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Testing Bioactivity Effects of Transition Metal Complexes with Bidentate Ion

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Abstract

The study involves the production of two different kinds of complexes with the metals Fe(III) and Cu(II) that contain oxalate ions. They had been studied by molar conductance, melting point, atomic absorption measurements (A.A), magnetic moment measurements infrared (FTIR) and electronic (UV.VIS) spectra. Encompasses the investigation of these complexes' biological effects on many harmful bacterial species: Staphylococcus aureus is a gram positive (+ve) bacteria, while the other bacteria, such as Escherichia coli (E. coli) and Pseudomonas aeruginosa, are gram negative (-ve). The Muller Inhibitors Concentration (MIC) method is used to assess the impact of metal ions during chelation and demonstrate the various levels of inhibition on bacterial growth.

Keywords: Metal complexes; Antibacterial activity; Transition metal; Bidentate ion

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1. Introduction

This material was extensively investigated to its wide applications in photochemical [1,2]. The ferrate(III) oxalate was reported for the first time by Blair and Jonesin studies, actinometery, sensors and magnetic materials [3-5].

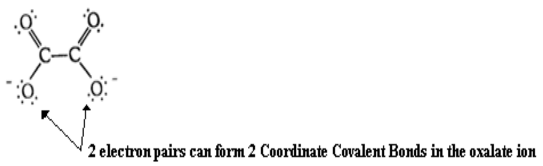


Fig. (1) Structure of oxalate ion

The complexation of metals with ligands can drastically change the physico–chemical and biological properties of the metal species [6]. Metal ions play an important role in bioinorganic chemistry and metals such as Fe and Cu may exist in trace amounts in biological systems. Structural studies of the complexes of theses metals with biological compounds are extremely important [7].

Scientific researchers working in the field of bioinorganic chemistry, the copper represents one of the most interesting biometals for the preparation of new metal-based drugs with strong potential for therapeutic applications [8]. Copper is an essential micronutrient that, its ability to undergo Cu(I) to Cu(II) redox cycling, plays a role in cellular redox models of copper enzymes [11-13]. Copper deficiency has been reported to cause hematologic disorders, hypo pigmentation, defective connective tissue cross-linking and ataxia [14,15]. The antibacterial activity of the complexes was investigated against representative microorganisms using the method previously reported [16].

2. Experimental Part

2.1 Materials

All chemicals used were of reagent grade (supplied by either Merck or Fluka) and used as supplied. All the metal ions Cu(II) and Fe(III) were of Analar grade

(BDH). They were used without further purification.

2.2 Instruments

Electronic spectra of the prepared complexes were measured in the region 200-1100nm quartz cell Shimadzu, UV-160A Ultra Violet Visible-Spectrophotometer. FTIR spectra were recorded as KBr pellets using Fourier transform Infrared Spectrophotometer Shimadzu 24 FTI.R 8400s. While metal contents of the complexes were determined by Atomic Absorption (A.A) Technique using Japan A.A-67G Shimadzu. Electrical conductivity measurements of the complexes were recorded at room temperature using conductivity meter (Philips). Melting points were recorded to ligand and complexes by using Stuart melting point. Magnetic susceptibility measurements were measured using molecular structure of the complexes were determinate by using ChemBio office v.13.0 (2012) used for drawing the 2D and 3D - structure of compounds [17].

2.3 Preparation of complex potassium tris(oxalato) ferrate (III) trihydrate=

Ferric chloride hexahydrate (0.016 mole) is dissolved in distilled water, then is added to the solution Potassium oxalate hydrate (0.048 mole), the product is cooled in bath ice and filtered to obtain green crystals.

2.4 Preparation of complex sodium bis(oxalato) cuprate (II) dihydrate

Copper sulfate pentahydrate (0.008 mole) is dissolved in distilled hot water, then is added to the solution sodium oxalate (0.014 mole) with stirring and heating to 90°C, the product is cooled in bath ice and filtered, washed and dried to obtain blue complex.

