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SYNTHESIS, CHARACTERIZATION AND INVESTIGATION OF ANTI-OXIDANT PROPERTIES OF TRANSITION METAL COMPLEXES DERIVED FROM METHIONINE AND GLYOXAL SCHIFF BASE [2-((E)-((E)-2-((1-carboxy-3-(methylthio)propyl)imino)ethylidene)amino)-4-(methylthio)butanoic acid]

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ABSTRACT

This work investigated the anti-oxidant properties of transition metal complexes derived from methionine and glyoxal Schiff base. The Schiff base was complexed by four metal ions: Co(II), Ni(II), Cu(II), Zn(II). All complexes including the Schiff base were characterized by magnetic susceptibility, FT-IR, XRD, UV-vis. The Schiff base and the complexes gave good yield (> 60%). The complexes except zinc complex were coloured. The FT-IR results showed the formation of the Schiff base as v(C=N) of the IR was observed at 1643.41cm^{-1}. The XRD displayed sharp peaks which confirmed the crystalline structure of the complexes. All the complexes showed promising antioxidant property, which implies that they all exhibited scavenging power more than average of the control (ascorbic acid). However, the cobalt complex showed more scavenging power than other complexes and this can be due to the fact that its paramagnetic property is more than others. Schiff bases are generated by the body and they can be incorporated into the body. The C=N azomethine nitrogen of Schiff base has provided a binding site for metal ions so that they can be attached with different bio-molecules that can scavenge.

Keywords: Schiff base, anti-oxidant, methionine, glyoxal.

INTRODUCTION

Transition metals are the d – block elements. They are found in group three (3) to group twelve (12) of the periodic table, with property of variable oxidation states. These occur as a result of their progressive filling of the d- orbital, a property that makes it easy for them to form complexes with molecules and anions. They have empty d- orbital which makes it easy for them to undergo coordination, forming coordination complexes [1].

The interaction of transition metal complexes with DNA has been extensively studied in the development of new tools for nanotechnology, with vast applications [2]. Schiff bases, discovered by Hugo Schiff in 1864 are produced when primary amines or amino acids and carbonyl compounds condensed [3-4].

L- methionine is a sulphur containing amino acids with the formular $C_5H_{11}NO_2S$ which was detected by Feitmann in 1847 at Liebig's Laboratory. It is found in high content (about 5%) in albumins especially the egg albumin belonging to the water soluble protein called globulins [5]. Antioxidants are naturally producing chemical substances from the body that protect the living organisms from dangers caused by harmful molecules called free radicals [6].

In a review work by Uddin *et al.* [7], the functional group C=N found in Schiff bases are versatile pharmacophores and hence shows beneficial effects in pharmacology, such as antifungal, antibacterial, antimalarial, antituberculosis, anti-HIV, anticancer, anti-inflammatory effects. Amino acids are known to be biologically active, hence, their coordination with metals make them more active against microbes [8]. Metal compounds and complexes are used in wide variety of applications including catalysts like perovskites [9], pharmaceutics [10], corrosion, [11].

The aim of this work is to synthesis, characterize and investigate the anti-oxidant activities of transition metal complexes derived from methionine and glyoxal Schiff base.

MATERIALS AND METHOD

All chemicals and reagents used are of analytical standard. Equipment used include Stuart SMP30 melting point apparatus (Made in Sweden), magnetic susceptibility balance, EMPYREAN Model XRD (Made in UK), UV-2550 Shimadzu spectrophotometer (Made in Japan), Agilent Spectrophotometer (Made in US), Stuart SB302 hotplate stirrer (Made in Sweden), Shimadzu FT-IR 8400S (Made in Japan).

Refluxing method as described by Deeksha et al [12] was used.. The Schiff base was prepared by condensation of (0.04 mol) glyoxal with (0.08 mol) methionine in ethanol (25 mL). About 2-3 drops of acetic acid were added and the mixture was refluxed for 4 h on a magnetic stirrer with vigorous stirring at room temperature. After completion of the reaction, the mixture

was cooled on crushed ice. The product which was collected by filtration was washed several times with ethanol and air dried before kept in vacuum desiccator.

The metal complexes were prepared by dissolving the calculated quantity of the metal nitrates [0.86 g of $Cu(NO_3)_2$, 1.05 g of $Zn(NO_3)_2$, 1.03 g of $Co(NO_3)_2$, and 1.03 g of $Ni(NO_3)_2$] respectively in 25 ml ethanol, and the Schiff base ligand in 25 ml ethanol in (1: 3). About 2-3 drops of diethylamine were added as a catalyst. The mixture was refluxed on a magnetic stirrer with vigorous stirring for 3-4 hours. The precipitates formed were filtered and washed with ethanol until the washing became colourless [13].

The temperature at which the complexes decomposed were recorded as explained by Sandeep *et al* [14]. The magnetic susceptibility of the metal complexes was carried out using method by Ibthial *et al* [15], in which the metal complexes were placed into capillary tubes and the reading were taken using the magnetic susceptibility balance. The gram magnetic moment (X_g) was calculated using Guoy techniques and Johnson Mattey catalytic system as given in the Equation 1.

$$X_g = \frac{C \times L\,(R - R_0)}{10^9 m} \quad \text{---------- 1}$$

Where:

X_g = gram magnetic moment, C = 1, a constant of proportionality of the balance

L = sample length in tube (cm) R = reading obtained of the pre-weighed empty sample tube

R_o = reading obtained of the sample packed in the tube, m = mass of the sample in the tube (in grams)

The molar magnetic moment, Xm and the effective magnetic moment, μ_{eff} were calculated according to Equations 1 and 2 respectively.

