ISSN Print: 2664-6188
ISSN Online: 2664-6196
Impact Factor: RJIF 5.35
IJCBB 2024; 6(1): 56-61
www.biochemistryjournal.net
Received: 11-12-2023
Accepted: 13-01-2024

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Synthesis, characterization and biological activity of some Schiff base metal complexes

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DOI: https://doi.org/10.33545/26646188.2024.v6.i1a.60

Abstract
A new five metal complexes C1 – C5 [M = Zn=1, Co=2, Ni=3, Mn=4 and Fe=5], synthesized via the reaction between ligand as (HL) and metal chloride (metals: Zn, Co, Ni, Mn and Fe), the ligand (HL) synthesized from same moles of p-anisidine and salicylaldehyde. The complexes determined via different spectroscopic techniques such as, FT-IR and ^{1}HNMR. Finally, these complexes tested agent different bacteria to investigate the biological activity of these complexes.

Keywords: Schiff base, metal complexes, biological activity

Introduction
The amino compound undergoes a reaction with the carbonyl compound, resulting in the formation of Schiff bases. Schiff bases are a significant class of ligands due to their inclusion of C=N as the active group. These Schiff bases can then couple with metal ions through azomethine [1], a molecule that is now the subject of much investigation. The presence of a C=N bond is essential for the biological activity of azomethine derivative products. Several azomethine derivatives have demonstrated remarkable antibacterial, antifungal, anticancer, and antimalarial characteristics [2]. Schiff base ligands have garnered significant attention in the field of coordination chemistry owing to their straightforward production, abundant accessibility, and favorable electrochemical characteristics. Schiff base coordination chemistry has garnered significant interest in recent times because to its crucial role in several fields such as chemical synthesis, analytical chemistry, metal refining, metallurgy, electroplating, and photography [3-5]. Schiff bases have several uses in the dye market, in catalytic reactions, fungicides, and as agricultural chemicals [6-7]. Several Schiff bases are known to have exceptional antibacterial, antifungal, and anticancer properties [8].

Metal compounds have been utilized in medical science for thousands of years due to their diverse properties. However, it was only in the past forty years that the scientific community became interested in the modes of action of complexes composed of metal ions and organic ligands. This development established a significant connection between inorganic and organic chemistry. The field of inorganic medicinal chemistry mostly focuses on investigating the anticancer properties of metal complexes. However, there is also considerable interest in exploring the antimicrobial and anti-inflammatory effects of metal-based medications, such as Auranofin, which is a gold-based treatment for rheumatoid arthritis [9-13].

Experimental
General and instrumentals
All the reagents, starting chemicals, and solutions were obtained from a commercial source and used without additional purification. On a Gallen Kamp melting point apparatus with a heated stage, the melting points were recorded. FTIR Bucker Spectrophotometer was used to record the infrared (FTIR) spectrum. On a Bucker 500 MHz spectrometer, ^{1}HNMR spectra were acquired with deuterated d_6-DMSO as the solvent.

Synthesis of the Schiff base ligand (HL) [14-15]

The P-anisidine (0.01 mol, 1.23 g) reacted with salicylaldehyde (0.01 mmol, 1.22 g, 1.39 ml) in 15 ml of EtOH, refluxed more than 2 hours. Finally, produce yellowish solid compound separated via filtration, then washed with diethyl ether, and dried.

Synthesis of metal complexes C1 – C5 [16-18]

0.02 mole of the Schiff base ligand (HL) reacted with 0.01 mole of metal chloride ($ZnCl_2.H_2O$ as C1, $CoCl_2.H_2O$ as C2, $NiCl_2.H_2O$ as C3, $MnCl_2.H_2O$ and $FeCl_2.H_2O$) in 2:1 molar ratio. In hot ethanol dissolved the mixture, reflux for 3 hours and led to form colored products.

Table 1: The physicochemical properties of synthesized compounds.

Compound No.	Melting point °C	Color	Yelled %
HL	129 - 131	Yellow	59
C1	125 - 127	Yellowish green	70
C2	119 - 121	Blue	69
C3	97 - 100	Green	72
C4	89 - 91	Yellowish green	68
C5	102 - 104	Black	69

Results and Discussion

The ligand HL, FT-IR (cm^{-1}) as shown in figure 1: FT-IR ($cm-1$): The ν(OH) appeared at 3333 (19, 20), ν(C=N) 1621, ν(C-N) 1333, ν(C-O) phenolic 1253, ν(C-H) Aromatic 3089 [21].