2.5 Antibacterial Activity Test

Antibacterial activities of the complexes were tested in different concentrations against three types of pathogenic species of standard bacteria which are isolated in general central lab in ministry of health; Staphylococcus aureus gram positive (+ve), the others are gram negative (-ve) which are included Escherichia coli (E.coli) and Pseudomonas aeruginosa by using Muller Inhibitors Concentration (MIC) method [18].

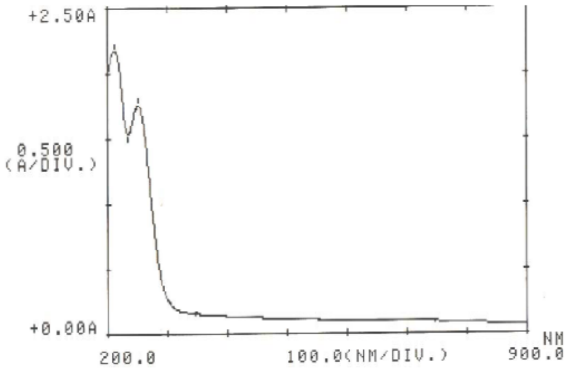
The sterilized (autoclave at 121 °C for 15 min) medium (40-50°C) was poured into Petri dishes to give a depth of 3-4 mm and allowed to solidify. The suspension of the standard microorganism then streaked on plates which pre-incubated for 1 hr. at room temperature and incubated at 37°C for 24 hr. The antibacterial activity was evaluated by measuring the diameter of the inhibition zone (I.Z) around the hole in mm [19].

3. Results and Discussion

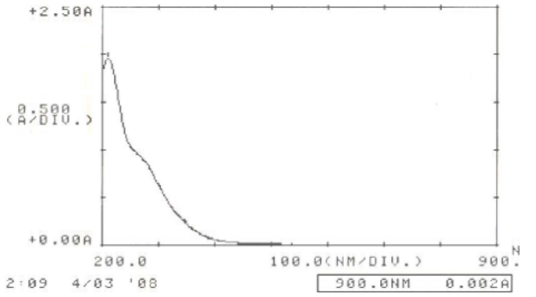
Potassium trisoxalatoferrate(III) trihydrate, $K_3[Fe(C_2O_4)_3].H_2O$ is a green crystalline salt, soluble in hot water but rather insoluble when cold. It can be prepared by the reaction of $K_2C_2O_4.H_2O$ with $FeCl_3.6H_2O$.

The synthesis of potassium tris(oxalato)ferrate(III)trihydrate was in 1939 [20]. This material was extensively investigated owing to its wide applications in photochemical studies, actinometery ,sensors, magnetic materials, etc. [21-23].

The ground state of d5 ion, 6S transforms into 6A1g - a singlet state. It is not changes by two and hence they are too weak. Thus sextet- split by the effect of crystal field and hence all the transitions are spin forbidden and are of less intensity In excited state, d5 ion gives rise to quartets (4G, 4F, 4D, 4P) and doublets (^{2}I, ^{2}H, ^{2}G, ^{2}F, ^{2}D, ^{2}P, ^{2}S) . The transitions from the ground to doublet state are forbidden (ν3) appear around 22000 cm^{-1}. The last transition is field independent. The ligand field spectrum of ferric iron appears as if the first (ν1) and the third (ν3) bands of octahedral symmetry are only present. The analysis of general features of the spectrum of Fe^{3+} containing plumbojarosite is discussed here. The first feature observed in the copper ion has oxidation number (O.N) equal to +2 and coordination number (C.N) equal to 4 because the oxalate anion coordinates to a metal as bidentate Chelate. The copper ion has ground state 2D. The electronic spectra of the Cu(II) complex exhibited $\lambda_{max.}$ at 251nm (absorbance was 1.753) is attributed ($\pi \rightarrow \pi^*$) transition which means ultraviolet region and charge transfer from L to M, an electron moves versa ligand-to-metal charge transfer (LMCT); take M with high ionization energy. The other regions at 212nm (absorbance was 2.176) and 235nm (absorbance was 1.5416) which means ultraviolet region (near UV). The spectra of complexes Fe(III) and Cu(II) are shown in figures (2) and (3).

