



Synthesis, characterization and biological activities of Cu(II) and Zn(II) mixed ligand complexes with 1,2,3-triazole and thiocyanate

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ABSTRACT: Copper (II) and Zinc (II) mixed ligand complexes of 1,2,3-triazole and thiocyanate as a secondary ligand had been synthesised in water and methanol media. The complexes have been characterized on the basis of elemental analyses, conductivity, solubility, UV-visible and infra-red spectra data. 1,2,3-triazole in complex 1 binds to the metal bidentately. The thiocyanate ions coordinate to copper through the nitrogen atom of the isocyanate group and binds to zinc through the sulfur atom. The isolated metal chelates were screened for their antimicrobial activities and the results revealed that copper (II) complexes were more fungi toxic and proactive against bacteria than the Zn (II) complexes.

Keywords: Ligands; Synthesis; Triazole; Thiocyanate; Bio-Activities

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INTRODUCTION

Mixed ligand complexes have a key role in biological chemistry because the mixed chelation occurs commonly in biological fluids as millions of potential ligands are likely to compete for metal ions in vivo (Reisner *et al.*, 2004). Among these ligands are azole derivatives which are being used to model important bioinorganic systems. Azole is a suffix used for five-membered rings containing two or more heteroatoms, at least one of which is nitrogen (Finar, 1989). The imidazole nucleus and derivatives thereof are known to play extremely crucial parts in the structures and functioning of a number of biological important molecules, generally by virtue of their being coordinated to metal ions (Gilchrist 1997). Imidazole is a moderately strong base but the other azoles are weak bases, the

base strength generally decreasing as the number of nitrogen atoms increases because of the inductive electron withdrawing effect of the additional nitrogen atoms. Conversely, the acidity of the azoles increases with the number of nitrogen; triazoles are comparable in acid strength with phenol and tetrazole is about as strong as acetic acid. 1,2,4-triazole and in particular, its derivatives are very interesting ligands for their important properties because of the position of the donor atoms in the five-membered ring. The triazoles appear to possess the possibility of linking metal ions together thereby constituting a bridge between the metal ions (Haasnoot, 2002). The bridge can be of several different geometries, depending on the donor atoms of the ligand and the properties of

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the metals. Triazoles and triazole derivatives have been extensively studied as complexing molecules. The dithiosubstituted triazoles are good chelating molecule and form both mono and polynuclear complexes (Gadget and Gagendregad.;1978). Diacido complexes of Pd(II) and Pt(II) with 3,5-dithiobenzyl 1,4-amino-1,2,4-triazole have been prepared and characterized from the studies of UV visible, Infra red, magnetic susceptibility and electrical conductance measurements. The complexes have been suggested to be planar and ligand coordinated to the metal atom through S and N donor atoms (Ojha, 2005). Synthesis and crystal structure of

Cu (II) complex with 4-(pyridyl-2)-1,2,4-triazole has been reported. The structure consists of linear trinuclear cations with a +6 charge and six non coordinated NO_3^- anions (Olga et al.; 2002). Solid complexes, of Co and Zn have been isolated and characterized by elemental analysis, spectral, conductance, magnetic measurements and thermal studies (Susmuta.; 2004).

The aim of this work is to synthesize, characterize and evaluate the biological activities of the mixed ligand metal complexes of 1,2,3-triazole and potassium thiocyanate (as the secondary ligand.)

MATERIALS AND METHODS

Materials and Physical measurement

Materials

All the chemicals were of analytical grade (AR) and were used as purchased. They were Copper (II) sulphate pentahydrate and Zinc (II) sulphate heptahydrate (Sigma), potassium thiocyanate (BDH) and 1,2,3-triazole (Aldrich).

Synthesis of the metal complexes

Zinc (II) complexes were prepared by adding equimolar concentrations of the salt and ligand (1,2,3-triazole) in 20ml (distilled water/ methanol solution ratio 1:1) on separate beakers. The mixture gave colourless solution which was stirred for 2hrs. NaOH solution (0.1M) was added and the agitation was continued for another 1hr. until a white precipitate was formed. The precipitate was filtered, washed with methanol, n-hexane and diethyl ether. It was vacuum dried until a constant weight was obtained. The subsequent complexes were prepared at different ratios (1:1, 1:2). Thiocyanate complexes were synthesized by adding 0.1M of potassium thiocyanate dissolved in water to the metal: ligand mixture. Likewise, copper (II) complexes were obtained in similar way.

