

Synthesis, Characterization, Anticancer, and Molecular Docking Investigations of Benzothiazole Metal Complexes

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Abstract

The synthesized 2-aminobenzothiazoles based ligand reacted with various transition metal salts were smoothly converted to square planer complexes. The synthesized transition metal complexes are analyzed by using various characterization techniques. Anticancer activity of Schiff base ligand and synthesized metal complexes are examined against human prostate cancer cell line (DU145) MTT assay at different concentration (1, 2, 4, 8, 16, 32, 64, 128, 256, and 512 $\mu\text{g/mL}$). The IC_{50} values of metal complexes and free ligand were 16.21 (SBI-Co), 75.98 (SBI-Ni), 25.53 (SBI-Cu), 81.71 (SBI-Zn), and 29.6 (free ligand) $\mu\text{g/mL}$ respectively. Among them SBI-Co has more potent against human prostate cancer cell line (DU145). In contrast, the molecular docking study shows, Cu (II) complex has significant inhibition against human 2W3L protein.

Keywords

Schiff Base, Metal Complexes, Spectral Characterization, Anticancer, Molecular Docking

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1. INTRODUCTION

Schiff base ligands have readily synthesized from primary amine reacted with carbonyl compounds as a result of azomethine nitrogen (Vigato and Tamburini, 2004). In particular, azomethine has donor atom of nitrogen and composed. The nitrogen atom having donor atoms readily coordinated with the metal ions to formed dative bonds to produced coordination complexes (Supuran et al., 1996). Generally, Schiff base ligands have exhibiting a remarkable pharmacological activities such as antiinflammatory (Iftikhar et al., 2018) antiviral (Alam et al., 2012), antimicrobial (Da Silva et al., 2011), antituberculosis (Cordeiro and Kachroo, 2020), antioxidant (Rana et al., 2024) and anticancer (Yin et al., 2023) activities. Because of their intriguing physicochemical characteristics and wide variety of applications in various scientific fields, the majority of metal complexes with Schiff base ligands have recently become the focus of intensive research (Alminderej and Lotfi, 2021; Alorini et al., 2022; Lotfi, 2020). And also, Schiff base ligands have also exhibited different coordination modes as a result which produced tri, tetra, penta, hexa, and heptadentate coordinated metal complexes (Alfonso-Herrera et al., 2022; Alfonso-Herrera et al., 2024; Liu and Hamon, 2019; Raji and Bader, 2024). In this continuation, nitrogen, oxygen and sulphur containing heterocyclic compound has played a vital function in the medicinal chemistry (Zheng et al., 2024). Among them, nitrogen and

sulphur containing heterocyclic compounds are extensively found in nature. In addition, benzothiazoles based derivatives have been widely utilized pharmaceuticals industries as well as metallo-enzymes (Chen et al., 2012; Venkatraman et al., 2010; Yenilmez et al., 2013). Moreover, in the recent years thiazoles containing compounds are essential building block for synthesis of inorganic complexes (Abd-Elzaher et al., 2016). According to Turan-Zitouni et al. (2016), its bis-thiazole metal complexes shown significant activity against both the A549 and C6 cell lines, with IC_{50} values of $37.3 \pm 6.8 \mu\text{g/mL}$ and $11.3 \pm 1.2 \mu\text{g/mL}$, respectively. The bisN-phenyl-N'-[(thiophen-2-yl)methylidene] carbamohydrazonothioato-nickel(II) and Cu(II) complex was exhibited excellent antiviral activity against HIV-1 virus (Choudhary, 2022). Co^{2+} , Ni^{2+} , Cu^{2+} , and Cd^{2+} metal complexes was also shown excellent α -amylase activity as well as moderate anti-oxidant activity (Singh and Bala, 2023). After subsequently, metal complexes based on hydrazone ligands (Co^{+2} , Ni^{+2} , Cu^{+2} , and Zn^{+2}) have demonstrated antihypertensive properties; of these, the copper complex and ligand demonstrated exceptional antihypertensive properties (Bakale et al., 2023). Then, benzothiazole Schiff bases based lanthanide (III) complexes were shown good antibacterial activity against *Staphylococcus aureus* and *Propionic bacteria acnes* bacterial strains (Mishra et al., 2020). After that, benzothiazole based binary metal complexes have been established against Gram-positive

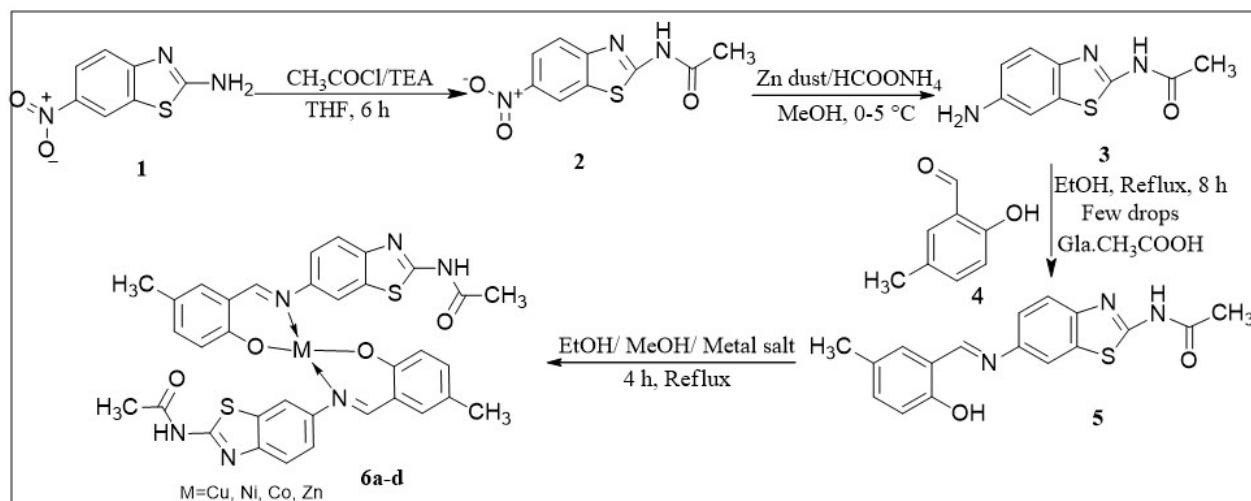


Figure 1. The Synthetic Route for the Synthesis of SB1 and its Metal Complexes (Co (II), Ni (II), Cu (II) and Zn (II))

