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## Chelation Effect of 2,4-Pentadione with Ni(II) and Cu(II) Ions

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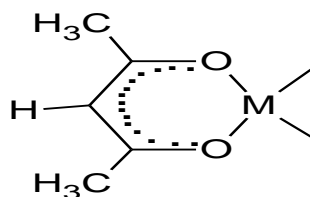
**Abstract** Synthesis of inorganic compounds with medical application is the aspect this work set to contribute. Ni(II) and Cu(II) chelates of 2,4-pentadione (acetylacetone) were obtained from the reaction of hydrated divalent metal chloride salts with acetylacetone in aqueous ammoniacal medium. The complexes were prepared in order to examine the effect of chelation of 2,4-pentadione with metal ions, and antimicrobial activity on some pathogens. The compounds were characterised by infrared spectrophotometry. The absorption bands of the carbonyl group after coordination with Ni(II) and Cu(II) ions were lowered to  $1605\text{ cm}^{-1}$  and  $1575\text{ cm}^{-1}$ , respectively. The spectral results suggest that there is a reduction in bond order of C=O after chelation, the consequence of resonance effect. The compounds were subjected to antimicrobial activity using Mueller Hinton agar and Sabouraud dextrose agar. Minimum Inhibition Concentration and Minimum Bacteria/Fungi Concentration were determined using serial broth dilution method. Ni(II) complex had shown significant antimicrobial activity on two fungi. Cu(II) complex on the other hand had shown wide biological activity on the tested microbes exception of *P. milibilis*. The metal chelates demonstrated better activities against the tested pathogens than the free ligand due to increase in permeability of the metal chelates through the microbe's cell.

**Keywords** Metal chelate, ligand, Biological Activity, Pathogens, FTIR

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### Introduction

Metal chelates are chemical compounds composed of a metal ion and chelating agent. Chelating agents are organic or inorganic compounds that binding metal ions to form complex ring-like structure called 'chelate'. They have binding atoms like S, N and O which perform the function of a ligand, examples:  $\text{SH}^-$ ,  $\text{S}_2^{2-}$ ,  $\text{NH}_2^-$ ,  $\text{OH}^-$ ,  $\text{Acac}^-$  and many others. They consist of either one or more covalent linkages with the central metal ions. Many donors' atoms act as bidentate ligands forming five-membered rings. They are stable and often formed from ligand such as  $\text{O-CH}_2\text{-CH}_2\text{-O}$ , [1,]. Stabilisation of metal chelates is attributed to chelating ligand's delocalized electronic structures, and in addition to entropy factor change, that occur during chelation process [2]. Acetylacetone (2,4-pentadione,  $\text{C}_5\text{H}_7\text{O}_2\text{H}$  or  $\text{acacH}$ ) is a bidentate ligand having two hydrogen atoms on the  $\beta$ -carbon atom and exhibit keto-enol tautomerism. The compound acetylacetone, complexes with 3d metal ions such as Mn(II), Ni(II) and others to form stable six-membered compound, having a molecular formula,  $\text{M}(\text{acac})_2$  with aromatic behaviour [1,3,4]. The general structure of these metal chelates is shown in Figure 1.



Where M = Divalent transition metal ions

Figure 1: General structure of metal Chelates

Metal chelates play key roles in biological processes and medicinal chemistry [5]. Their potential activities are also known in the areas of analytical, catalytic, microbial, pesticides, antibiotic and others [6]. Metals scavenge ligands via complexation, consequently, metal chelate are utilised as drugs to target organs, or for reduction of toxic compounds due to metabolic activity. Chelation pave way for metals to be transported to and fro vulnerable target sites. This prevents interaction of intracellular that may cause cancer [7]. Other usefulness found both in theoretical and applied chemistry has gained considerable attention [6]. Acetylacetonate metal chelates have various applications in basic research, clinical, industrial as well as agricultural (pesticides) processes. They are used in chemical processes like polymerisation, hydrogenation reactions, where metal acetylacetonates act as a catalyst [3,8]. Acetylacetonate complexes of most 3d series are used to inhibit corrosion due to their adsorption properties on metals [9]. The chemistry of metal acetylacetonates are of significant in the area of study because they serve as a starting materials in organometallic chemistry (metallocene) [10].