Characterization

Sulphate contents of the complexes were analysed by gravimetric method; metal contents were determined via complexometric titration. The molar conductance of the solid complexes in DMSO- H_2O mixture was measured by using a model WPACM35 conductivity meter. Solutions of the complexes were run on UV-2500PC UV-visible series (8000-200nm). Solid state FTIR spectra of the metal complexes were recorded on a Shimadzu FTIR spectrophotometer using KBr pellets in the range of 400-4000 cm^{-1} .

Antifungal evaluation of the Complexes

Five organisms screened for this work were *Aspergillus niger*, *Collentridium facillium*, *Alternaria solani*, *Fusarium spp* and *Rhizoctonia solani*. The triazole and its metal complexes were directly added to the growth media in varying concentrations (2.5% and 5.0%). 5ml of each prepared sample was measured into a conical flask (50ml), 25ml of sterile Potato Dextrose Agar was added and mixed properly before pour plating and allowed to set at ambient temperature. A sterile 5mm diameter cork borer was used to inoculate the fungal isolates grown

over a period of 72hrs at the centre of the plate. The plates were incubated at $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 5-7 days. The radial growth of the mycelia of the fungi isolates were measured every 24hrs (Mistra *et al.*; 1995; Onifade 1998). The diameter of the zone inhibition produced by the complexes was compared with the Benlate.

Antibacterial screening test

A-24h old pure broth culture of micro-organisms was used and agar pour plate technique was employed for the tests. The organisms used for the screening are *Staphylococcus aureus*, *Escherichia Coli*, *Klebsiella aerogenes*, *Bacillus subtilis* and *Salmonella typhi*. 2ml of the organisms were

aseptically injected into the sterilized plates and 20ml sterilized nutrient agar was poured on top of the tested organism aseptically after it has been allowed to cool to 45°C . The medium was swirled gently for even distribution of the inoculums in the medium and was allowed to solidify at ambient temperature. Standard cork borer of 5mm diameter was used to make well on the solidified agar into which 0.5 ml of the samples was aseptically introduced, using a pipette. A control experiment was set-up with well containing standard antibiotic streptomycin sulphate at 0.2 mg/ml. The plates were incubated at 37°C for 24hrs. The zone of inhibition in radii around the well was measured and recorded appropriately.

RESULTS AND DISCUSSION

Results of elemental analysis, molar conductivity, melting point, UV and Infrared spectroscopic analysis of the complexes are presented in Tables 1 and 2. Data on the antifungal and antibacterial activities of the complexes are also presented as Tables 3 and 4. Metal complexes of 1,2,3-triazole were obtained in powdery, amorphous, non-crystalline form and stable to air. They were found to be insoluble in water and other organic solvents like chloroform, benzene, ether and dimethylsulphuroxide but soluble in a mixture of dimethyl sulphuroxide/water (DMSO- H_2O). The reaction of copper (II) sulphate with 1,2,3-triazole in the ratio of 1:1 gave green coloured precipitate in 36.52% yield. The poor yield may be attributed to solubility of this product in the mixture of $\text{H}_2\text{O}/\text{CH}_3\text{OH}$ used as solvent for the synthesis.

The proposed formulae of the compound is $[\text{CuLSO}_4\text{H}_2\text{O}]3\text{H}_2\text{O}$ (where L = 1,2,3-triazole).

In the compound, the ligand 1,2,3-triazole is attached to the central metal bidentately

through the number 2 and 3 nitrogen atoms. The complex has a melting point of 240°C and conductivity value of $2.80\text{Ohm}^{-1}\text{cm}^2\text{mol}^{-1}$ indicating a non electrolyte. From the spectral data presented in Table 2, a broad band at 3418cm^{-1} is ascribed to the N-H vibration. The appearance of this band is an indication that bonding was through the $\text{N}=\text{N}$, and not through the N-H . Attachment of nitrogen to the copper central metal was through dative bonding.