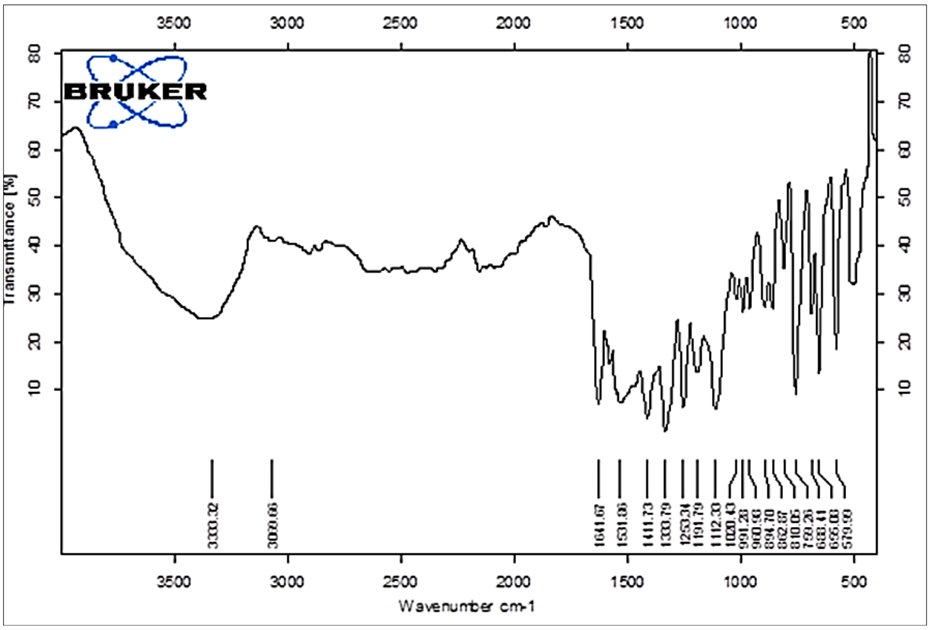

Fig 1: FTIR spectrum of compound HL.

The ligand HL, [1]HNMR (500 MHz, DMSO-d6, δ, ppm) as shown in figure 2: δ 9.66 (s, O-H), 8.44 (s, proton of azomethine), 7.90- 6.63 (C-H aromatic) [22, 23], 3.50 (HDO), 2.45 (DMSO as solvent).

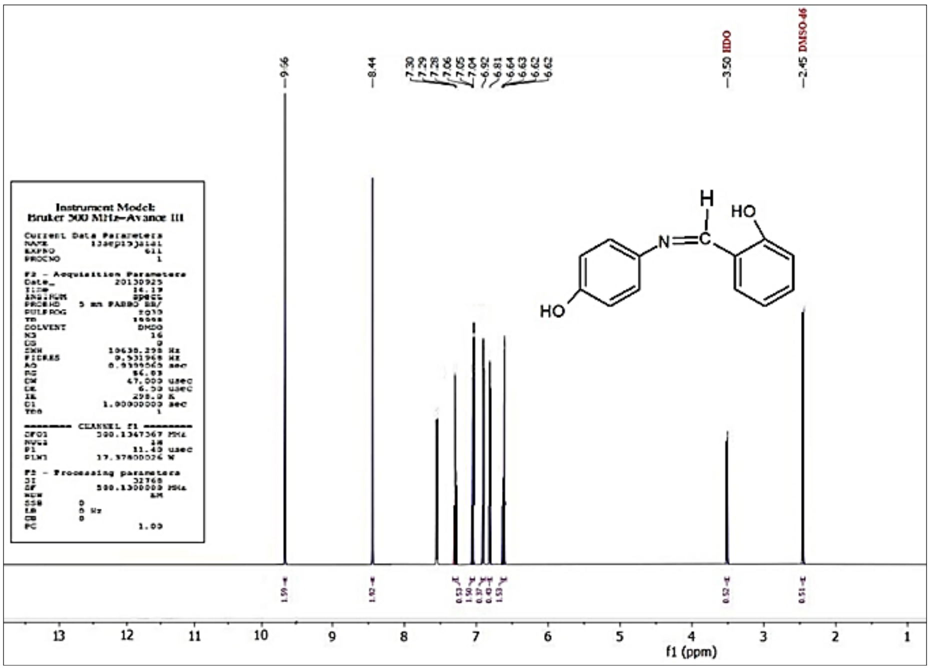

Fig 2: HNMR spectrum of compound HL.