bacterial strain (*Bacillus amyloliquefaciens* & *Staphylococcus aureus*) Gram-negative (*Escherichia coli*) and fungal strain (*Macrophomina phaseolina* & *Sclerotium rolsfii*) respectively (Daravath et al., 2019). The *in-vitro* results examined metal complexes were shown more significant activity than thiazole ligands, and modest activity when compared to standard drugs. Additionally, metal complexes have good antioxidant and DNA cleavage ability against the pBR322. Therefore, benzothiazole based metal complex has potent biological activities.

According to the literature investigation, we have described the preparation of SB-1 ligand by condensing of S1 with 2-hydroxy-5-methylbenzaldehyde. We have utilized benzothiazole Schiff base ligand for synthesis of various metal complexes including Co (II), Ni (II), Cu (II) and Zn (II). The synthesized metal complexes were analyzed by using various spectroscopic methods. The anticancer effectiveness of synthesized SB-1 and metal complexes were also studied.

2. EXPERIMENTAL SECTION

2.1 General Procedure for the Synthesis of (S1)

2-Amino-6-nitrobenzothiazole (5 g, 0.025 mmol) was dissolved in THF (65 mL) with constant stirring at $0-5^\circ\text{C}$. Subsequently, 10.8 mL of triethylamine (0.076 mmol) were added into the solution, followed by 2.72 mL of acetyl chloride (0.038 mmol), with 10 mL of THF added dropwise. At room temperature, the resultant reaction mixture was stirred for six hours. TLC (ethyl acetate:hexane, 7:3) was used to monitor the reaction's progress. Ethyl acetate (250 mL) and water (200 mL) were used to extract the crude reaction mass. Spectroscopic methods were used to analyse the obtained pure products.

2.2 General Procedure for the Synthesis of (S2)

To a solution of S1 (2.5 g, 0.010 mmol) in methanol (50 mL), ammonium formate (4.72 g, 0.073 mmol) and zinc dust (4.63 g, 0.073 mmol) were added and the reaction mixture was

