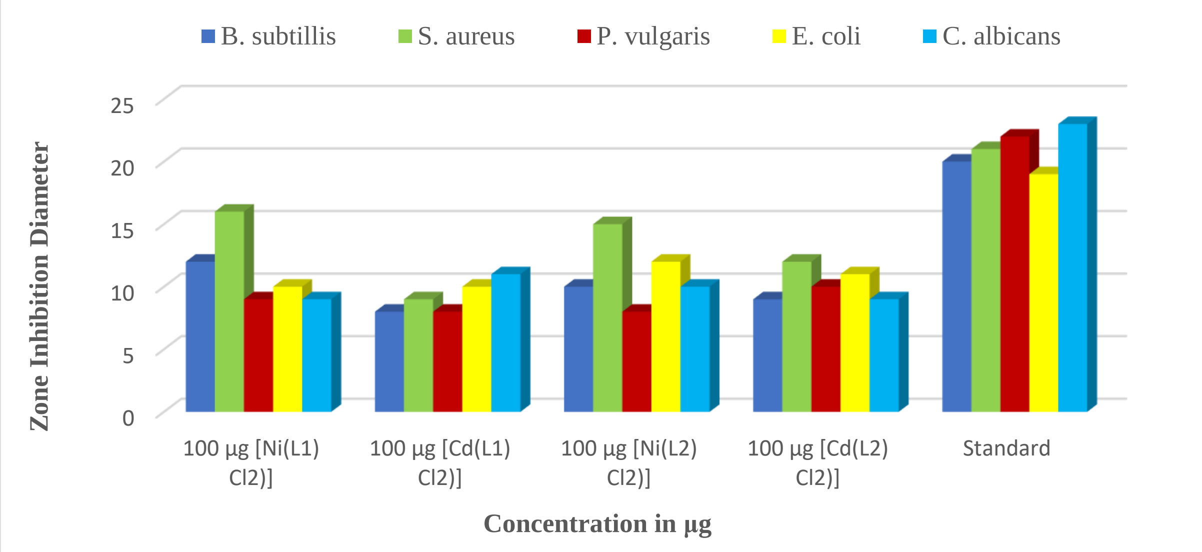

Figure 3. Graphical representation of antibacterial and antifungal activities of the Schiff base metal complexes.

IV.CONCLUSION

We have developed the easier and simple synthetic technique of Schiff base related diazo moiety containing derivatives and the reactions occurred much secured, under modest condition using reasonable solvents and reagents. The anti-bacterial activity of newly synthesized novel Schiff bases metal complexes was effectively screened against fungal strain Candida albicans, Gram-positive bacteria Bacillus subtilis and Staphylococcus aureus, and Gram-negative bacteria Proteus vulgaris and Escherichia coli bacterial strains. Ni complex having L_1 and L_2 ligand show excellent activity against B. subtillis, Staphylococcus aureus and E. coli as compared to cadmium complex. Cd complex having L_2 ligand shows slightly higher activity for P. vulgaris. The antifungal activity of synthesized compounds was checked against *Candida albicans.* Cd complex having L_1 ligand shows higher activity for fungi C. albicans then for the remaining metal complexes.

V.APPRECIATION

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VI.REFERENCES

[1]. Ren T, Wang J, Li G, Li Y. Synthesis, Characterization and*in vitro* Antitumor Activity of Novel Schiff Bases ContainingPyrazole Group. Asian J Chem 2014;26:8309-13.

[2]. Gama S, Mendes F, Marques F, Santos IC, Carvalho MF,Correia I, *et al*. Copper(II) complexes with tridentate pyrazolebasedligands: synthesis, characterization, DNA cleavageactivity and cytotoxicity. J Inorg Biochem 2011;105:637-44.

[3]. Abu Bakr S, Abd El-Karim SS, Said MM, Youns MM.Synthesis and anticancer evaluation of novel isoxazole/pyrazole derivatives. Res Chem Intermed 2016;42:1387-99.

[4]. Subhashini NJP, Amanaganti J, Nagarjuna PA. Synthesis,characterization and biological activity of (N1E,N2Z)-N1,N2-Bis((1-Phenyl-3-Aryl-1H-Pyrazol-4-yl)methylene)benzene-1,2-diamines. J Applicable Chem 2014;3:2358-64

[5]. Burns, C. J., Neu, M. P., Boukhalfa, H., Gutowski, K. E., Bridges, N. J., & Rogers, R. D. (2003). The Actinides. Comprehensive Coordination Chemistry II, 189–345. doi:10.1016/b0-08-043748-6/02001-6

[6]. Jyoti D, Kumar A. (2019). Synthesis, Characterization and application of Schiff base metalcomplexes, 2019, 6 (5)

[7]. M. R. Badhe, T. S. Umasare, Synthesis, Characterization and Antimicrobial Evaluationof New Di-Schiff Bases Derived From 2,2′-[Butane-1,4-Diylbis(Oxy)]Dibenzaldehyde

[8]. *International Journal for Multidisciplinary Research*, Volume 8, Issue 2, March-April 2026.
[9]. K. K. Sivakumar, A. Rajasekharan, R. Rao1 and B. Narasimhan, Synthesis, SAR Study and Evaluation of Mannich and Schiff Bases of Pyrazol-5(4H)-one Moiety Containing 3-(Hydrazinyl)-2-phenylquinazolin-4(3H)-one *Indian Journal of Pharmaceutical Sciences, July - August 2013*
[10]. Olyaei, A., Sadeghpour, M. Lawsone-based benzo[a]phenazin-5-ol: synthetic review.RSC Advances. 2022, 12(22), 13837–13895.
[11]. Gull, P. Hashmi, A. Adil, A. Biological activity studies on metal complexes of macrocyclic Schiff base ligand. Journal of the Brazilian Chemical Society 2015, 26(7),1331–1337.
[12]. Kumar, A., Tevatia, P., Sweety, Singh, R. Synthesis and antibacterial studies of Mn(II) and Co(II) macrocycles. International Journal of Pharmaceutical Chemistry. 2015, 5(4), 149–157.
[13]. Tevatia, P., Sweety, Kumar, A., Singh, R. Catalytic oxidation using Co(II) and Mn(II) macrocycles. Journal of Applied Chemistry (IOSR-JAC). 2014, 7(9-I), 51–53.
[14]. Hubin, T.J., McCormick, J.M., et al. New Fe(II) and Mn(II) macrocycles for catalysis. Journal of the American Chemical Society. 2000, 122, 2512–2522.
[15]. Ilhan S. Temel H, Kikic A & I Yilmaz, Trans Met Chem, 32, 2007, 344
[16]. Ilhan S. Temel H, Kikic A & I Yilmaz, Trans Met Chem, 32, 2007,1012
[17]. Ilhan S. Temel H, Hosgoren H & Boybay M, Spectroscopy Lett, 34, 2002, 1.
[18]. Ilhan S. Temel H, I Yilmaz, & Sekerci M, J Org Met Chem, 692, 2007, 3855