The complexes C1, FT-IR (cm^{-1}) as shown in figure 3: The ν (OH) hydroxyl group appeared as broad band at 3461, the active group of azomethine for schiff base appeared at 1647, ν(C-N) 1374, ν(C-O) 1228. the coordinated water ν(H_2O) as two stretching bands 847 and 785, coordinated water ν(M-O) as stretching bands 501, the band of ν(M-O) that appeared at 612. finally, the metal-nitrogen ν(M-N) appeared at 419 [24].

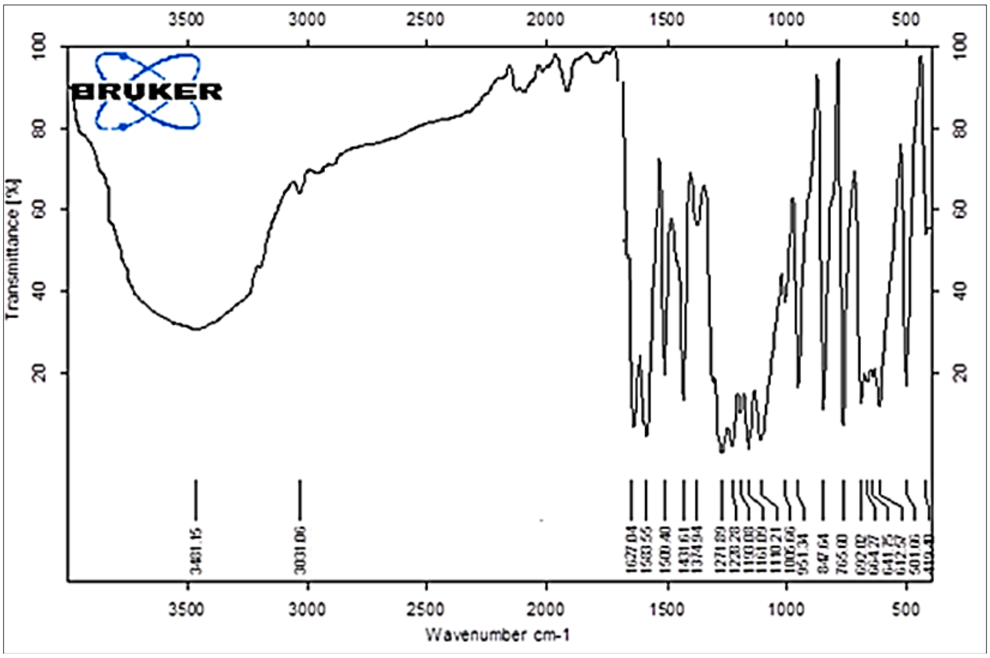

Fig 3: FTIR spectrum of complex C1.

The complexes C1, ^{1}HNMR (500 MHz, DMSO-d6, δ, ppm) as shown in figure 4: 9.25 and 9.27 (s, proton of OH phenolic), 6.87– 7.44 (m, protons of aromatic ring), 7.89 and 7.91 (s, CH=N) [25].