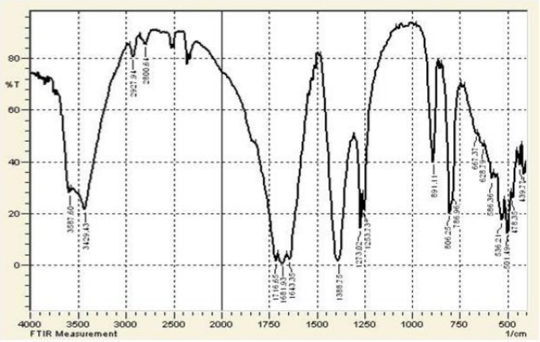


Figure(2) : (UV-Vis) Spectra of complex Cu(II)

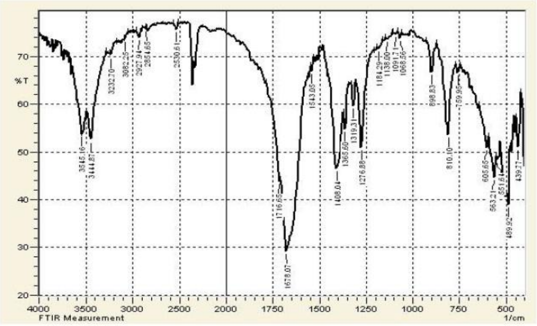


Figure(3) : (UV-Vis) Spectra of complex Fe(III)

The oxalate anion (ox^{-2}) coordinates to a metal as an unidentate (I) or bidentate (II) ligand: the bidentate chelate structure (II) is most common [28]. Carried out normal coordinate analyses on the 1:1 metal-ligand model of the $[M(OX)_2]^{2-}$ and $[M(OX)_3]^{3-}$ series, and obtained the band assignment listed in table (1). In the divalent metal series as Cu(II), υ(CO) becomes higher, and υ(C-O) becomes lower. In the trivalent metal series Fe(III) found υ (MO stretching) follows the same trend as the crystal field stabilization energies (CFSE) of these metals [29,30]. The FTIR spectra of complexes are shown in figures (4) and (5). Complexes were screened for their antibacterial activities according to the respective literature protocol [31] and the results are obtained in table (2).



figure(4) : FT-IR spectrum of complex Fe(II)



Figure(5) : FT-IR spectrum of complex Cu(II)

Table(2): effect a concentration of complexes on diameter of inhibition in millimeter for bacteria

Compounds	Concentration (M)	E .Coli	Pseudomonas aeruginosa	Staphylococcus aureus
$K_3[Fe(C_2O_4)_3].3H_2O$	0.1	30	12	0
	0.2	30	14	0
	0.3	40	20	20
$Na_2[Cu(C_2O_4)_2].2H_2O$	0.1	18	0	0
	0.2	20	0	0
	0.3	22	40	0

Antibacterial activities of the complexes were tested in different concentrations against three types of pathogenic species of standard bacteria which are isolated in general central lab in ministry of health; Staphylococcus aureus gram positive (+ve), the others are gram negative (-ve) which are included Escherichia coli (E.coli) and Pseudomonas aeruginosa, and the minimum inhibitory concentration (MIC), then compared with the theoretical calculations with energies of docking.