$Xm = Xg \times M.m$ ---------- 2

Where:

Xm = molar magnetic susceptibility, M.m = molar mass

$\mu_{eff} = 2.828\ (Xm/T)^{1/2}$ ---------- ------3

Where:

μ_{eff} = effective magnetic moment in Bohr magnetons (BM),

T = absolute temperature in Kelvin

The XRD studies of the Schiff base and its metal complexes were carried out using XRD analyzer equipped with monochromatic Cu-Kα (λ = 1.5406 A°) radiation operating at 40 mA and 45 kV. The patterns were recorded in the 2θ range of 5 - 75° with a step size of 0.026°s^{-1} using continuous scan mode and the crystallite sizes calculated by using Scherrer equation. Crystallite sizes calculated by using Scherrer equation.

$$L = \frac{K\lambda}{\beta.cos\theta} \quad ---------- 4$$

Where:

L = nanoparticle size, λ(nm) = wavelength, β = maximum peak in radian at any 2θ in the pattern

K = Scherrer's constant (0.98)

While the percentage crystallinity was gotten using the relation:

$$\%\ Crst. = \frac{I_2}{I_{2+\theta_2}} ---------- 5$$

Where:

I_2 = highest peak intensity, θ_2 = 2θ of the highest peak

The electronic absorption of the Schiff base and the metal complexes were carried out on in distilled water.

Antioxidant Property

The anti-oxidant property of the Schiff base and its metal complexes were determined at Biochemistry Department, Ahmadu Bello University, Zaria, Nigeria.

The Schiff base and its metal complexes were tested for their antioxidant activities using 1,1-diphenyl-2-pherylhydrazyl (DPPH). This was done using the method reported by Liyana-Pathiranan *et al* [16] and Oyedemi *et al* [17]. A solution of 0.135 mM of DPPH in methanol was prepared and 1.0 ml of this solution was mixed with 1.0 ml of the sample prepared on methanol containing 0.025 – 0.5 mg of the samples and standard drugs (ascorbic acid). The reaction mixture was vortexed thoroughly and left in the dark at room temperature for 30 mins. The absorbance of the mixture was measured using spectrophotometer at 517 nm. The ability of the sample to scavenge DPPH radical was calculated by the equation;

$$\text{DPPH RSA} = \frac{(Ac - As)}{Ac} \times 100 \quad \text{---------- 6}$$

Where:

DPPH RSA = DPPH radical scavenging activity; Ac = Absorbance of control, As = Absorbance of samples

RESULTS AND DISCUSSION

The synthesized compounds from methionine and glyoxal Schiff base gave coloured complexes which is similar to the report by Michael *et al* [8]. The percentage yield, decomposition temperature, magnetic susceptibility, colour and their molar mass are recorded in Table 1.

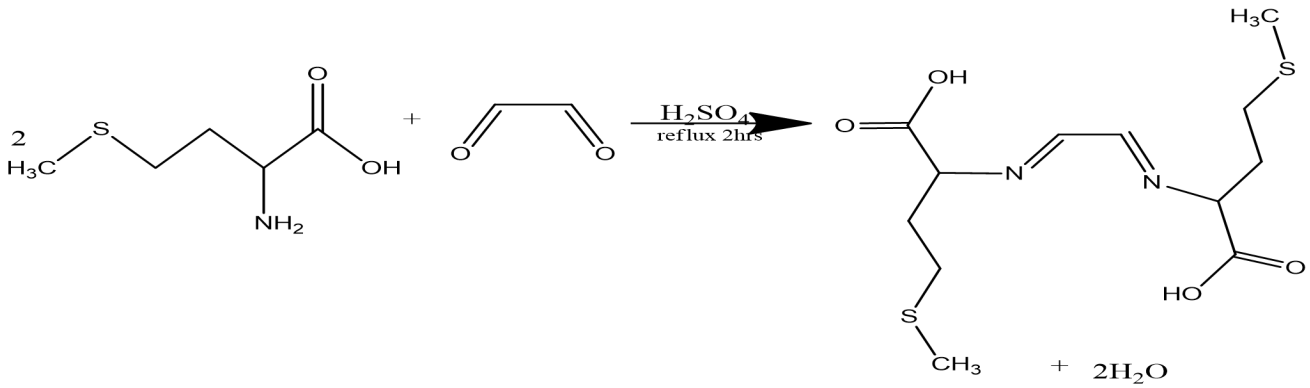
Table 1: Physiochemical properties of the compounds