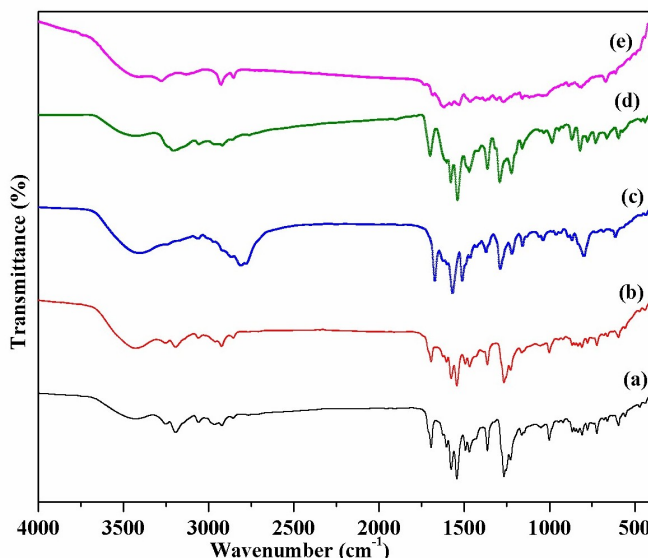


Figure 2. FTIR Spectrum of a) SB1 b) Co c) Ni d) Cu e) Zn Complex

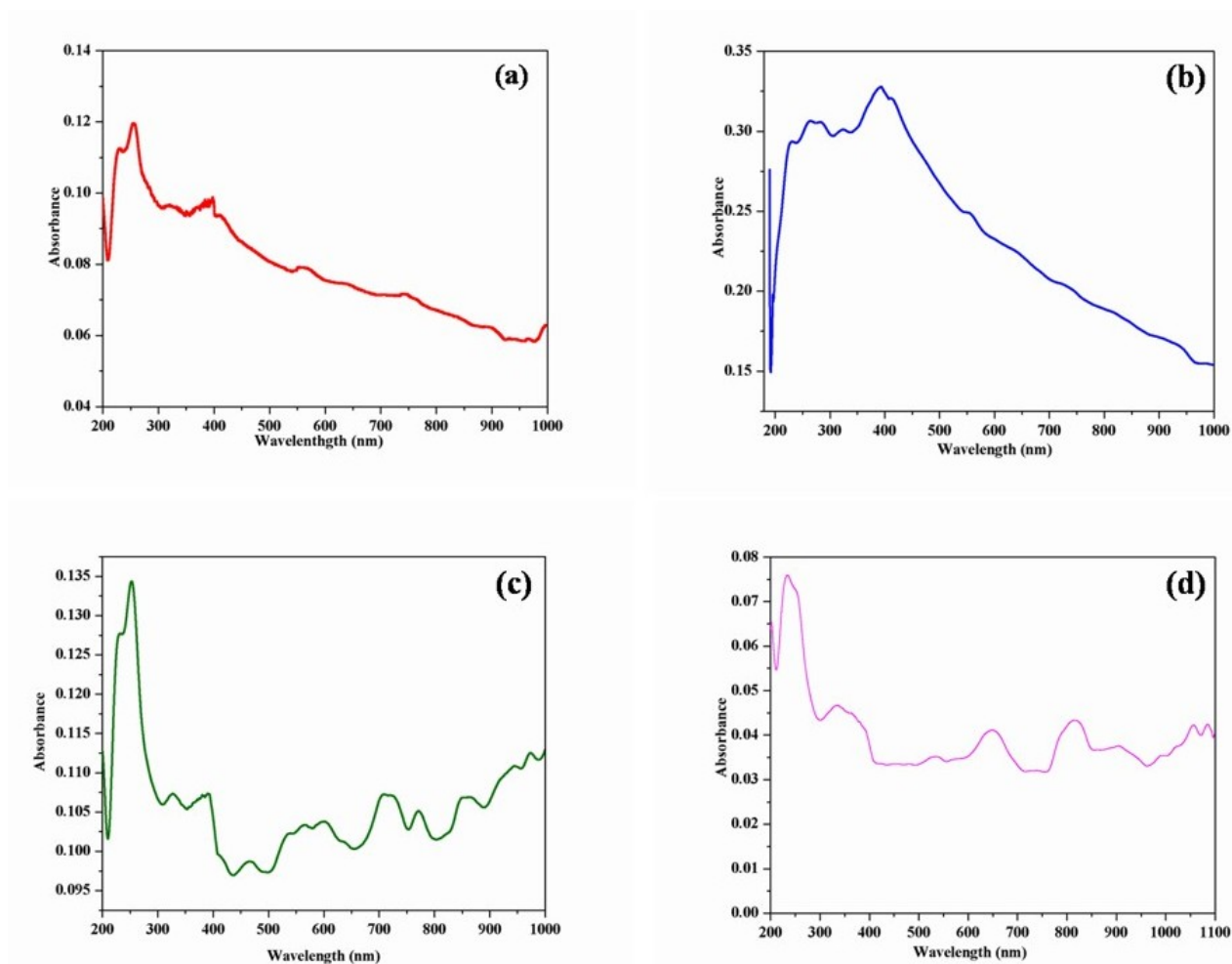
stirred at $0-5^\circ\text{C}$ for 45 minutes under room temperature. Next, the reaction mass was filtered, resulting filtrate was evaporated under reduced pressure using rotary evaporator to furnish the pure product (S2).

2.3 Procedure for the Synthesis of N-(6-(E)-[2-(Hydroxy-5-Methylphenyl)methylidene]Amino-1,3-Benzothiazol-2-yl)Acetamide Schiff Base (SB-1)

A mixture of S2 (1.5 g, 0.007 mmol), 2-hydroxy-5-methylbenzaldehyde (1.08 g, 0.008 mmol), and a few drops of glacial acetic acid was dissolved in ethanol (30 mL) (Abd-Elzaher et al., 2016). The reaction mixture was allowed to reflux for 8 hours. The completion of the reaction was monitored by TLC.

Table 1. FTIR Spectral Data of Ligand and Respective Transition Metal Complexes

Ligand/Complex	ν (OH) cm^{-1}	ν (Ar- C-H) cm^{-1}	ν (C=O) cm^{-1}	ν (Amide N-H) cm^{-1}	ν (C=N) cm^{-1}	ν (C=N thia- zole) cm^{-1}	ν (C-O) cm^{-1}	ν (C-S) cm^{-1}	ν (M- O) cm^{-1}	ν (M- N) cm^{-1}
$\text{C}_{17}\text{H}_{15}\text{N}_3\text{O}_2\text{S}$	3249	3056	1531	3197	1695	1584	1264	770	–	–
$\text{C}_{34}\text{H}_{28}\text{CoN}_6\text{O}_4\text{S}_2$	–	3049	1554	3182	1681	1580	1249	774	565	469
$\text{C}_{34}\text{H}_{28}\text{NiN}_6\text{O}_4\text{S}_2$	–	3049	1524	3167	1658	1584	1294	772	602	484
$\text{C}_{34}\text{H}_{28}\text{CuN}_6\text{O}_4\text{S}_2$	–	3049	1531	3197	1592	1584	1249	776	572	438
$\text{C}_{34}\text{H}_{28}\text{ZnN}_6\text{O}_4\text{S}_2$	–	3108	1524	3116	1531	1582	1264	778	669	476

**Figure 3.** UV-Vis Spectrum of a) Co (II) b) Ni (II) c) Cu (II) d) Zn (II) Metal Complexes

To generate the pure product (SB-1), the corresponding solid powder was filtered, dried, and recrystallised from methanol.

2.4 Synthesis of Metal Complexes

A mixture of N-(6-(E)-[(2-hydroxy-5-methylphenyl)methylidene]amino-1,3-benzothiazol-2-yl)acetamide (0.25 g, 0.0008 mmol) and $\text{Cu}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ (0.118 g, 0.0004 mmol) was dissolved in methanol (Abd-Elzaher et al., 2016). The re-

action mixture was allowed to reflux for 4 h. The obtained metal complex was filtered and rinsed with ethanol, dried under vacuum to remove excess solvent. As per the following procedure, the individual metal complex was synthesized using $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$, $\text{CoCl}_2 \cdot \text{H}_2\text{O}$ and $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ metal salts.