Water molecules are believed to have bonded to the metal atom and this is shown by the appearance of bands at 790cm^{-1} assigned to coordinated H_2O . Equally some molecules of H_2O were found at the outer sphere of the complex and this appears at 3618cm^{-1} as broad band. Sulphate ions have retained their position with the appearance of bands at 1179cm^{-1} assigned to inorganic SO_4^{2-} . On the basis of IR data and element analysis, the proposed structure for this complex is given in Fig. 1.

Table 1: Colour, melting point and elemental analysis of 1, 2, 3 triazole metal complexes

| COMPLEXES L = Ligand C ₂ H ₃ N ₃ | colour | % yield | Melting point | Metal | S | C Calculated, (found) | H |
|--------------------------------------------------------------------------|--------|---------|--------------------------|------------------|------------------|--------------------------|----------------|
| [CuLSO ₄ (H ₂ O)]3H ₂ O | Green | 36.52 | 240 - 242 ⁰ C | 21.20 (19.45) | 10.00 (10.98) | 9.10 (10.30) | 4.20 (3.92) |
| [CuL ₂ (SO ₄)(H ₂ O)]2H ₂ O | Green | 47.60 | 215 - 216 ⁰ C | 18.2 (18.60) | 9.20 (10.40) | 13.80 (14.50) | 3.60 (3.90) |
| K[CuL(SO ₄) (SCN)H ₂ O] | Green | 71.60 | 210 - 212 ⁰ C | 18.49 (19.50) | 18.63 (20.50) | 10.48 (10.90) | 1.40 (1.20) |
| K[CuL ₂ (SO ₄) (SCN)] | Green | 71.7 | 210 -212 ⁰ C | 16.09 (16.9) | 16.22 (16.70) | 15.20 (14.82) | 1.52 (2.60) |
| [ZnL(SO ₄)2H ₂ O] 2H ₂ O | White | 55.06 | 254 256 ⁰ C | 21.62 (20.50) | 10.58 (10.09) | 7.94 (10.05) | 3.64 (4.07) |
| [ZnL ₂ (SO ₄) H ₂ O] H ₂ O | White | 61.2 | 260 261 ⁰ C | 19.49 (20.00) | 9.54 (10.88) | 7.15 (7.20) | 2.09 (2.20) |
| [Zn L(SCN) ₂ H ₂ O] | White | 64.9 | 250 252 ⁰ C | 22.83 (21.30) | 22.34 (23.04) | 17.89 (18.63) | 2.61 (2.05) |
| [ZnL ₂ (SCN) ₂] | White | 66.0 | 253 - 254 ⁰ C | 20.47 (19.20) | 20.04 (21.30) | 15.03 (16.02) | 1.88 (2.00) |