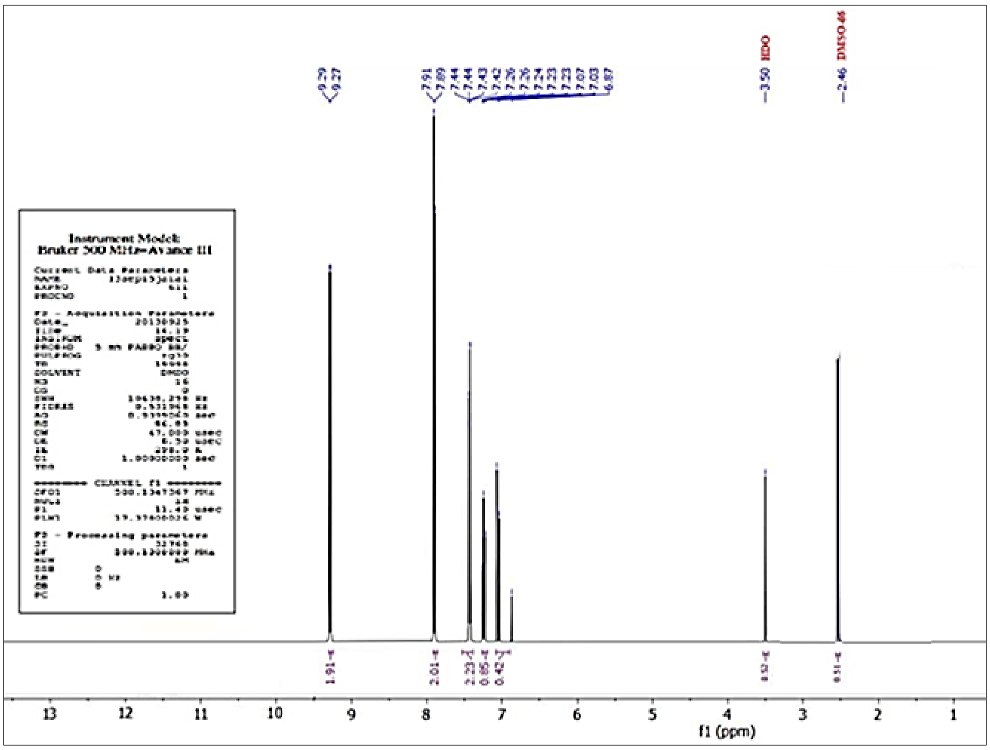

Fig 4: HNMR spectrum of complex C1.

The complexes C1, FT-IR (cm^{-1}) as shown in figure 5: the broad band of ν (OH) appeared at 3383, the group ν (C=N) appeared at band 1653, ν (C-N) 1367, ν (C-O) 1248. The stretching bands of ν (H_2O) coordinated water showed two band 832 and 779, ν (M-O) stretching bands of coordinated water 557, metal-oxygen band as ν (M-O) that showed at 651. Finally, the band ν (M-N) at 466 [26-28].

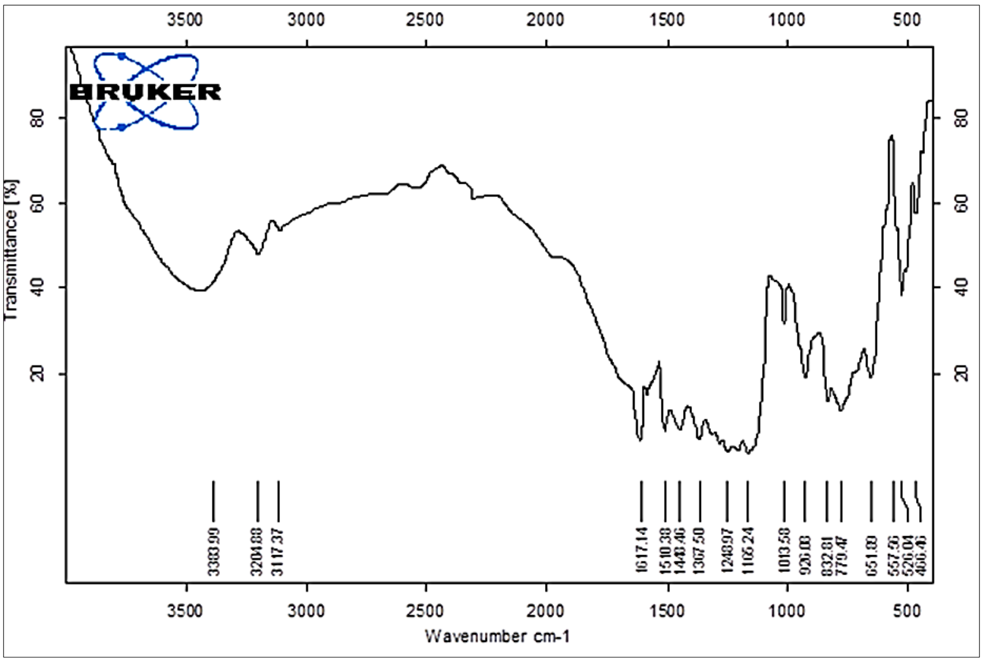

Fig 5: FTIR spectrum of complex C2.

The complexes C2, 1HNMR (500 MHz, DMSO-d6, δ, ppm) as shown in figure 6: 9.49 (s, proton of OH phenolic), 6.63 – 8.61 (m, proton of aromatic ring), 7.61 and 7.41 (s, H, CH=N) [29-30].