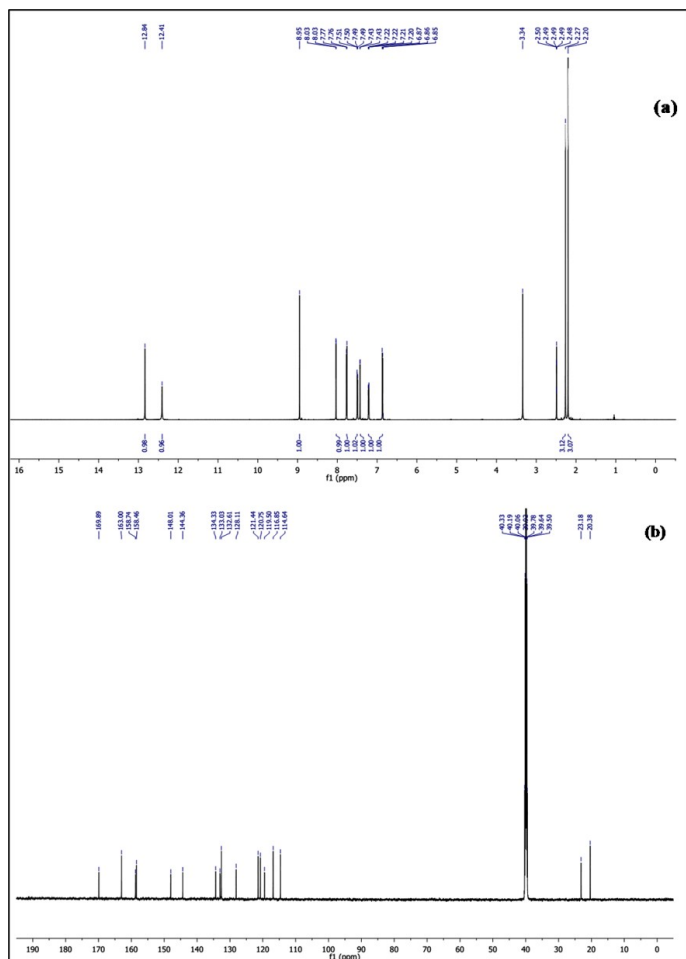


Figure 4. Proton Nuclear Magnetic Resonance of Schiff Base Ligand, 4 (B). Carbon Nuclear Magnetic Resonance Spectrum of Schiff Base Ligand

2.5 Spectral Data of the Synthesized Compounds

S1: Off-white solid; Yield 65%; M.P. 284–285 °C; FT-IR (KBr) ν_{max} in cm^{-1} : 3174 (N-H, Stretching), 3071 (C-H, Stretching), 2949 (C-H, Stretch), 1701 (Carbonyl, Stretching), 1553, 1340 (Nitro group Stretching), 883 (C-H, bending), 748 (C-S Stretching); Nuclear resonance of proton (300 MHz, DMSO- d_6) δ ppm: 2.24 (s, 3H), 7.84 (d, 1H), 8.24 (dd), 8.97 (d, 1H), 12.72 (s, 1H, amide); Nuclear resonance of carbon (300 MHz, DMSO- d_6) δ ppm: 22.76, 118.85, 120.44, 121.63, 132.09, 142.86, 153.39, 163.37, 170.11; LC-MS (ESI) m/z : 236.21 (M-H) $^-$.

S2: Pale yellow solid; Yield 72%; M.P. 251–252 °C; FT-IR (KBr) ν_{max} in cm^{-1} : 3412, 3291 (N-H, Stretching, amine), 3135 (C-H), 2917 (C-H), 1694 (Carbonyl), 1604 (C=N), 1553 (N-H, bending), 1250 (C-N, Stretching), 845 (C-H, bending); Nuclear resonance of proton (300 MHz, DMSO- d_6) δ ppm: 2.14 (s, 3H, methyl), 5.13 (s, 2H, amine), 6.70 (dd, 1H), 6.98 (d, 1H), 7.38 (d, 1H), 11.98 (s, 1H, amide); Nuclear resonance of carbon (300 MHz, DMSO- d_6) δ ppm: 22.61, 104.09,

114.38, 120.77, 132.86, 139.59, 145.62, 153.05, 168.62; LC-MS (ESI) m/z : 206.27 (M-H) $^+$.

N-(6-((E)-[2-hydroxy-5-methylphenyl)methylidene]amino)-1,3-benzothiazol-2-yl)acetamide (SB-1): 1.92 g of SB-1, orange solid; Yield 82%; M.P. 292–293 °C; FT-IR (KBr) ν_{max} in cm^{-1} : 3427 (N-H, amide), 3063 (C-H), 2956 (C-H, asymmetric), 2918 (C-H, symmetric), 1694 (C=O), 1612 (C=N), 1574 (N-H bending), 1273 (C-N, amide), 708 (C-S); Nuclear resonance of proton (300 MHz, DMSO- d_6) δ ppm: 2.20 (s, 3H), 2.27 (s, 3H), 6.86 (t, 1H), 7.43 (d, 1H), 7.49 (s, 1H), 7.50 (d, 1H), 7.76 (d, 1H), 8.03 (d, 1H), 8.95 (s, 1H), 12.41 (s, 1H), 12.84 (s, 1H); Nuclear resonance of carbon (300 MHz, DMSO- d_6) δ ppm: 20.38, 23.18, 114.64, 116.85, 119.50, 120.75, 121.44, 128.11, 132.61, 133.03, 133.33, 144.36, 148.01, 158.46, 158.74, 163.00, 169.89; LC-MS (ESI) m/z : 326.19.21 (M+H) $^+$.

3. RESULTS AND DISCUSSION

The SB-1 was synthesized from the condensation of S1 and 2-hydroxy-5-methylbenzaldehyde, dissolved in ethanol with a few drops of glacial CH_3COOH , followed by reflux conditions (Figure 1) for an appropriate reaction time. The corresponding ligand was directly reacted with metal salts such as $\text{Cu}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$, $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$, $\text{CoCl}_2 \cdot \text{H}_2\text{O}$, and $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ in a mixture of ethanol and methanol under reflux conditions. The synthesized metal complexes were isolated by simple filtration. These metal complexes are more soluble in polar aprotic solvents (DMSO) and exhibit higher melting points compared to SB-1. The synthesized metal complexes were analyzed by spectroscopic techniques.