Compound	Empirical formular	Colour	d.t (^{O}C)	Yield (%)	BM
SB	$C_{12}H_{20}S_2N_2O_4$	Whitish	278.9-279.1	70.00	_
Co SB	$C_{12}H_{20}S_2N_2O_4Co$	Light pink	273.9-274.5	61.63	1.22
Ni SB	$C_{12}H_{20}S_2N_2O_4Ni$	Light green	271.9-272.7	61.17	9.31
Cu SB	$C_{12}H_{20}S_2N_2O_4Cu$	Blue	223.9-224.1	80.28	5..89
Zn SB	$C_{12}H_{20}S_2N_2O_4Zn$	Whitish slivery	271.0-271.2	67.64	-0.0029

SB-Schiff base, MG – Methionie-glyoxal, d.t- decomposition temperature

FT-IR Spetrosopy

The Fourier - transform infrared spectroscopy (FT-IR) data and spectra of the Schiff base and its metal complexes are presented in Figures 4-9. FT-IR spectroscopy is a very useful method for structure elucidation of compounds. The formation of Schiff base (MG) was spectrally detected by the appearance of C=N band and the disappearance of N-H band. The peak between 1658-1519cm^{-1} confirmed v(C=N), [15,18] and the v(N-H) stretching peak of 3340-3220cm^{-1} [2] is not present. The stretching vibration of v(M-N) showed at 455-421cm^{-1} indicates the formation of the complex. Comparing the IR of the methionine and the Schiff base ligand, spectral data of the Schiff base ligand showed a band at 1643.41 cm^{-1}, which is the characteristic band of the azomethine nitrogen vC=N present in the Schiff base as similarly reported [19,20]. Likewise, in the complexes, the bands for azomethine nitrogen group vC=N shifted downfield (1585- 1624 cm^{-1}) probably due to the coordination of C-N with metal ion as reported by Raman et al [21]. On complexation, the disappearance of v N-H bands of the methionine at 3340 – 3220 cm^{-1} in the IR spectra of the metal complexes also suggested the formation of the Schiff base. Characteristics broad band in the range of 3300-3500cm^{-1} is assigned to –COOH group in the ligand [22]. However, the appearance of weak bands in the region 432.07 – 486.08 cm^{-1} and 605.67 – 678.97 cm^{-1} is attributed to v(M-N) and v(M-O) respectively.

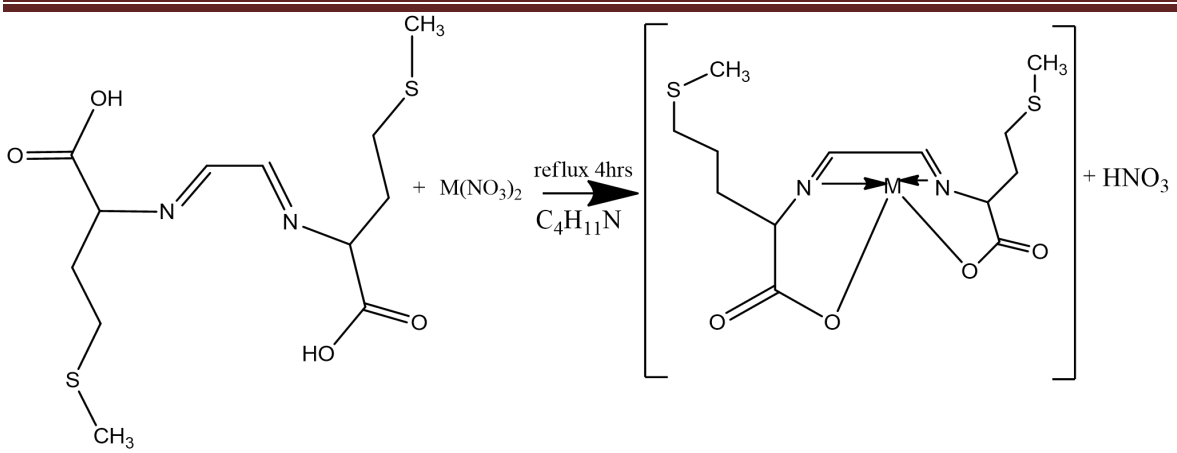


Methionine

Glyoxal

2-((E)-((E)-2-((1-carboxy-3-(methythiolprppyl)imino)ethylidene)amino)-4-(methylthiol)butanoic acid