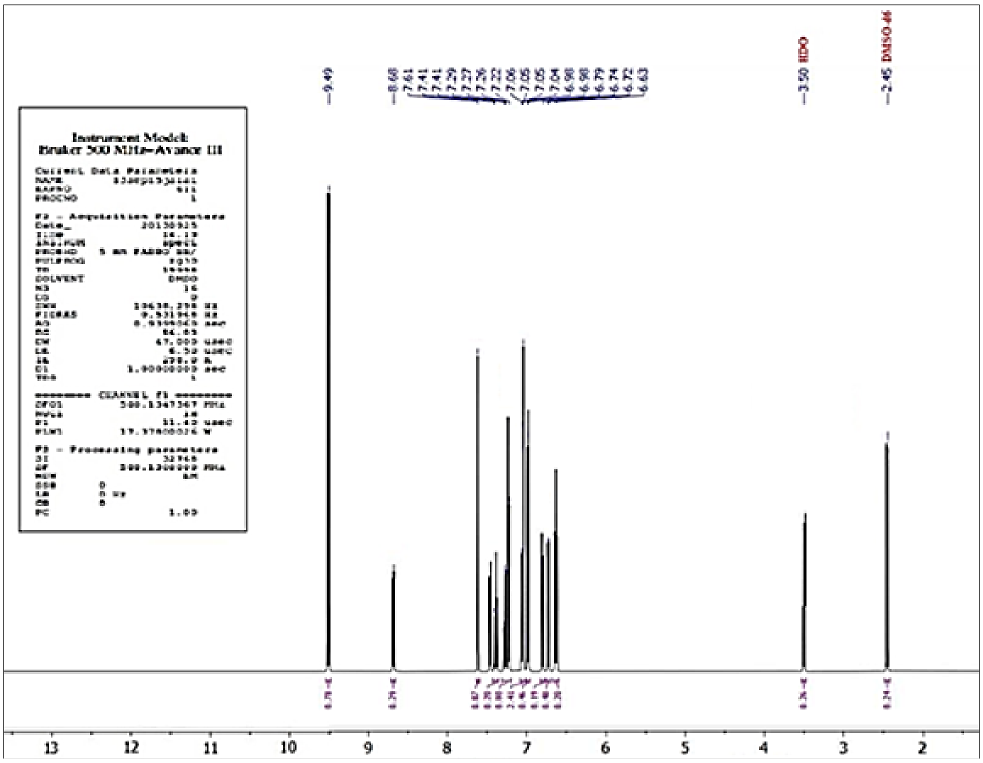

Fig 6: HNMR spectrum of complex C2.

Table 2: FTIR spectrum for compounds C1 – C5.

Compound NO.	O-H	C-H Aromatic	C=N	C-O	M-O	M-N
HL	3333	3089	1641	1239	---	---
C1	3461	3031	1627	1228	612	419
C2	3383	3117	1617	1248	651	466
C3	3401	3067	1632	1236	643	438
C4	3379	3146	1628	1231	647	426
C5	3301	3089	1616	1235	639	425

The molar conductivity (10^{-3} M, DMSO / Ω^{-1} cm^2 mol^{-1}): 19.40 for complex C1, 41.20 for complex C2, 43 for complex C3, 38.20 for complex C4 and 67 for complex C5.

Biological Activity of synthesized compounds C1-C3

The synthetic complexes C1 and C3 have undergone testing against both gram-positive and gram-negative bacteria, such as Staphylococcus, bacillus subtilis, pseudomonas aerugi, and escherichia coli. The microorganisms were provided as pre-cultured bacterial cultures at concentrations of 25 and 50 mg/ml using the Agar well Diffusion technique [31]. The inhibitory diameter of each pore was measured using a ruler. The zone of inhibition refers to the translucent area that encloses the disc, including the unaffected diameter of the disk. All of these results are displayed in Table 2.

The cell wall of bacterial cells is composed of peptidoglycan, a complex network of elongated sugar polymers. The process of cross-linking the glycan strands in the peptidoglycan is facilitated by transglycosidases. This entails the extension of peptide chains from the sugars present in the polymers, resulting in the formation of cross linkages between peptides (32). In the presence of penicillin binding proteins (PBPs), the D-alanyl alanine segment of the peptide chain undergoes crosslinking through glycine residues [33].

Table 3: Antibacterial activities of the compounds (C1 and C3).

Bacteria name	Zone of inhibition (mm)			
	Compound C1		Compound C3	
	[con. 25 mg/ml]	[con. 50 mg/ml]	[con. 25 mg/ml]	[con. 50 mg/ml]
Staphylococcus	37	40	36	39
Bacillus subtilis	40	43	43	45
Pseudomonas aerug	45	47	42	48
Escherichia coli	37	42	40	47

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