Infrared absorption measurements of metal chelates have been reported by various researchers. The spectra studies are important because alters in infrared frequency provide information about the chelating forming groups in the molecule and the kind of linkages with the metal ions. The information obtained from spectral changes are help in establishing the geometry of the complexes [2,11]. Infrared spectra of tropolone and its derivatives had been revealed. The report shows that a shift of  $20\text{ cm}^{-1}$  towards lower wavenumbers for the carbonyl frequency after chelation was observed [11]. Although, majority of infrared works described in the literatures were of several 1,3-diketones derivatives and their metal ions. However, the amount of work on absorption measurements to investigate effect of 2,4-pentadione metal chelates on C=O frequency in infrared spectra and the use of acetylactone as a chelating agent is negligible [12]. Herein, we reported work on the studies of infrared spectra, and antimicrobial activity of 2,4-pentadione metal chelates.

## Materials and Method

### Materials

All the chemicals used were of analytical, spectroscopic grade. Nickel(II) chloride hexahydrate (98.0% pure), Copper(II)chloride dihydrate (99.0% pure) from Yueqiao and Guangdong; China, respectively. Acetylacetonate (99 % pure) and ammonia solution (99.99% pure) were from Qualiken Delhi and Lobal Chemie Mumbai, India, respectively. *n*-Hexane (97% pure), ethanol (99.9% pure), methanol (99.8% pure), and DMSO (99.5% pure), from JHD, BDH, Sigma Aldrich and Guangong Guanghua Science Technology Company, respectively. These were used as received.

### Methods

5.0 g of each sample:  $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$  (21 mmol) and  $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$  (29mmol) was taken in a 500 mL separate flasks. 25 mL of distilled water was added and stirred to dissolve, followed by the addition of 10 mL ammonia solution.  $11\text{cm}^3$  of acetylacetonate was then added dropwise to the resulting mixture, with constant stirring until precipitation was completed. The reaction flask was allowed to cooled, and then in ice-bath. The residue obtained was filtered and washed with excess ice-cold distilled water and dried in vacuum desiccators.



### Physical Property Measurements

Infrared spectra were recorded as Nujol mulls using KBr pellets on Fourier Transform (FT-IR) spectrophotometer (8400S). 2 mg of each sample was weighed into a small agate mortar and a drop of nujol was added and ground. The mull obtained was suspended on the cell of the spectrophotometer and scanned between 4000-400  $\text{cm}^{-1}$  at 32 runs per minute. Molar conductivities of each complex were measured using conductivity meter (EC 215). 1 mM of the complex was prepared and 20 mL of the solution was transferred into an electrolytic cell, measurements were taken when the meter readings were steady. The solubility of the metal complex was tested using distilled water, ethanol, methanol, DMSO and n-hexane. The test was conducted by dissolving 10 mg of each complex in each of the test-tube containing 2 mL of the corresponding solvent to check for the solubility. Thin layer chromatography (TLC) of the complexes was performed on 2 cm $\times$ 4 cm aluminium plate coated with silica gel. A solvent combination of benzene, acetone and methanol in the ratio 4:3:1 was used. The plates containing the mixture were placed in a chromatographic chamber saturated with mobile-phase vapour. The substances were separated as a mixture and detected as coloured spots using iodine crystals.