Scheme 1**:** Schiff base synthesized from methionine and glyoxal



Scheme 2 : Schiff base metal complex synthesized from methionine and glyoxal

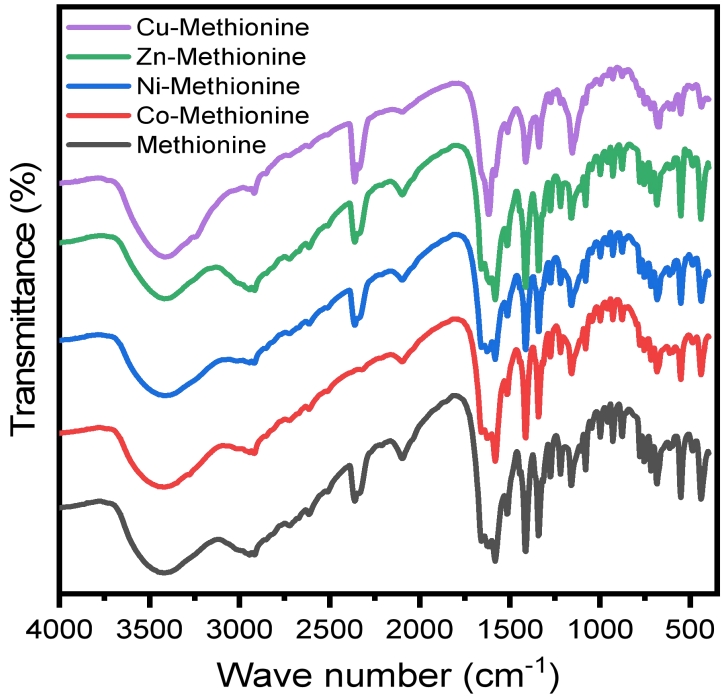


Figure 1: FT-IR Analysis of the Schiff base and the complexes

X-ray Analysis

X-ray diffraction (XRD) is a unique technique for phase identification of materials and it can also provide information on unit cell spacing. X-ray diffraction is made up of three chambers: an

X-ray tube, a sample holder, and a detector. Either Cu-Kα or Mo-Kα radiations are used in the X-ray powder diffractometry [23]. The X-ray pattern of the Schiff base and its metal complexes displayed sharp peaks and this indicates that the materials are crystalline and not amorphous as it was also confirmed by Equation 4. The complexes have high crystalline sizes ranging from 31 nm – 80 nm as presented in Table 2.

Table 2: Percentage crystallinity, crystallite size and d-spacing

Sample	% crystallinity	crystallite size (nm)	d- spacing
SB	81.70	45.19	3.9746
Co-SB	81.6S	52.74	3.9496
Ni-SB	81.99	39..54	4.0468
Cu-SB	81.65	79.11	3.9561
Zn-SB	81.62	31.61	3.9472