Table 2: Conductivity, Infrared and electron spectra data of the metal complexes

| Emp. Formula | Molar conductivity ohm ⁻¹ m ³ mol ³ | IR Spectra cm ⁻¹ | UV-vis. nm |
|--------------------------------------------------------------------------|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|---------------|
| [CuLSO ₄ (H ₂ O)]3H ₂ O | 2.8 | 790(H ₂ O), 651(s)(Cu-N), 1179(SO ₄ ²⁻), 1635.69, 3029.31, 3171(NH), 3618(s)(-OH) | 833 |
| [CuL ₂ (SO ₄)(H ₂ O)]2H ₂ O | 4.2 | 447.602(M-N),870.(H ₂ O) 1001(SO ₄ ²⁻), 1634, 3095.85, 3219.(s)(N-M) 3569.(s) OH | 805 |
| K[CuL(SO ₄) (SCN)H ₂ O] | 2.3 | 431.10, 743(H ₂ O),868.(Cu-N),1112(SO ₄ ²⁻), 2167(s) (SCN) 2894.28(),3440 (-NH) | 739 |
| K[CuL ₂ (SO ₄) (SCN)] | 2.6 | 422.42, 740(H ₂ O), 866(Cu-N), 1112(SO ₄ ²⁻), 2167(SCN) (s) 2893(w) ,3483(-OH) | 742 |
| [ZnL(SO ₄)2H ₂ O] 2H ₂ O | 1.6 | 457.07, 526.54,690(Zn-N), 786(H ₂ O),1154(SO ₄ ²⁻)1429, 1619,1673, 3377(-NH),3497(-OH) | 895 |
| [ZnL ₂ (SO ₄) H ₂ O] H ₂ O | 2.6 | 493.7, 622,(Zn-M) 746(H ₂ O),1039(SO ₄ ²⁻) 1497.7, 1665.3202(-NH), 3496 (-OH) | 866 |
| [Zn L(SCN) ₂ H ₂ O] | 3.0 | 455.62, (Zn-L)1131. (SO ₄ ²⁻) 1568(S) 2108(SCN), 3224 (N-M),3424(-OH), | 865 |
| [ZnL ₂ (SCN) ₂] | 2.0 | 461(Zn-L), 1206, 1619,2161(s)(SCN),3363 (s)(-NH) | 868 |
| Ligand (C ₂ H ₃ N ₃) | | 597 1056,1574(NH,)3267(-NH) | |

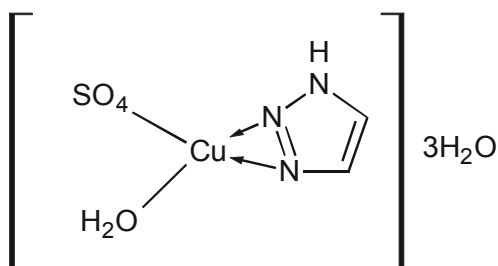
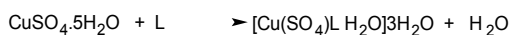


Fig. 1: Aquo sulphato 1,2,3-triazole Copper (II) tri hydrate

The mechanism of reaction shows that the ligand attachment is through dative bonding.



Reacting at a ratio of 1:2, a similar compound as in ratio 1:1 was obtained in 47.60% yield. However, two molecules of the ligand 1,2,3 – triazole were attached to the copper atom. The proposed formula for this complex is given as: $[\text{Cu}(\text{SO}_4)_2\text{L}_2(\text{H}_2\text{O})_2]\text{H}_2\text{O}$ (where $\text{L} = \text{C}_2\text{N}_3\text{H}_3$)

The 1,2,3 – triazole coordinated monodentately to the central atom through the number 2 Nitrogen and this apparently is responsible for the absorption in the region of vibration of the free (N – H) from 3264cm^{-1} (in the ligand) to 3219cm^{-1} in the complex. The inorganic sulphate ion retained its position in the inner core of the complex. The FTIR spectra of the complex also show that there is a coordinated water molecule in the complex with its band appearing at 870cm^{-1} while unbound water molecules appeared at 3569cm^{-1} . This complex is equally a non electrolyte since the conductivity analysis gave $4.20 \text{ Ohm}^{-1}\text{cm}^2\text{mol}^{-1}$. Low conductance values of the complexes indicate that water molecules are within coordination sphere (Pulimamidi et al.; 2010). UV – visible spectra of the metal complexes as presented in Table 2 displayed bands in the regions 742-833 nm. These bands correspond to d-d transitions (Iqbal, et al. 2009; Dun-Ru Zhu, 2000).

In a mixed ligand reaction, copper sulphate, 1,2,3

– triazole and potassium thiocyanide were reacted at 1:1:1 ratio. The resulting product, an ash coloured complex was obtained in good yield (71.60%). The complex has a melting point of 214°C and conductivity value of $2.3 \text{ Ohm}^{-1}\text{cm}^2\text{mol}^{-1}$ an indication of non electrolyte. From the results of analysis conducted the proposed formula for the complex is given as: $\text{K}[\text{CuL}(\text{SO}_4)(\text{SCN})\cdot\text{H}_2\text{O}]$. The suggested mechanism of the reaction indicate that the ligand 1,2,3 – triazole attach monodentately through position 2 Nitrogen. In the IR – spectra of the complex, vibrations assigned to (N – H) are retained at 3440cm^{-1} as in the ligand though with a slight shift of 51cm^{-1} towards the lower region. The complex is believed to have a tetrahedral geometry (Fig. 2).