### Antimicrobial Activity Studies

Antimicrobial activity of 2,4-pentadione and its metal chelates were screened against eight microbes to assess their growth inhibiting potential: *Staphylococcus aureus*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa* and *Proteus mirabilis* (bacteria); *Candida krusei*, *Microsporium distortum*, *Mucor muceller* and *Penillium chrysogenum* (fungi). The bioactivity of the ligand and its metal chelates were obtained using the disc diffusion method [13,14]. The sterilised Mueller Hinton and Saubouraud dextrose agars were used as the growth media for bacteria and fungi, respectively. The media were fed with 0.1 mL standard inoculum of the microbes. A cork borer of 6 mm in diameter was used to cut a well at the centre of each inoculated medium. The concentration of 10  $\mu\text{g/mL}$  of each sample in DMSO was prepared and 0.1 mL of the concentration was introduced into each well on the inoculated medium. The plates were incubated at 37  $^{\circ}\text{C}$  for 24 h for bacteria and at 30  $^{\circ}\text{C}$  for 72 h for fungi, after which each plate was observed for zone of inhibition of growth. DMSO solvent was used as a negative control, and experimental data were compared with 10  $\mu\text{g/mL}$  concentration of the standard drugs (Ciprofloxacin and Fulcin).

### Determination of Minimum Inhibition Concentration

The minimum inhibition concentration (MIC) of the metal chelates was determined by broth dilution technique [15]. The concentration of each complex was between (0.625 and 10  $\mu\text{g/mL}$ ). Each microbe (0.1 mL) was introduced into the different concentrations of the metal complexes and incubated as before. The lowest concentration of the complexes which shows no turbidity was recorded as the minimum inhibition concentration.

### Minimum Bactericidal/Fungicidal Concentration MBC/MFC

The contents of the MIC were then sub cultured onto the transparent media and incubated at 37  $^{\circ}\text{C}$  for 24 h for bacteria and at 30  $^{\circ}\text{C}$  for 72 h for fungi [15]. The lowest concentration of the antimicrobial agents at which all microbes were killed was taken as the minimum bactericidal/fungicidal concentration.

### Results and Discussion

Some of the physical parameters of the prepared metal chelates were presented in Table 1.

**Table 1:** Some physical properties of the metal chelate acetylacetonates

| Metal chelate          | % Yield | Colour | Molar conductance ( $\mu\text{S m}^2 \text{mol}^{-1}$ ) | Solubility |          |         |      |          |
|------------------------|---------|--------|---|------------|----------|---------|------|----------|
|                        |         |        |   | water      | methanol | ethanol | DMSO | n-hexane |
| Ni(II) acetylacetonate | 85      | Green  | 27  | ss         | ss       | ss      | s    | ss       |
| Cu(II) acetylacetonate | 82      | Blue   | 16  | ss         | ss       | ss      | S    | ss       |



The yields of the metal chelates were found to vary as the moles of the reactants varies. Although, the percentage yield of Ni(II) acetylacetonate is (85%) high than Cu(II) acetylacetonate (82%). The difference is that the theoretical yield of Cu(II) complex is higher compare to Ni(II) complex. The data agree with percentage yield reported by Rohini and Urul in 2014, and Mihir et al, in 2004 [16,17]. The Ni(II) and Cu(II) acetylacetonates were green and blue colours, respectively. The differences in colours could be due to different in their absorption wavelength in ultraviolet visible spectrum. The colours conform to what other researchers have obtained [18,19]. The metal chetates show low values of molar conductivity below  $10 \text{ mS m}^2 \text{ mol}^{-1}$ , the expected value for an electrolyte. Hence they are non-electrolytes [20,21].

The solubility of metal acetylacetonates in various solvents portrait that the metal chelates are soluble only in dimethyl sulfoxide (DMSO). The solubility in DMSO could be the hydrophobic nature of metal acetylacetonates. Metal acetylacetonates form lipophilic shell around the metal ion [22]. Besides, the solvent, DMSO is an aprotica polar solvent that have lipophilic portions through which organic compounds dissolve [23]. In addition, the structure of DMSO molecule is trigonal pyramidal in shape with lone pair of electrons at the apex of the pyramid that cause the sulphur-oxygen bond in DMSO molecule to be more polar with high dielectric constant (46.7) to permits easy charge separation. Hence DMSO is a good solubility solvent for variety of ionic, polar and polarisable molecules [24]. The metal chelates also show slight solubility in distilled water, methanol, ethanol and n-hexane. This signifies that there is an interaction between the metal chelate and these solvents. Therefore, we assumed that the chemical structure of acetylacetonate metal complex compose partly of hydrophobic and hydrophilic portions. TLC results shows that each of the metal chelate yielded a major and faint spots. The faint spot is an indication that small amount of solvent is present in the complexes [25].