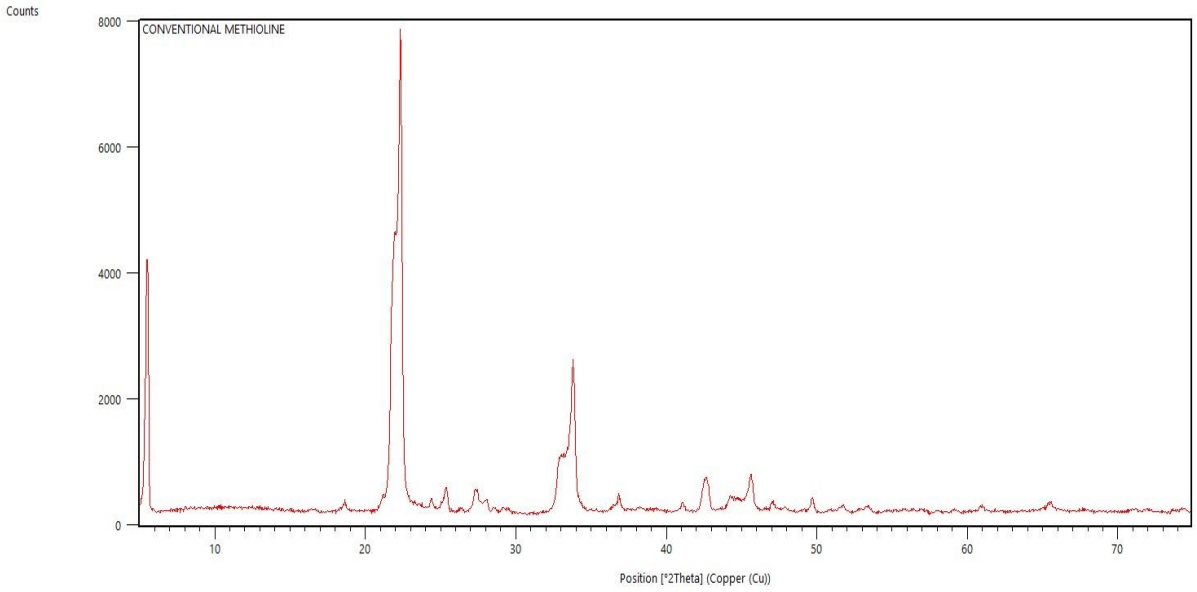


Figure 2 : Schiff base XRD spectrum

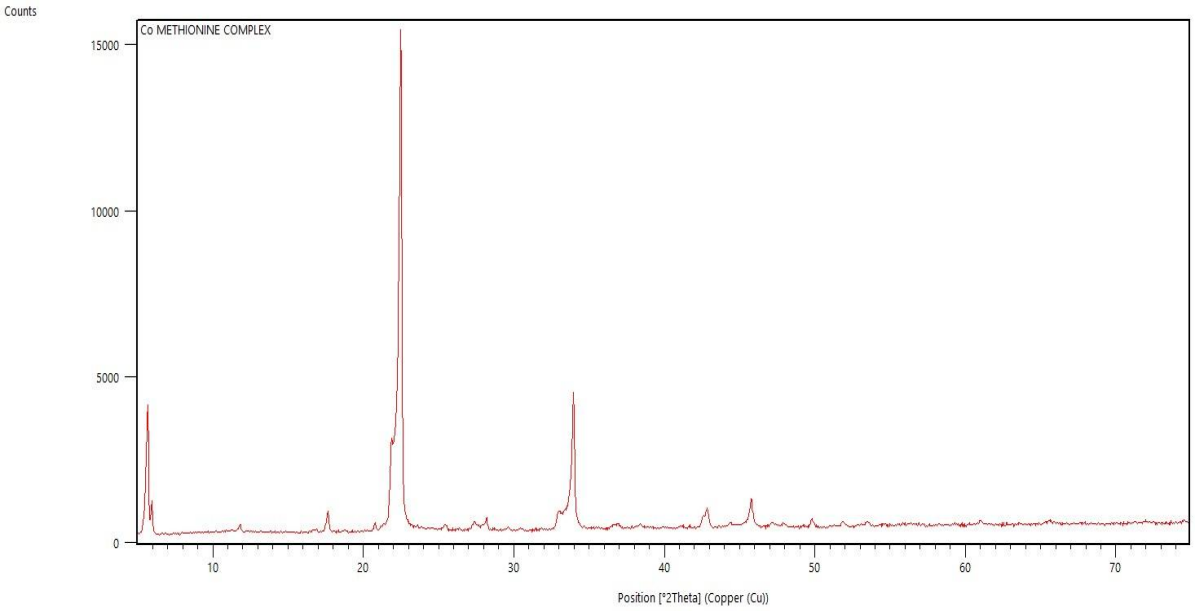


Figure 3: Co-complex XRD spectrum

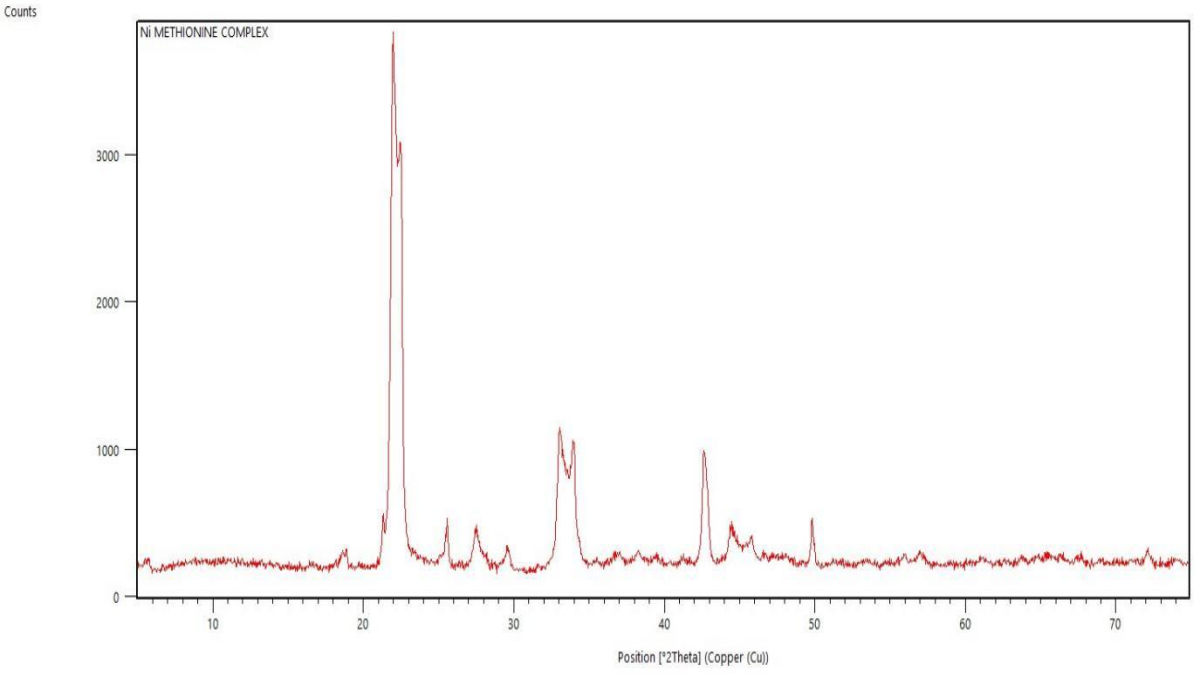


Figure 4: Ni-complex XRD spectrum

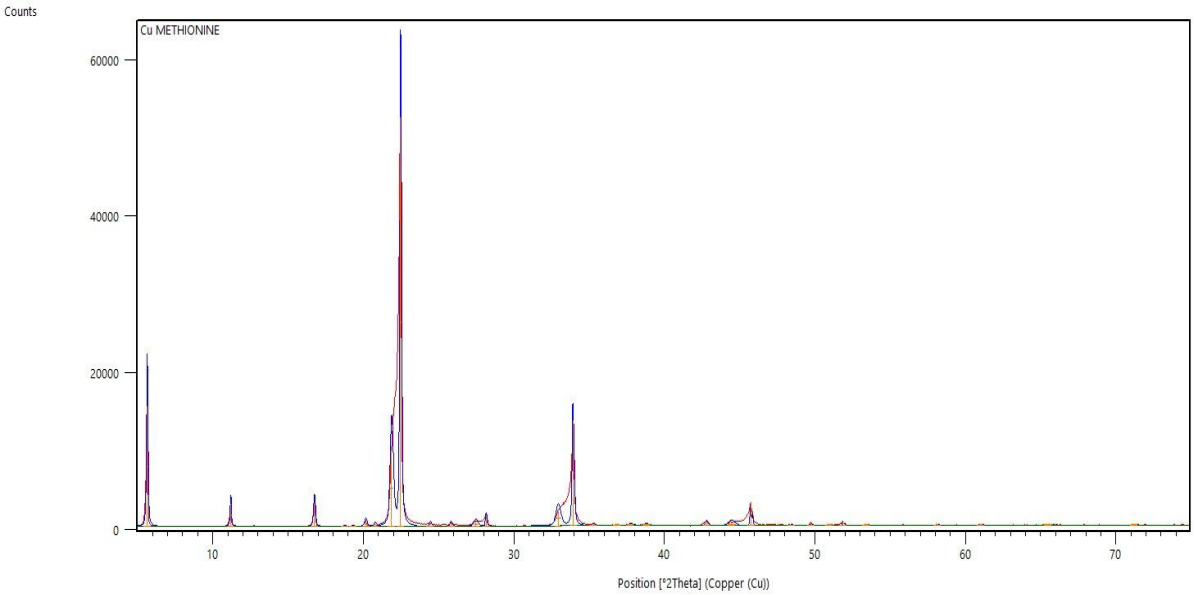


Figure 5: Cu-complex spectrum

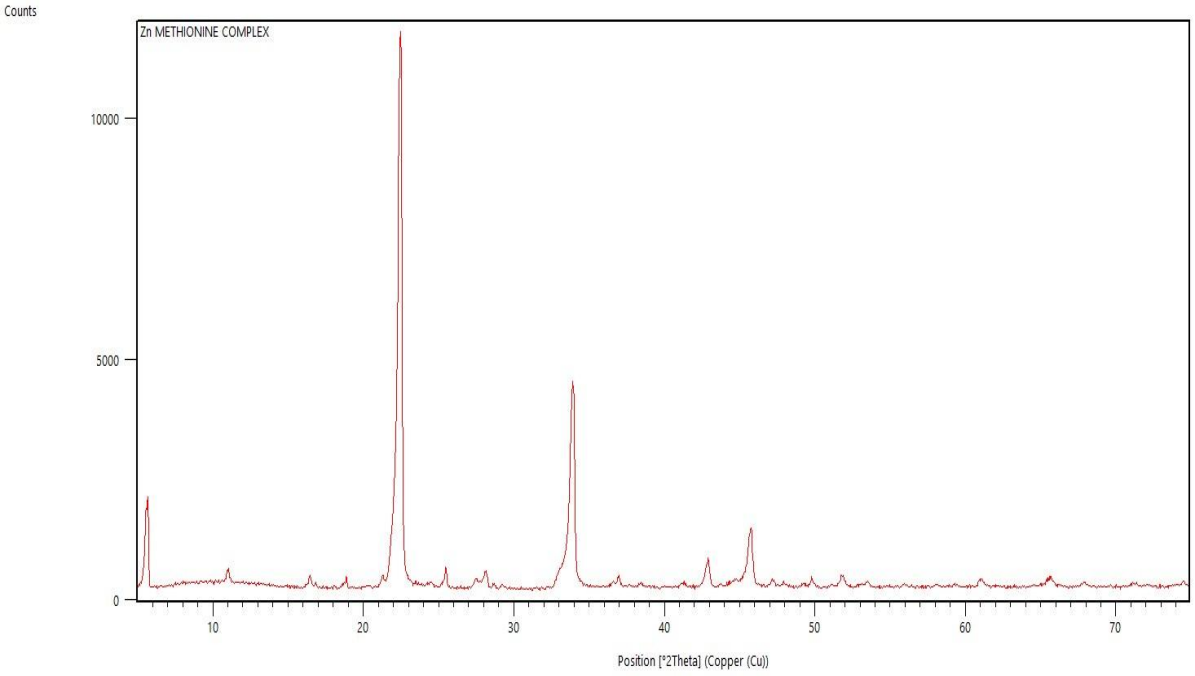


Figure 6: Zn-complex XRD spectrum

Ultra- Violet Spectrophotometer

The ligand's electronic spectrum shows a strong absorption at 210 nm due to $\pi \rightarrow \pi^*$ transitions. Similarly, the electronic spectrum of the Co(II), Ni(II), Cu(II), Zn(II) complex exhibits peaks at 207, 209, 212, and 211, also attributed to $\pi \rightarrow \pi^*$ transitions, indicating no distortion of the ligand structure upon complexation. The absence of bands around 500 nm suggests that the complexes do not have a tetrahedral geometry, but rather a linear geometry with two coordinations with the imine nitrogen. This implies that the absorbance measurements support the absence of ligand structure distortion and the specific geometry of the complexes. [24]