3.1 FTIR Spectral Analysis

Table 1 showed the metal complexes (6a-d)'s fourier transform infrared spectral data. The synthesised SB1's FTIR spectrum revealed the azomethine (C=N) group as a prominent, intense band at 1688 cm^{-1} . The thiazole ring's C=N is represented by the peak that emerged at 1561 cm^{-1} . The strong peaks that followed at 3249, 3182, 3049, and 1531 cm^{-1} are responses to the carbonyl moiety, aromatic C-H, phenolic OH, and NH of acetamide, respectively. Then, phenolic C-O and C-S-C stretching vibration of thiazole ring was appeared at 1264 and 769 cm^{-1} . Though, the azomethine (C=N) moiety was appeared in the metal free ligand at 1695 cm^{-1} whereas metal complexes shifted at low intensity at $1681\text{--}1531 \text{ cm}^{-1}$, this is due to the azomethine coordinated to the metal ions as a result formation of transition metal complexes. Additionally, the C=N in the thiazole ring is exhibit a peak at 1584 cm^{-1} in the free ligand and metal complexes, which proved that C=N moiety not involving the coordination of the metal ions. Further, SB1 and metal complexes were displayed a peak at $770\text{--}778 \text{ cm}^{-1}$, which indicates C-S-C stretching vibration of thiazole ring sulphur not involving the complexation. In particular, the new bands displayed at $565\text{--}669 \text{ cm}^{-1}$ and $469\text{--}476 \text{ cm}^{-1}$ which is not found in the SB1, these bands corresponds to the

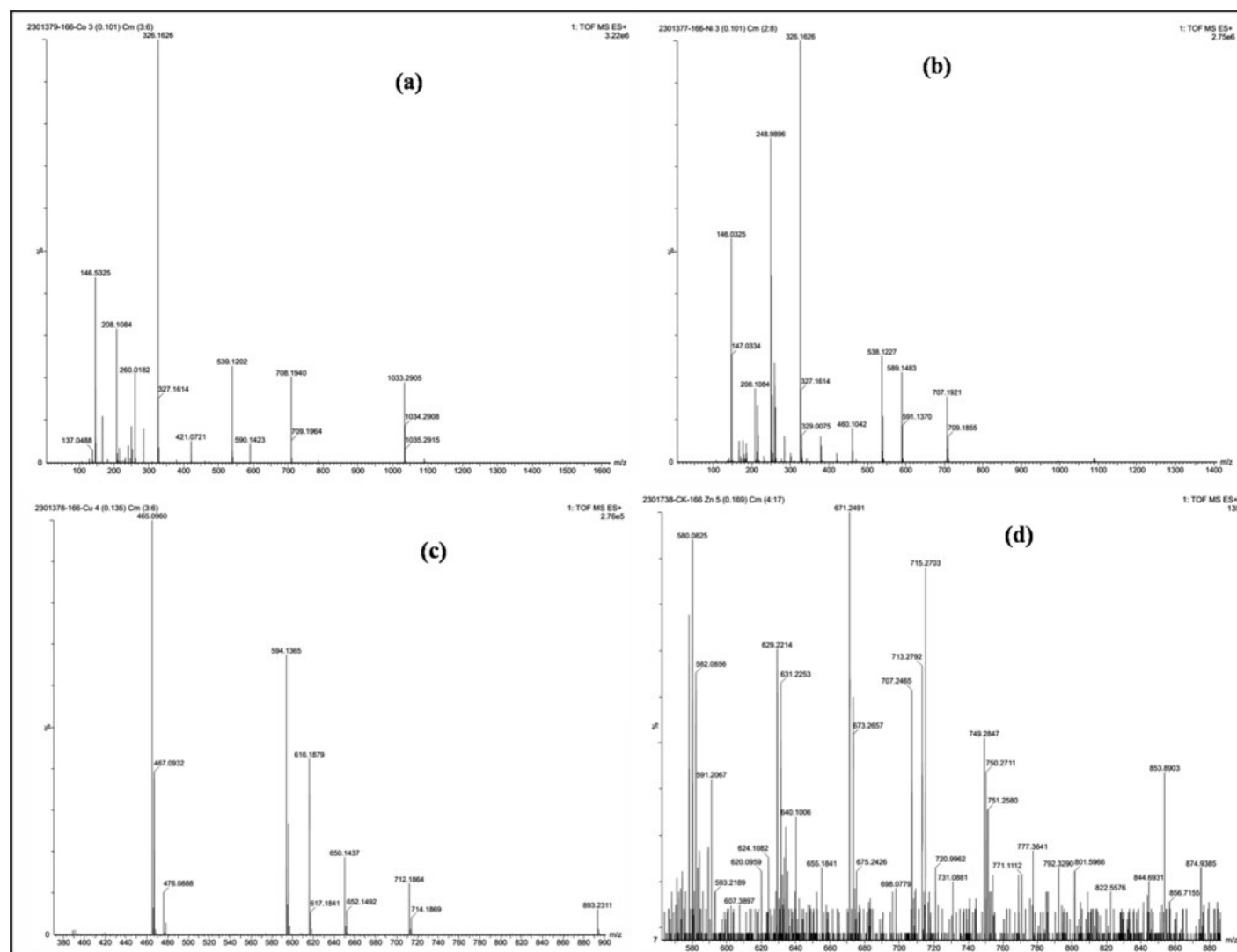


Figure 5. Mass Spectrum of Co Complex, (B). Mass Spectrum of Ni, (C). Mass Spectrum of Cu Metal Complex, (D). Mass Spectrum of Zn Metal Complex

M–O and M–N bonds in the metal complexes respectively (Figure 2).

3.2 UV-Vis Spectra Studies

Every complex's UV-Vis spectra were recorded at room temperature in DMSO. The π - π^* and n - π^* charge transfer transitions for the azomethine and thiazole rings, respectively, are denoted by the bands at 280 and 342 nm in the free ligand's UV-Vis spectrum. The Co (II) complex's UV-Vis spectra showed a band at 555 and 396 nm that was ascribed to the 2B_{1g} - 2E_g transition. Next, the Ni complex was shown a band at 562 and 388 nm corresponds to 1A_{1g} - 1B_{1g} transition. Similarly, both Cu and Zn complexes were displayed broad band at 535-631 nm ascribed to the 2B_{1g} - 2A_{1g} and 2B_{1g} - 2E_g transition (Figure 3). Based on the previous literature report, the electronic spectral information was confirmed the complex formation (Vamsikrishna et al., 2017).