The results show antibacterial activity to complex $K_3[Fe(C_2O_4)_3].3H_2O$ best results which mean the diameter of inhibition in mm, and the results were best on E.coli, Pseudomonas aeruginosa while Staphylococcus aureus was least. While the results of complex $Na_2[Cu(C_2O_4)_2].2H_2O$ on that bacteria appear effect the raising of concentration on the diameter of inhibition to E.coli, Pseudomonas aeruginosa bacteria, while the used concentration of complexes do not affect on Staphylococcus aureus bacteria. The Docking (interaction) Energies in unit (kcal/mol) to the complexes against three types of bacteria appear the negative values which refer to theoretical calculations were performed by using a personal computer with a Core i7 processor (CPU 2.20GHz) and RAM 8GB, with a Windows 7 operating system, and these computational works used five software, and figures are sketched by ChemBio office v.13.0 (2012) [32]. While molecular operating environment MOE v.(2009) software developed was by Chemical Computing Group, Montreal, Canada [33] used for graphical illustrations and molecular interaction potentials, in addition that, used for docking calculations. whenever a value was greatest its best. The Docking (interaction) Energies were shown in table (2), and the possible binding mode of the complexes with bacteria was showed in figures [6,7].

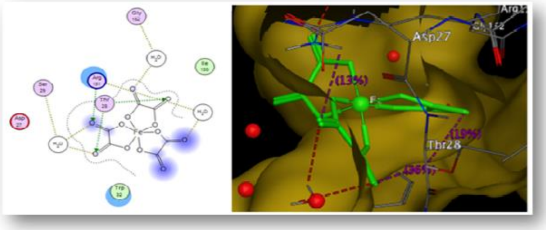


Figure (6): Binding mode of top ranked of complex $\mathbf{K_3[Fe(C_2O_4)_3].3H_2O}$ in the binding site of Escherichia coli **(1llb)** from PDB.

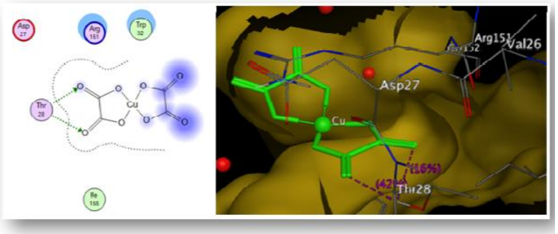
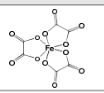
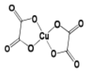
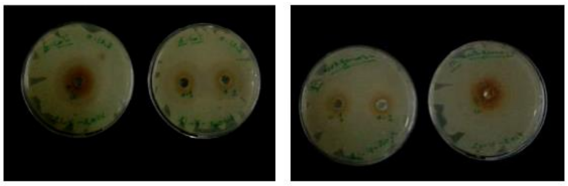


Figure (7): Binding mode of top ranked of complex $\mathbf{Na_2[Cu(C_2O_4)_2].2H_2O}$ in the binding site of Escherichia coli **(1llb)** from PDB.

Table (3): interaction Energies of complexes with bacteria

No.	**Compound**	**Structure**	E-Doc of **A**	E-Doc of **B**	E-Doc of **C**
1	$\mathbf{K_3[Fe(C_2O_4)_3].3H_2O}$		**-9.4**	**-7.4**	**-7.5**
4	$\mathbf{Na_2[Cu(C_2O_4)_2].2H_2O}$		**-6.66**	**-6.4**	**-6.9**
E-Doc. is the interaction energy in kcal/mol of: A- staphylococcus aureus **(PDB:2z6f)**, B- pseudomonas aeruginosa **(PDB:1lry)**, C-Escherichia coli **(PDB:1llb)**					

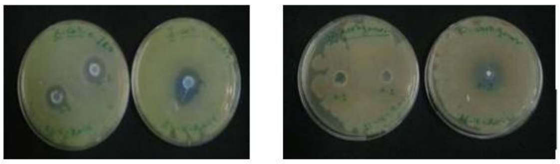


Inhibition Zones against E .coli (gram -ve)

Inhibition Zones against Pseudomonas aeruginosa (gram -ve)

Inhibition Zones against Staphylococcus aureus (gram +ve)

The Antibacterial activity of complex $K_3[Fe(C_2O_4)_3].3H_2O$ appears the inhibition zones against three types of bacteria



Inhibition Zones against E .coli (gram -ve)

Inhibition Zones against Staphylococcus aureus (gram +ve)

The Antibacterial activity of complex $Na_2[Cu(C_2O_4)_2].2H_2O$ appears the inhibition zones against three types of bacteria

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