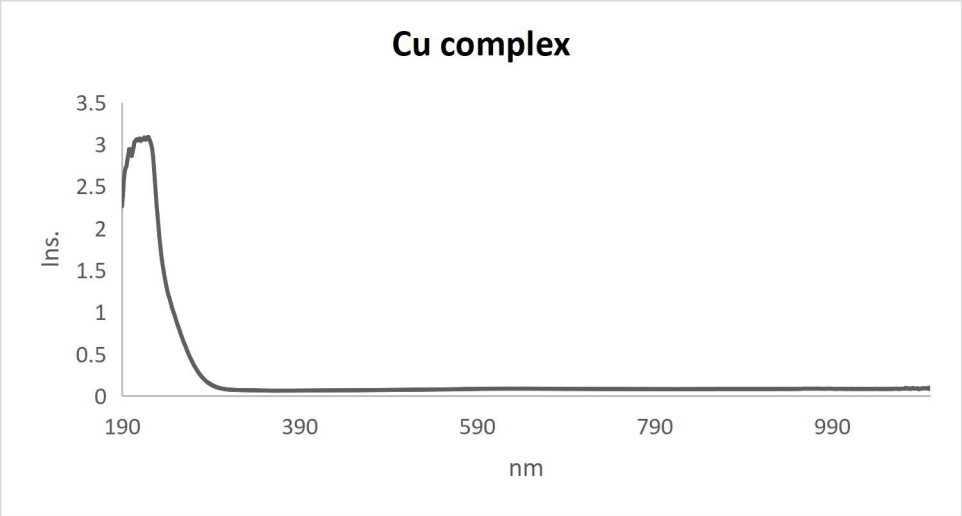


Figure 7: UV-Vis of Cu complex

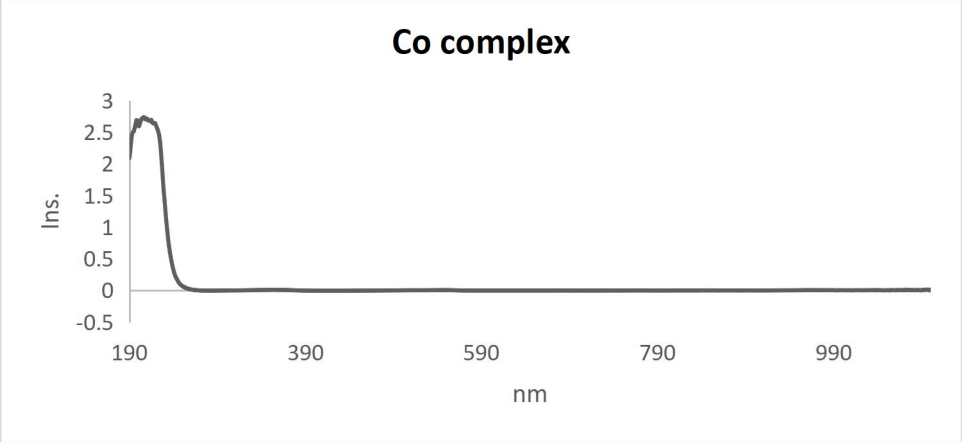


Figure 8: UV-Vis of Co complex

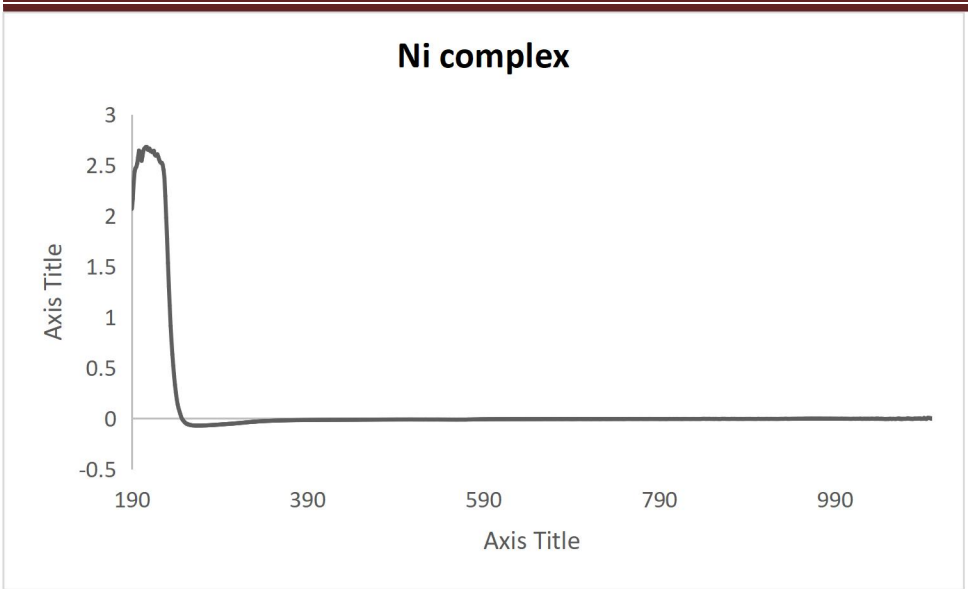


Figure 9: UV-Vis of Ni Complex

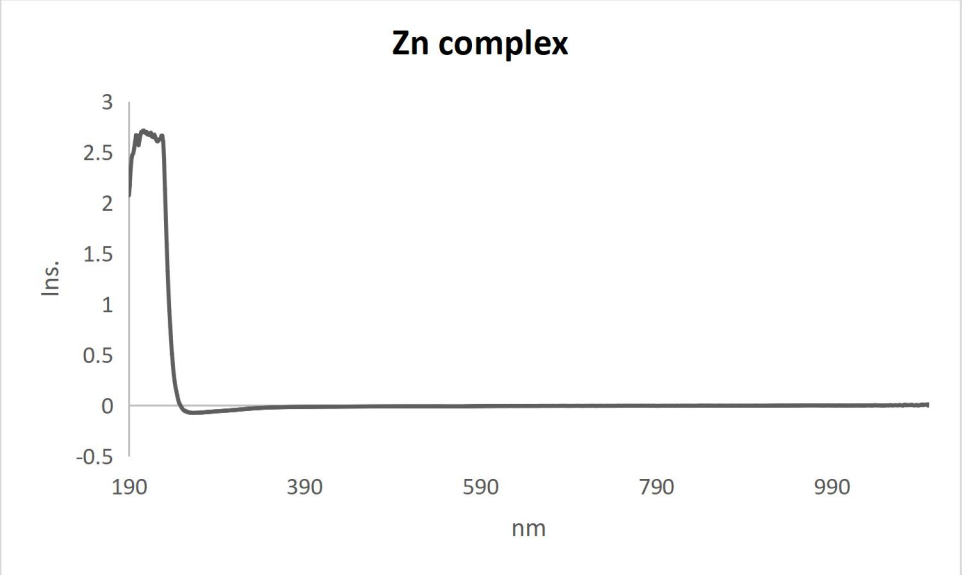


Figure 10: UV-Vis of Zn complex

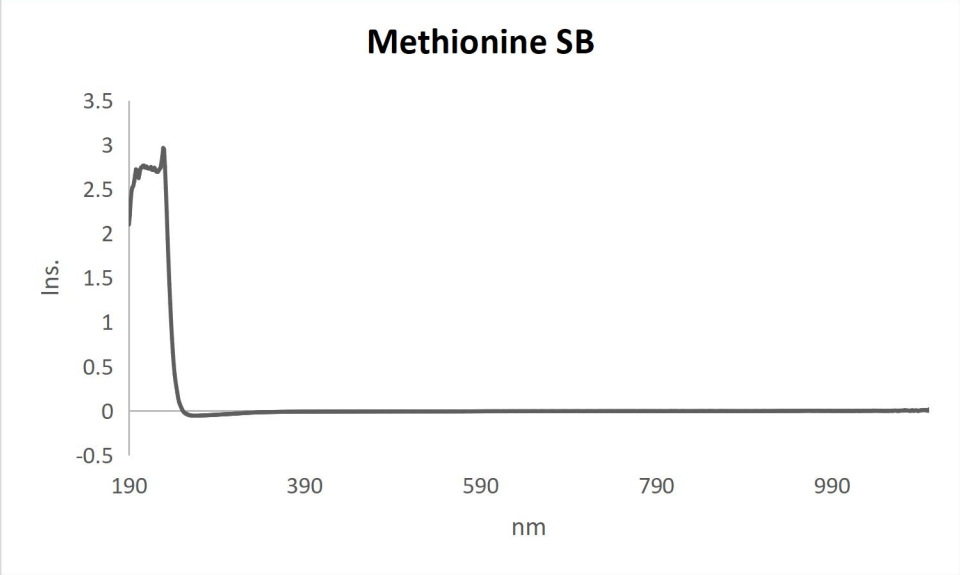


Figure 11: UV-Vis of Schiff base

Table 3: Scavenging activity of the Schiff base, its metal complexes and control

Concentration (µg/ml)	Average SB RSA	Average RSA Co	Average RSA Ni	Average RSA Cu	Average RSA Zn	Control
62.5	52.82	71.16	56.19	56.73	51.34	87.31
125	57.11	82.04	59.91	73.40	61.42	89.83
250	59.88	84.22	60.95	79.03	61.25	94.11
500	65.78	84.80	65.39	81.36	64.43	96.95

The use of DPPH to study radical scavenging activity is a standard examination in antioxidant activity. This method is a fast method used to investigate free radical scavenging activity of compounds [25]. The ability of a sample or material to reduce or to protect the body from free radicals is detected by using DPPH as the result was showed in Table 3. The scavenging property or the ability of the Schiff base ligand and all its complexes showed that they all exhibit scavenging power more than average of the control (ascorbic acid) with cobalt complex showing more scavenging power than other complexes. From the magnetic susceptibilities values, it was deduced that Co, Ni and Cu complexes are paramagnetic having the magnetic moment greater

than 1. This is an indication that there are empty d – orbitals that can accommodate or trap any attachment. Co – complex having higher average reactive oxygen specie scavenger has magnetic moment of 1.21BM, a paramagnetic complex.

CONCLUSION

A new Schiff base synthesized from methionine and glyoxal and complexed by four metals has been prepared and characterized. The FT-IR analysis of the Schiff base and its complexes showed the presence of C=N group at 1658-1519 cm^{-1}. And the stretching vibration in v(M-N) showed at 455-421 cm^{-1}.The XRD spectra peaks were sharp and not broad, indicating the Schiff base and its metal complexes were crystalline and not amorphous. The percentage crystallinity of the Schiff base and its complexes are greater than 50%. The UV-Vis showed that the Schiff base and the complexes have a linear geometry. The Schiff base and its metal complexes showed promising anti-oxidant properties.

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