### Infrared Spectrum of 2,4-pentadione

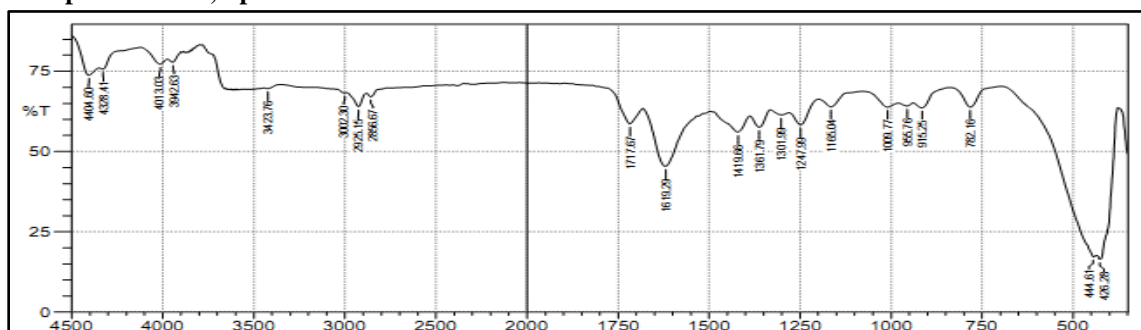


Figure 2: The infrared spectrum of acetylacetonate

The infrared spectrum of 2,4-pentadione shows a weak band at  $2925 \text{ cm}^{-1}$ ; the band is due to symmetric stretching mode of the methyl group,  $\nu_s(\text{CH}_3)$ , for keto and enol [3]. Two other bands; a weak band at  $1717 \text{ cm}^{-1}$  and broad band at  $1619 \text{ cm}^{-1}$  were observed. The former band is ascribed to carbonyl group (C=O) stretching frequency of the keto form, and the latter is interpreted as stretching modes of C=O and C=C coupled with C-H in plane of the enol. There is a shift of  $98 \text{ cm}^{-1}$  towards lower wavenumber for C=O frequency of the enol form. This could be attributed to an internal hydrogen bond and resonance effect, which signifies the conjugated system of enol [26, 27]. The bands,  $1717 \text{ cm}^{-1}$  and  $1619 \text{ cm}^{-1}$  assigned to  $\nu(\text{C}=\text{O})$  vibrations of 2,4-pentadione, is an indication that, acetylacetonate exist in two different forms [26] as shown in Figure 3.

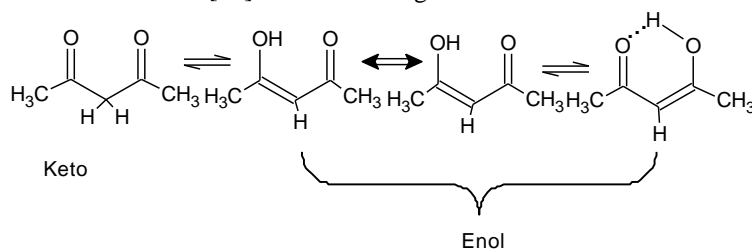


Figure 3: Keto-enol tautomers of 2,4-pentadione at equilibrium



The absorption band at  $1361\text{ cm}^{-1}$  is ascribed to vibrational wagging of  $\text{CH}_3^-$ , for both keto and enol. While the band at  $1301\text{ cm}^{-1}$  is attributed to vibrational twisting of  $\text{CH}_2^-$ , for keto form; in enol, is referred to bending of OH. The wave number  $955\text{ cm}^{-1}$  is assigned to absorption band of C-H groups for both keto and enol [3]. The wave numbers:  $2925\text{ w}$ ,  $1361\text{ w}$  and  $955\text{ vw}$ , is clearly evidence of keto and enol tautomers of 2,4-pentadione at equilibrium (Figure 3).