The thiocyanate absorbs at 2165cm^{-1} and the coordination is believed to be through the Nitrogen of the isocyanate group (Nakamoto, 1998). Complexation of copper with 1,2,3 – triazole and potassium thiocyanate in a mixed ligand reaction at 1:2:1 ratio yielded a similar compound as in ratio 1:1:1. FT-IR spectra of this complex indicate that all water molecules were lost in the course of the reaction. This is responsible for the disappearance of the peaks assigned to bonded H_2O . Reactions of zinc sulphate heptahydrate with 1,2,3 triazole in both direct and mixed ligand conditions yielded white

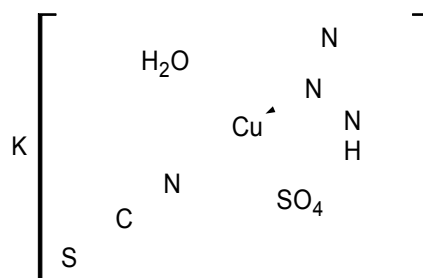
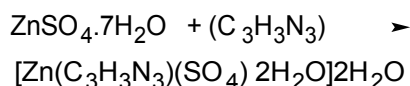


Fig. 2: Potassium aquo sulphato thio cyanato 1,2,3-triazole copper (II)

compounds. In a mole ratio of 1:1, the reaction of this metal salt with the ligand yielded 55.06% of the compound. This compound has a melting point of 255°C and conductivity of 10 $\text{Ohm}^{-1}\text{cm}^2\text{mol}^{-1}$. This compound diaquasulphato 1,2,3-triazole zinc (II) dihydrate is assigned the formula $[\text{Zn}(\text{C}_2\text{N}_3\text{H}_3)(\text{SO}_4)_2\text{H}_2\text{O}]2\text{H}_2\text{O}$, and the compound is believed to have a tetrahedral arrangement with two water molecules at the outer sphere. FTIR spectrum of this complex indicate that the ligand 1,2,3-triazole coordinated monodentately through the position 3 nitrogen, whereas $\nu(\text{NH})$ vibration originally appearing at 3267cm^{-1} in the ligand shifted and appeared at 3377cm^{-1} in the complex. The sulphate group in this complex appeared at 1154cm^{-1} . Two groups of water molecule as proposed in the formula appeared in two region of the spectrum, at 786cm^{-1} for coordinated water and 3497cm^{-1} for unbound water. The mechanism of reaction shows that the interaction of 1,2,3-triazole with zinc sulphate yielded a type 1:1 complex.



The proposed structure of this complex is given as Fig. 3.

In a mole ratio of 1:2, aquo sulphato di 1,2,3-triazole zinc (II) monohydrate is formed in good yield (61.17%). The presence of two ligand molecules,

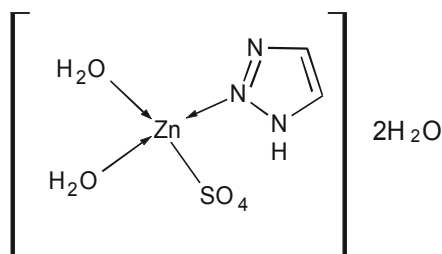
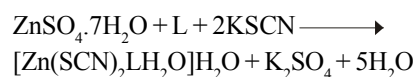


Fig. 3: Diaquo Sulphato 1,2,3-triazole zinc (II) dihydrate

a water molecule and sulphate ion in the inner sphere is supported by the result of elemental analysis in which the calculated and observed element composition differed from those of ratio 1:1. The FTIR spectrum of this complex showed bands at 493cm^{-1} , attributed to (M-N), the sulphate group of inorganic salt was found in the inner sphere of the complex as it reflected in the appearance of a strong band at 1039cm^{-1} ascribable to $\nu(\text{SO}_4^{2-})$. The inner sphere of the complex also has a water molecule (coordinated water) and this is indicated in the spectra band at 746cm^{-1} and an unbound water molecule outside coordination sphere with the appearance of a strong band at 3490cm^{-1} . The peak at 3202cm^{-1} is attributable to $\nu(\text{N-H})$ similar to that found in the free ligand.