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3.3 ¹H-NMR and ¹³C-NMR Spectra Studies

The ¹H-NMR spectrum of SB1 shows a singlet at δ 2.22 ppm corresponding to the presence of CH₃ group in the aromatic ring. Next, the singlet was displayed at δ 2.27 ppm corresponding to the methyl proton of the acetamide moiety. The azomethine proton showed a singlet at δ 8.95 ppm, and the aromatic ring displayed a singlet and doublets at δ 7.43, 6.86, and 8.86 ppm, respectively. In the ¹³C NMR spectrum, a peak at δ 169.89 ppm corresponded to the presence of the carbonyl

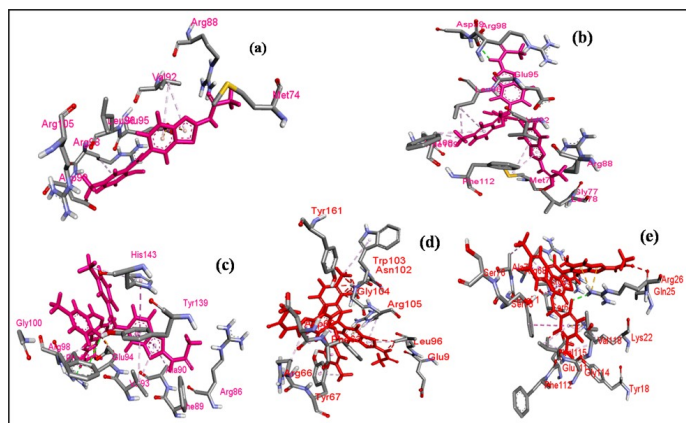


Figure 6. Interaction View 2W3L Protein with a) Schiff Base Ligand b) Co c) Ni d) Cu and Zn Complexes

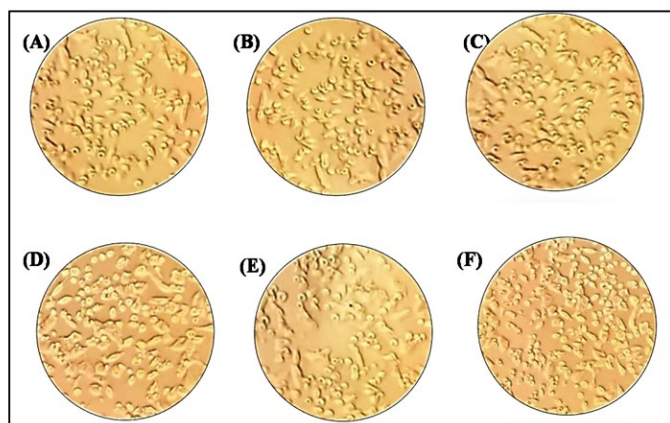


Figure 7. DU145 Cell Viability Before Sample Incubation (A) SBI-Co, (B) SBI-Ni, (C) SBI-Cu, (D) SBI-Zn, (E) SBI And (F) Control

group, and δ 163.00 ppm was attributed to the azomethine carbon. Since the acetyl group's carbonyl carbon was present, the methyl proton showed a single peak at δ 20.38 ppm and a singlet at δ 23.18 ppm. From δ 114 to 158 ppm, the remaining aromatic carbons were visible (Figures 4a & 4b). This extension of the ligand's mass spectrum disclosed the molecular ion peak at $m/z = 326.19$. Additionally, the complexes' mass spectra showed that the Co, Ni, Cu, and Zn complexes had molecular ion peak values (m/z) at 708, 707, 712, and 715, respectively (Figures 5a-d).

3.4 Molecular Docking Studies

According to the molecular docking analysis, synthesized transition metal complexes of 6a, 6b, 6c and 6d were exhibited good to excellent binding energy with crystal structures of 2W3L human protein. And also, the studies performed by using the Hex.8.0.0 software and docking poses are depicted in Figure 6. The binding energy value of Schiff base ligand is -263.81 kcal/mol and it didn't interact with the protein amino acid. Next,

the binding energy value of Co (II) is -326.66 kcal/mol and it exhibited interaction with amino acid residue Asp99 (2.72Å) with one conventional hydrogen bond interaction. The binding energy value of Ni (II) complex is -333.56 kcal/mol and exhibit three hydrogen bonding interaction with Glu94 (3.12Å), Arg98 (2.34Å) and Tyr39 (1.95Å). Similarly, the binding energy of Cu (II) is -348.85 kcal/mol and the amino acid residue Asn102 (2.06Å) shown conventional hydrogen bonding interaction and also with pi-donor hydrogen bond interaction Arg105 (2.61Å) whereas, the binding of Zn (II) complex is -341.52 kcal/mol, this value very less when compared to the Cu (II), while it shows two conventional hydrogen bonding interaction with Arg 26 (2.18Å) and Arg 68 (2.78Å). The molecular docking study was strongly supported the biological performance of the complexes.