### FT-IR of 2,4-pentadione Metal Chelates

The infrared spectra of Ni(II) and Cu(II) complexes were shown in Figure 4 and 5, respectively. The assignment of infrared absorption spectra to the metal complexes was achieved by comparing their vibrational frequencies with those of the free ligand.

**Table 2:** Absorption bands for 2,4-pentadione and the metal chelates

| Compound               | $\nu(\text{OH})$ | $\nu(\text{CH}_3)$ | $\nu(\text{C}=\text{O})$       | $\delta(\text{OH})$ | $\nu(\text{M}-\text{O})$ |
|------------------------|------------------|--------------------|--------------------------------|---------------------|--------------------------|
| 2,4-pentadione         | -                | $2925\text{ w}$    | $1717\text{ w}, 1619\text{ m}$ | $1301\text{ vw}$    | -                        |
| Ni(II) acetylacetonate | $3224\text{ b}$  | $2936\text{ w}$    | $1605\text{ m}, 1517\text{ s}$ | $1264\text{ w}$     | $579, 668$               |
| Cu(II) acetylacetonate | $3465\text{ b}$  | $2926\text{ w}$    | $1575\text{ m}, 1532\text{ w}$ | $1274\text{ w}$     | $531, 665$               |

Key: b = broad, m = medium, s = strong, w = weak, vw = very weak

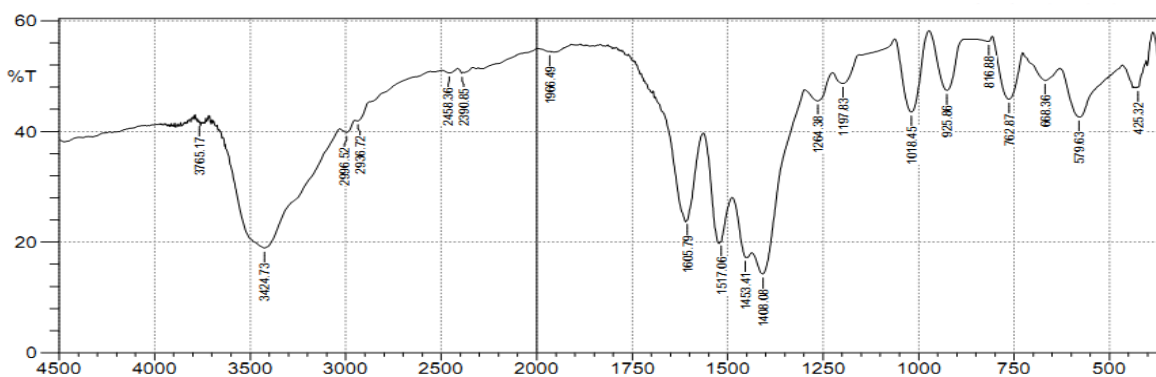


Figure 4: FT-IR spectrum Ni(II) acetylacetonate

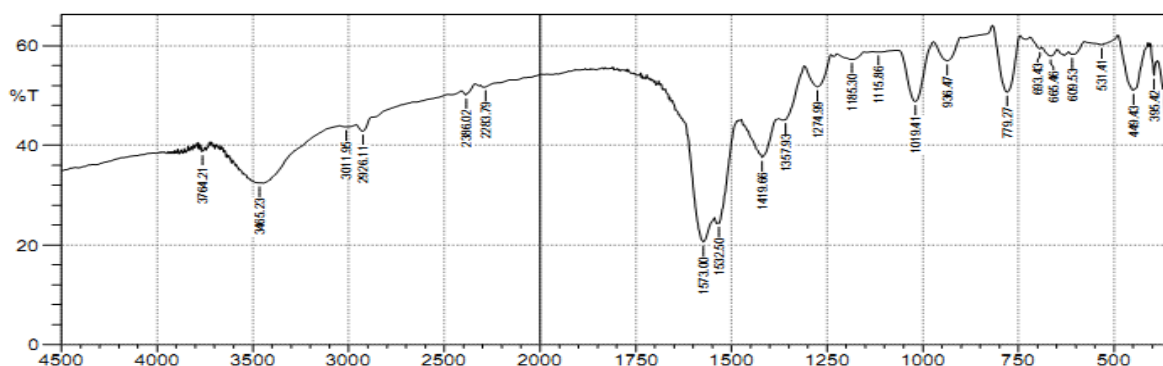


Figure 5: FT-IR spectrum Cu(II) acetylacetonate

Table 2 show specific spectral regions of Ni(II) and Cu(II) acetylacetonates with characteristic differences between the free 2,4-pentadione and its metal chelates. The broad absorption bands appeared at  $3224\text{ cm}^{-1}$  and  $3465\text{ cm}^{-1}$  in Ni(II) and Cu(II) spectra, respectively, assigned to  $\nu(\text{OH})$  were absent in 2,4-pentadione spectrum. This signifies the presence of water molecules in the prepared complexes [28,29,30]. The band,  $2925\text{ cm}^{-1}$  assigned to vibration stretching mode of methyl group, ( $\text{CH}_3$ ), in 2,4-pentadione, upon complexation, was shifted to higher wave number in the metal chelates; suggesting change of methyl proton's environment from olefin to aromatic [31]. The frequencies of  $1717\text{ cm}^{-1}$  and  $1619\text{ cm}^{-1}$  assigned to C=O vibrations of 2,4-pentadione, upon chelation the bands