The introduction of thiocyanate into the reaction mixture at a ratio of 1:1:2 gave a whitish compound with the yield of 64.90% and conductivity of $3.0\text{ Ohm}^{-1}\text{cm}^2\text{mol}^{-1}$. The introduction of thiocyanate into the inner sphere of the complex was evident with a sharp band appearing at 2108cm^{-1} and ascribed to $-\text{S}=\text{C}=\text{N}$. Evidently, the thiocyanate group attaches through the sulphur atom (Salim, 2001 and Barros-Garcia, *et al*, 2005). Likewise, 1,2,3-triazole ligand attaches itself monodentately to the metal through the position 3-nitrogen atom. The proposed reaction mechanisms supports that potassium interacts with the sulphate ions to form a water soluble K_2SO_4 that is removed by filtration.



Furthermore, reacting potassium thiocyanate with zinc sulphate and 1,2,3-triazole in the proportion of 1:2:2 a tetrahedral zinc (II) complex (Fig. 4), white in colour was obtained in good

yield (66.0%), with conductivity value of 2.80 $\text{Ohm}^{-1}\text{cm}^2\text{mol}^{-1}$ and a melting point 251°C.

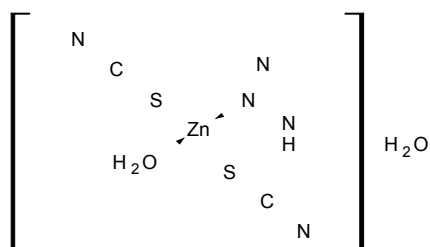


Fig. 4: Aquo dicyanato – 1,2,3 – triazole zinc (II) monohydrate

Antimicrobial Activity of 1,2,3 – Triazole metal complexes

Copper II complexes of 1,2,3 – triazole looked more promising as antifungal agents than the free ligands and other salt metals on which least activities were recorded. The effect of the copper (II) triazole complexes appear more prominent in nearly all the fungi especially at 72 – 96 hours exposure periods with an average performance of 50 – 64% inhibition, but least performance was experienced with *Pythium Aphanermatum*. Increased activities were also noted with mixed ligand complexes in all the fungi species with an average performance of 55 – 59% inhibition. It has been observed that metal complexes of ligands containing sulphur are biologically active on complexation (Iqbal *et al.*, 2009). Zinc (II) 1,2,3 – triazole complexes were also screened against plant pathogenic fungi. It was noted that the zinc (II) complexes show moderate potency against nearly all the

organisms but with least performance or bioactivities against *Aspergillus niger* and *Rhizoctonia solani* with 25 – 30% and 34 – 40% inhibitory activities respectively at 72 – 96 hours exposure periods at 2.5% concentration but with an improved performance at 5.0% concentration which increased the inhibition to 30 – 41% and 52 – 64% respectively for $[\text{ZnLSO}_4 \cdot 2\text{H}_2\text{O}]2\text{H}_2\text{O}$ and $[\text{ZnL}_2(\text{SO}_4)\text{H}_2\text{O}]\text{H}_2\text{O}$ complexes. The increase in antifungal activity of the complexes can be ascribed to the effect of the metal ions on the normal cell process and partly due to faster diffusion of the metal chelates through the cell membrane due to chelation (Srivastava, 1981). The results also have revealed that metal complexes have potency against bacteria species. antibacterial activities increased as the concentrations of the ligands increased. The increase in antifungal activity of the metal complexes is due to the overlap of ligand orbital and partial sharing of the positive charge of the metal ions with donor groups, this further increases the delocalization of π electrons over the whole chelate ring and enhances the lipophilicity of the complexes (Srivastava 1981). However, increased liposolubility of the ligand upon metal complexation may contribute to the facile transport into the bacterial cell which blocks the metal binding sites in enzymes of the microorganisms. These complexes also disturb the respiration process of the cell and thus block the synthesis of proteins, which restricts further growth of the organism (Saeed *et al.*, 2009).