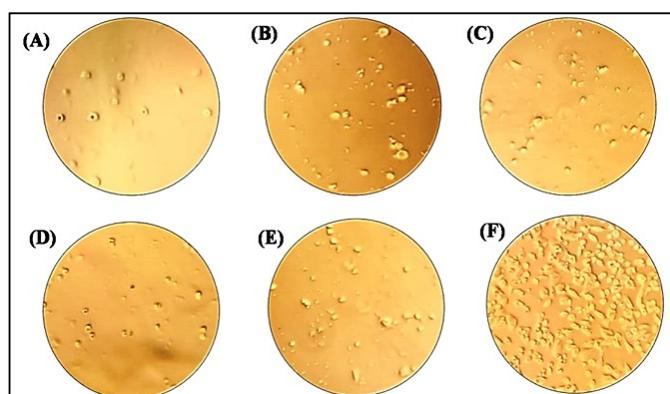
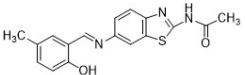
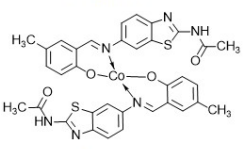
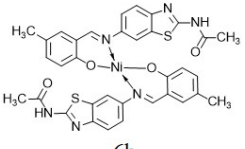
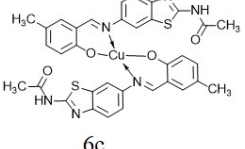
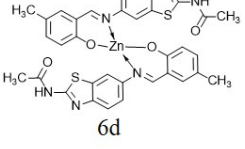


Figure 8. DU145 Cell Viability After Sample Incubation (A) SBI-Co, (B) SBI-Ni, (C) SBI-Cu, (D) SBI-Zn, (E) SBI And (F) Control

3.5 Anticancer Activity

SBI-Co, SBI-Ni, SBI-Cu, SBI-Zn, and SBI were treated with DU145 to investigate the anticancer activity of the synthesized metal complexes, and the MTT assay was employed to determine the IC_{50} values (Table 2). Particularly, before incubation of the metal complexes and free ligand on DU145 cell line, there was no change observed in the morphology of the cell line (Figure 7). The cytotoxicity effect of all the prepared metal complexes and Schiff base ligand were studied using different concentrations from 1, 2, 4, 8, 16, 32, 64, 128, 256 and 512 $\mu\text{g/mL}$. Significant anticancer activity was demonstrated by the synthesized metallic complexes and Schiff base ligand, even if the complex's concentration was also raised from 1 to 512 $\mu\text{g/mL}$. In addition, both the metal complexes and ligand shown 50% of cell death was observed from 16.21-81.71 $\mu\text{g/mL}$ (Figure 8). Apparently, SBI-Co, SBI-Cu complexes and Schiff base ligand (SBI) have demonstrated the IC_{50} values such as 16.21, 25.53 and 29.6 $\mu\text{g/mL}$ respectively. Meanwhile, SBI-Ni and SBI-Zn complexes were shown IC_{50} values 75.98 and 81.71 $\mu\text{g/mL}$. The observed result clearly proved that, at low concentration of metal complexes like Co,

Table 2. Preparation of Transition Metal Complexes of N-(6-{(E)-[(2-Hydroxy-5-Methylphenyl)Methylidene]Amino}-1,3-Benzothiazol-2-yl)Acetamide

Ligand/Complex	Molecular Formula	Molecular Weight	Time (h)	Colour	Yield (%)
 Ligand	C ₁₇ H ₁₅ N ₃ O ₂ S	325.38	8	Orange solid	82
 6a	C ₃₄ H ₂₈ CoN ₆ O ₄ S ₂	707.69	4	Brown solid	80
 6b	C ₃₄ H ₂₈ NiN ₆ O ₄ S ₂	707.45	4	Dark brown solid	84
 6c	C ₃₄ H ₂₈ CuN ₆ O ₄ S ₂	712.30	4	Maroon solid	80
 6d	C ₃₄ H ₂₈ ZnN ₆ O ₄ S ₂	714.30	4	Dark grey solid	78

Cu and SB1 were exhibited higher cytotoxic effect whereas, Zn and Ni complex was shown less cytotoxic effect while increasing the concentration.

Furthermore, the microscopic analysis was examined morphological damage and significantly decreased cell density (Figure 8) at the concentration of 512 µg/mL. Among them, SB₁–Co complex was shown more potent towards DU145 cancer line when than the other metal complexes and ligand. Therefore, the order of IC₅₀ values are 16.21 (SBI–Co), 25.53 (SBI–Cu), 29.6 (SBI), 75.98 (SBI–Ni) and 81.71 (SBI–Zn) µg/mL respectively. Finally, the growth inhibition of cancerous cell was observed in Figure 9. Finally, the order of potency of anticancer activity of IC₅₀ trends are 16.21 (SBI–Co) >25.53 (SBI–Cu) >29.6 (SBI) >75.98 (SBI–Ni) >81.71 (SBI–Zn) µg/mL (Figure 9). Among them, 2-aminobenzothiazoles based ligand was found to be low IC₅₀ values when compared to the 75.98 (SBI–Ni) and 81.71 (SBI–Zn) for complexes. This is due to the presence of imine, hydroxyl, methyl, acetamide, thiazole and benzene ring in the free ligand. The metal complexes and ligand was readily bind with DNA base and cause replication and transcription process as a result destruction of cancer cell (Aslan et al., 2020; Shiju et al., 2020).

Moreover, metal complexes and free ligand made strong hydrogen bonding was increased as result higher cytotoxic activity (Deswal et al., 2022). The microscopic analysis was shown morphological damage and drastically decreased cell density which cause cytotoxicity. Further, we have compared the IC₅₀ value of standard drug Paclitaxel and synthesized metal complex for DU145 cell line. The standard drug Paclitaxel has exhibited (3.16 ± 0.91) (Deswal et al., 2022) excellent anticancer activity compared to the synthesized metal complex and shown less potent against DU145 cell line.