shifted to lower wave numbers (see Table 2). The shift suggests the involvement of carbonyl group of 2,4-pentadione in coordination with metal ion through oxygen atom of the bidentate ligand [28,31]. The shift of absorption band of C=O to lower frequencies in the metal acetylacetonates is the consequence of delocalised  $\pi$ -electron between C=O and metal ion in the ring that influence the bond order between carbon and oxygen linkage to lie in the order  $\overset{\ominus}{\text{C}}\cdots\text{O}$  (that is,  $<1<2$ ). The shift in wavelength of C=O towards lower frequencies in the two complexes are of different magnitudes. This could be probably due to the extent of interaction of sigma ( $\sigma$ ) and pi ( $\pi$ ) involving the orbitals of C=O with the metal ion [2]. The weak band observed at  $1301\text{ cm}^{-1}$  in the spectrum of the parent ligand assigned to OH, is shifted to lower frequencies in the metal chelates. The shift signified the coordination of oxygen atoms with metal ion which result to the formation of C-O-M bond [32]. The coordination involving C-O has additional supportive information with the appearance new bands in the regions;  $579\text{-}668\text{ cm}^{-1}$  and  $531\text{-}665\text{ cm}^{-1}$  assigned to vibrations of Ni-O and Cu-O bonds, respectively [2]. Comparing the IR and TLC data, we observed a strong correlation between the two; that, all the prepared complexes contain small amount of binary solvent molecules. We therefore, proposed the structure of the prepared metal chelates on the basis of TLC and IR data as represented in Figure 6.

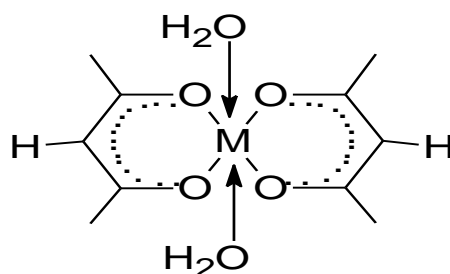


Figure 6: Proposed structure of M(II) chelate, where  $M = \text{Ni(II)}, \text{Cu(II)}$

### Antimicrobial Activity

Antimicrobial activity of the ligand and its metal chelates were expressed as the diameter of growth of inhibition zone in mm as shown in Table 3.