Table 3: Evaluation of antifungal activities of Triazole Metal Complexes at 2.5% and 5.0% Concentrations

| | Aspergillus niger. | Collentriculum falcatum | Alternaria solani | Fusanirum spp. | Rhizotonia solani |
|--------------------------------------------------------------------------|--------------------|-------------------------|-------------------|-------------------|-------------------|
| Exposure Time | 24 48 72 96 | 24, 48, 72, 96hrs | 24, 48, 72, 96hrs | 24, 48, 72, 96hrs | 24, 48, 72, 96 |
| [CuLSO ₄ (H ₂ O)]3H ₂ O | | | | | |
| 2.5% | 25 46 56 68 | 66, 69, 71, 71 | 35, 47, 49, 67 | 71, 92, 93, 93 | 48, 54, 63, 64 |
| 5.0% | 28 49 72, 72 | 68 72 74 76 | 46 55 61 61 | 73 95 97 97 | 51, 60, 68, 70 |
| [CuL ₂ (SO ₄)(H ₂ O)]2H ₂ O | | | | | |
| 2.5% | 32 52 72 73 | 66, 71, 78, 78 | 38, 47, 69, 69 | 72, 83, 93, 93 | 50, 56, 64, 68 |
| 5.0% | 37 59 78 78 | 68 76 82 84 | 50, 53, 70 70 | 76 94 95 97 | 54, 61, 71, 72 |
| K[CuL(SO ₄)(SCN)H ₂ O] | | | | | |
| 2.5% | 40, 47, 68, 70 | 65, 67, 71, 73 | 38, 50, 66, 69 | 71, 84, 86, 92 | 48, 60, 64, 65 |
| 5.0% | 49 53 79 79 | 67 74 86 86 | 50, 53, 69 73 | 72 88 95 96 | 50, 62, 67, 72 |
| K[CuL ₂ (SO ₄)(SCN)] | | | | | |
| 2.5% | 40, 49, 70, 74 | 67, 81, 86, 86 | 40, 56, 68, 71 | 74, 86, 89, 91 | 53, 59, 64, 65 |
| 5.0% | 49 56 77 79 | 69 84 88 89 | 54 60, 70 72 | 76 89 90 93 | 59, 63, 70, 74 |
| [ZnL(SO ₄)2H ₂ O] 2H ₂ O | | | | | |
| 2.5% | 17, 18, 30, 36 | 45, 55, 64, 66 | 46, 49, 58, 58 | 48, 49, 55, 58 | 35, 40, 46, 36 |
| 5.0% | 20, 22, 32, 38 | 49, 58, 68 68 | 51, 56, 60, 63 | 53 54, 59, 61 | 39, 44, 52, 59 |
| [ZnL ₂ (SO ₄) H ₂ O] H ₂ O | | | | | |
| 2.5% | 18, 28, 38, 44 | 45, 60, 66, 76 | 47, 56, 59, 63 | 50, 52, 56, 56 | 38, 43, 47, 58 |
| 5.0% | 22, 30, 42, 46 | 53, 55, 69, 78 | 60, 63, 66 69 | 54, 59, 63, 63 | 44, 47, 56, 63 |
| [Zn L(SCN) ₂ H ₂ O] | | | | | |
| 2.5% | 17, 30, 45, 50 | 56, 64, 70, 71 | 48, 67, 76, 76 | 51, 59, 64, 68 | 44, 53, 60, 60 |
| 5.0% | 24, 35, 54, 55 | 59, 69, 75 76 | 63, 71, 79, 80 | 57, 60, 66 70 | 56, 60, 63, 64 |
| [ZnL ₂ (SCN) ₂] | | | | | |
| 2.5% | 30, 40, 45, 59 | 56, 70, 74, 74 | 53, 76, 76, 78 | 52, 65, 68, 68 | 46, 58, 66, 66 |
| 5.0% | 37, 49, 60 60 | 60 72, 78, 78 | 63, 73, 80, 81 | 56, 68, 70 71 | 56, 61, 68, 68 |
| 1,2,3 triazole Ligand | | | | | |
| 2.5% | 11 | 15 | 12 | 15 | 14 |
| 5.0% | 15 | 20 | 18 | 20 | 20 |
| CuSO ₄ .5H ₂ O | | | | | |
| 2.5% | 10 | 10 | 11 | 18 | 12 |
| 5.0% | 16 | 14 | 20 | 24 | 15 |
| ZnSO ₄ .7H ₂ O | | | | | |
| 2.5% | 4 | 6 | 10 | 12 | 6 |
| 5.0% | 6 | 8 | 15 | 18 | 10 |
| Benlate | NO GROWTH | NO GROWTH | NO GROWTH | NO GROWTH | NO GROWTH |