According to the earlier literature report (Abd-Elzaher et al., 2016), the SAR of the metal complexes was assessed. The synthesized transition metal complexes having different metal atom coordinated to the benzothiazole ligand. The obtained metal complexes and Schiff base ligand was active against DU145 cancer cell line. The order of IC₅₀ value of metal complexes and ligands are 16.21 (SBI–Co (II)) >25.53 (SBI–Cu (II)) >29.6 (SBI) >75.98 (SBI–Ni (II)) >81.71 (SBI–Zn (II)) µg/mL. Among them, Co (II) complex has more potent against DU145 cancer cell line in Figure 10. Meanwhile, Ni and Zn complexes are less effective when compared the other metal complexes and ligand, this is due to their high lipophilicity

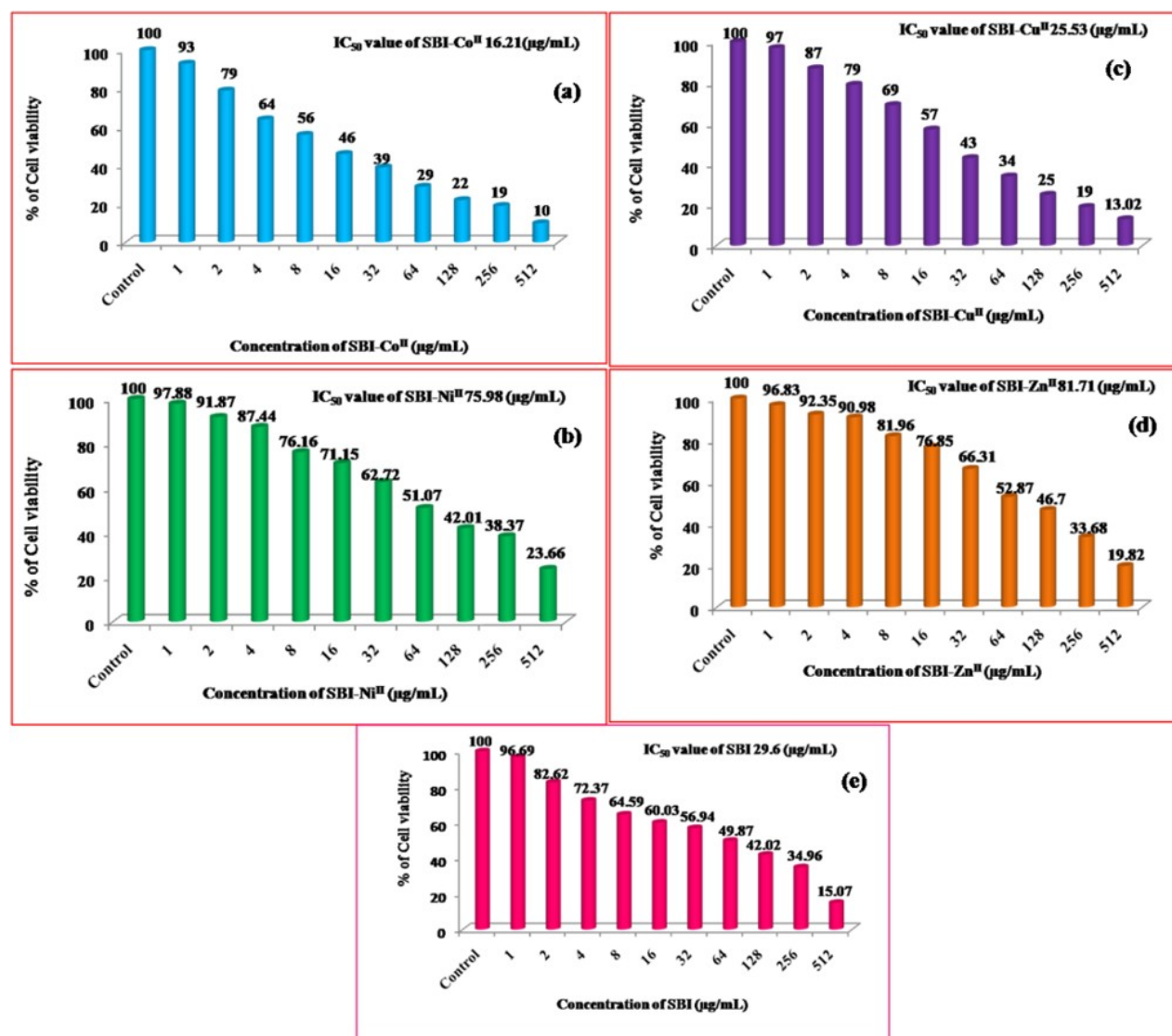


Figure 9. IC₅₀ Value of Various Concentrations of Metal Complexes a) SBI-Co b) SBI-Ni c) SBI-Cu d) SBI-Zn and e) SBI

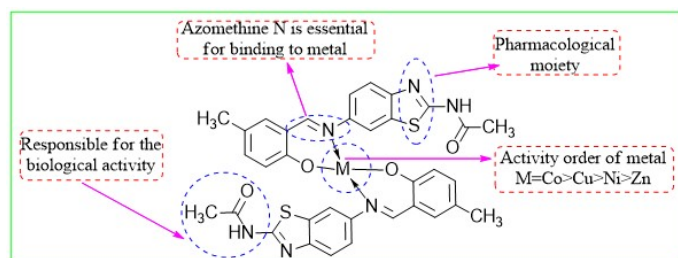


Figure 10. Schematic Illustration of Structure-Activity Relationship of Transition Metal Complex

(Devi et al., 2021). The results are good agreement with the previous literature report.

4. CONCLUSIONS

In conclusion, the prepared benzothiazole ligand and square planar complexes was confirmed by using spectroscopic methods. The cytotoxic activity of four transition metal complexes (Co, Ni, Cu, and Zn) against the DU145 cancer cell line was subsequently investigated. Co complex has more potential against DU145 carcinoma cell line, according to their IC₅₀ values (16.21 (SBI-Co (II)) >25.53 (SBI-Cu (II)) >29.6 (SBI) >75.98 (SBI-Ni (II)) >81.71 (SBI-Zn (II)) μg/mL), Co complex has more potential against DU145 cancer line.

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