Table 3: Zone of inhibition by metal chelates on some pathogens (mm)

| Microbes              | AcacH | Ni(C <sub>5</sub> H <sub>7</sub> O <sub>2</sub> ) <sub>2</sub> | Cu(C <sub>5</sub> H <sub>7</sub> O <sub>2</sub> ) <sub>2</sub> | Ciprofloxacin | Fulcin |
|-----------------------|-------|--|--|---------------|--------|
| <i>S. aureus</i>      | 24    | 30   | 29   | 35            | -      |
| <i>S. pyogenes</i>    | R     | R  | 28   | 32            | -      |
| <i>P. eruginosa</i>   | R     | R  | 30   | 37            | -      |
| <i>P. mirabilis</i>   | 21    | 26   | R  | 35            | -      |
| <i>C. kusei</i>       | 24    | R  | 27   | -             | 32     |
| <i>M. distortum</i>   | R     | 33   | 27   | -             | 30     |
| <i>M. muceller</i>    | 20    | R  | 26   | -             | 31     |
| <i>P. chrysogenum</i> | R     | 34   | 27   | -             | 34     |

Key: R = Resistant,

The results obtained for growth of zone of inhibition were compared with those of the Ciprofloxacin and Fulcin, the standard drugs. The metal chelates of acetylacetonate exhibited some antimicrobial property. The Ni(II) complex has highest antifungal activity on *Penillium chrysogenum* (34 mm), while Cu(II) complex is more antibacterial against *Pseudomonas aeruginosa* (30 mm). The results of the biological assay of the metal complexes have shown that, Cu(II) complex has wide spectrum, which proved to be active against almost the tested microbial strains [33], and narrow antimicrobial spectrum was noticed for Ni(II) complex [34]. The MIC of Ni(II) and Cu(II) acetylacetonates was determined by broth diffusion technique and the results are presented in Tables 4 and 5, respectively. While Ni(II) acetylacetonate shows a MIC of  $1.25\text{ }\mu\text{g/mL}$  for both microbes (Table 4), Cu(II) acetylacetonate show MIC of  $1.25\text{ }\mu\text{g/mL}$  for three bacteria, two fungi and MIC of  $2.50\text{ }\mu\text{g/mL}$  against *Microsporium distortum* (Table 5).

Further investigations were carried out to see whether the prepared metal complexes are bactericidal/fungicidal or bacteriostatic/fungistatic. The data for both bactericidal and fungicidal for Ni(II) and Cu(II) acetylacetonates were presented in Tables 6 and 7, respectively.

Table 4: MIC values of Ni(II) acetylacetonate on some pathogens ( $\mu\text{g/mL}$ )

| Microbes              | 10.0 | 5.0 | 2.50 | 1.25 | 0.65 |
|-----------------------|------|-----|------|------|------|
| <i>S. aureus</i>      |      | -   | -    | o+   | +    |
| <i>S. pyogenes</i>    | R    |     |      |      |      |
| <i>P. eruginosa</i>   | R    |     |      |      |      |
| <i>P. mirabilis</i>   | -    | -   | -    | o+   | +    |
| <i>C. kusei</i>       | R    |     |      |      |      |
| <i>M. distortum</i>   | -    | -   | -    | o+   | +    |
| <i>M. muceller</i>    | R    |     |      |      |      |
| <i>P. chrysogenum</i> | -    | -   | -    | o+   | +    |

Table 5: MIC values of Cu(II) acetylacetonate on some pathogens ( $\mu\text{g/mL}$ )

| Microbes              | 10.0 | 5.0 | 2.50 | 1.25 | 0.625 |
|-----------------------|------|-----|------|------|-------|
| <i>S. aureus</i>      | -    | -   | -    | o+   | +     |
| <i>S. pyogenes</i>    | -    | -   | -    | o+   | +     |
| <i>P. eruginosa</i>   | -    | -   | -    | o+   | +     |
| <i>P. mirabilis</i>   | R    |     |      |      |       |
| <i>C. kusei</i>       | -    | -   | -    | o+   | +     |
| <i>M. distortum</i>   | -    | -   | o+   | o+   | +     |
| <i>M. muceller</i>    | R    |     |      |      |       |
| <i>P. chrysogenum</i> | -    | -   | -    | o+   | +     |