Table 4: Antibacteria Activities of Triazole Metal Complexes at different concentrations of 2.5% and (5.0% Concentrations)

| Complexes | Staphylococcus aureus | Escherichia coli | Klebsiella aerogenes | Bacillus subtilis | Salmonella typhi |
|--------------------------------------------------------------------------|-----------------------|------------------|----------------------|-------------------|------------------|
| [CuLSO ₄ (H ₂ O)]3H ₂ O | 13mm (16) | 13mm (14) | 14mm (16) | 13mm (14) | 16mm (19) |
| [CuL ₂ (SO ₄)(H ₂ O)]2H ₂ O | 15 mm (20) | 14mm (16) | 17 mm (16) | 17 mm (18) | 18 mm (20) |
| K[CuL(SO ₄)(SCN)H ₂ O] | 1 0mm (15) | 12mm (13) | 15mm (18) | 11 mm (13) | 12mm (15) |
| K[CuL ₂ (SO ₄)(SCN)] | 16mm (18) | 17mm (15) | 17 mm (19) | 12 mm (15) | 14mm (16) |
| [ZnL(SO ₄)2H ₂ O] 2H ₂ O | 10mm (12) | 8mm (10) | 12 mm (12) | 11 mm (12) | 12 mm (14) |
| [ZnL ₂ (SO ₄) H ₂ O] H ₂ O | 10mm (14) | 9 mm (10) | 14mm (14) | 12mm (15) | 12mm (15) |
| [Zn L(SCN) ₂ H ₂ O] | 7mm (14) | 7mm (13) | 10 mm (15) | 12.5mm (13.5) | 13mm (14) |
| [ZnL ₂ (SCN) ₂] | 8 mm (15) | 9mm (13) | 11mm (15) | 12.5mm (14) | 14 mm (17) |
| Ligand (Triazole) | 10mm (10) | 6mm (10) | 8mm (11) | 8mm (11) | 10 mm (12) |
| Streptomycin Sulphate | 32mm (38) | 26 mm (35) | 27mm (38) | 28mm (40) | 34mm (41) |
| CuSO ₄ .5H ₂ O | 9mm (10) | 9.5mm (8) | 10mm (12) | 7.6 mm (8.0) | 8.5mm (10) |
| ZnSO ₄ .7H ₂ O | 4mm (6) | 4.3 mm (6) | 7 mm (8) | 8 mm (7.2) | 10 mm (12.4) |

CONCLUSION

The present investigation describes synthesis and characterization of Cu(II) and Zn (II) complexes involving 1,2,3-triazole and thiocyanate ligands. From the results it may be concluded that the synthetic procedure in this work resulted in the formation of complexes in the mole ratio (1:1), (1:2) and (1:1:1) respectively. In these complexes, the primary ligand (1,2,3-triazole) coordinate datively through the position 2 and

3 nitrogen while the thiocyanate is coordinated via the sulfur atom in the zinc complex. From elemental analysis, IR spectral and conductance measurement, all complexes are non-electrolytes with tetrahedral structure. The results of microbial tests show that the metal complexes exhibit antifungal and antibacterial activities and that the concentration of the complex plays a vital role in increasing the degree of inhibition.

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