Key: - = No turbidity, o+ = MIC, + = Turbidity, R= Resistant

Table 6: MBC/MFC values of Ni(II) acetylacetonate on some pathogens ( $\mu\text{g/mL}$ )

| Microbes              | 10.0 | 5.0 | 2.50 | 1.25 | 0.625 |
|-----------------------|------|-----|------|------|-------|
| <i>S. aureus</i>      | -    | -   | o+   | +    | ++    |
| <i>S. pyogenes</i>    | R    |     |      |      |       |
| <i>P. eruginosa</i>   | R    |     |      |      |       |
| <i>P. mirabilis</i>   | -    | -   | o+   | +    | ++    |
| <i>C. kusei</i>       | R    |     |      |      |       |
| <i>M. distortum</i>   | -    | -   | o+   | +    | ++    |
| <i>M. muceller</i>    | R    |     |      |      |       |
| <i>P. chrysogenum</i> | -    | -   | o+   | +    | ++    |

Table 7: MBC/MFC values of Cu(II) acetylacetonate on some pathogens ( $\mu\text{g/mL}$ )

| Microbes              | 10.0 | 5.0 | 2.50 | 1.25 | 0.625 |
|-----------------------|------|-----|------|------|-------|
| <i>S. aureus</i>      | -    | -   | o+   | +    | ++    |
| <i>S. pyogenes</i>    | -    | o+  | +    | ++   | +++   |
| <i>P. eruginosa</i>   | -    | -   | o+   | +    | ++    |
| <i>P. mirabilis</i>   | R    |     |      |      |       |
| <i>C. kusei</i>       | -    | o+  | +    | ++   | +++   |
| <i>M. distortum</i>   | -    | o+  | +    | ++   | +++   |
| <i>M. muceller</i>    | R    |     |      |      |       |
| <i>P. chrysogenum</i> | -    | o+  | +    | ++   | +++   |



Key: - = No colony growth, o+ = MBC/MFC, + = Scanty colony growth, ++ = Moderate colonies growth, +++ = Heavy colonies growth, R = Resistant

From Table 6, it can be observed that Ni(II) acetylacetonate has MBC/MFC value of 2.5 µg/mL and act as bactericidal/fungicidal at this concentration. However, at concentrations below this it rather acts as bacteriostatic/fungistatic. Cu(II) acetylacetonate is bactericidal with MBC values of 2.5-5.0µg/mL and fungicidal with MFC value of 5.0 µg/mL.

Generally, there is enhancement in antimicrobial activity of metal chelates relatively to the parent ligand. The enhancement is attributed to chelation concept, which increases the lipophilic behaviour of metal atom. This in turn enhanced the hydrophobic character of the complex by reduction of metal atom polarity due to delocalisation of  $\pi$  electron within the chelate ring system. Lipophilic and hydrophobic factors seem to be responsible for the permeability of the metal complexes through the lipid layers of the cell membrane of the microbes. The consequences being; the metal binding sites on enzymes of microorganism is blocked and the syntheses of nucleic acids, protein and cell wall are inhibited. Also key metabolic pathways and cell membrane structure are affected leading to cell growth inhibition and eventually death [35,36,37]. In contrary to this, some of the microorganisms are resistant to the antibiotics. This could be ability of the microbes to develop what is called genetic mutations. The mutations alter the antibiotic action via modifications of the antimicrobial target sites that is, decreasing the affinity for the drug and drug uptake, activation of efflux mechanisms to extrude the harmful molecule or genetic mutations might enable microbes to produce enzymes that deactivate antibiotics or eliminate the target that the antibiotics are supposed to attack [38].

### Conclusion

The Ni(II) and Cu(II) chelates were synthesised by using acetylacetone as a ligand in aqueous ammonical medium. The metal complexes were characterised by various physio-chemical methods. The FT-IR analysis results showed coordination of 2,4-pentadione to the metal ions through oxygen atoms as proven by lowered absorption band wavenumber of C=O after chelation, hence the bond order of the carbonyl group is reduced. Antimicrobial activity assay revealed that metal chelates have a bio-activity against some tested microbes. The bio-activity of the metal complexes is greater compare to its parent ligand. The potency of antimicrobial activity of Ni(II) chelate on *M. distortum* is higher compare to Fulcin. It also has the same bio-activity against *Penicillium chrysogenum* Fulcin. Therefore, Ni(II) complex can be used as a substitute for the treatment of the two microorganisms.

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