

INFRARED SPECTRA, THERMOGRAVIMETRIC ANALYSIS AND ANTIFUNGAL STUDIES OF NOVAL Cr(III), Fe(III) AND Cu(II) 2-METHYL-QUINAZOLINONE COMPLEXES

S.A. Sadeek^{1*}, M.S. El-Attar¹ and N.S. Abd El-Latif²

¹Department of Chemistry, Faculty of Science, Zagazig University, Zagazig, Egypt

²Department of Pesticides Formulation, Central Agricultural Pesticides Laboratory, Cairo, Egypt

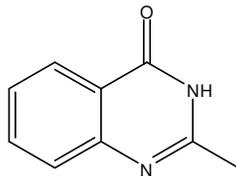
(Received June 17, 2013; revised December 4, 2013)

ABSTRACT. Some new solid complexes $[\text{CrCl}_3(\text{L})_3] \cdot 6\text{H}_2\text{O}$, $[\text{FeCl}_3(\text{L})_3] \cdot 6\text{H}_2\text{O}$ and $[\text{Cu}(\text{CH}_3\text{COO})_2(\text{L})_2] \cdot 2\text{H}_2\text{O}$ have been synthesized quantitatively by the interactions of 2-methyl-quinazolinone (L) with $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$, $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ and $\text{Cu}(\text{CH}_3\text{COO})_2 \cdot 2\text{H}_2\text{O}$ in a mixture of an ethanol-bidistilled water (1:1), at 60 °C. They were characterized by melting point, molar conductivity, magnetic moment, elemental analysis, infrared spectra and thermal analyses. The results supported the formation of the complexes and indicated that the ligand reacted as a monodentate ligand bound to the metal ion through the oxygen atom. The antifungal activity of the free ligand and their metal complexes were evaluated against several species, such as *Fusarium solani*, *Rizoctonia solani*, *Sclerotium rolfsii* and *Botryodiplodia* and they showed a good antifungal activity to some selected fungal strain as compared with free ligand.

KEY WORDS: Quinazolinone; Cr(III); Fe(III); Cu(II); Antifungal activity; Thermal analyses

INTRODUCTION

2-Methyl-quinazolinone (Formula 1) is one of the important compounds from the series of quinazolinone derivatives. Quinazolinone and its derivatives are inhibitory to a number of fungal pathogens of plants, including *Helminthosporium turcicum*, *Stagonospora nodorum*, *Microdochium nivale*, *Fusarium moniliforme*, *Fusarium culmorum*, and *Gaeumannomyces graminis*. Some isolates of *G. graminis*, *F. culmorum*, *F. moniliforme*, *F. subglutinans*, and of a number of other *Fusarium* species are able to degrade benzoxazolinone compounds to products which are less inhibitory to fungal growth and also important compounds in chemistry and pharmacology [1-5]. They have drawn much attention due to their broad range of pharmacological properties, which include anticancer, anti-inflammatory, anticonvulsant and antidiuretic activities [6-10]. Consequently, considerable efforts have been made to explore new simple and direct approaches towards the construction of 5(4H)-quinazolinone skeletons such as via amidation of 2-aminobenzonitrile, followed by oxidative ring closure and Pd-catalyzed heterocyclization of nitroarenes [11, 12].



Formula 1. Structure of 2-methyl-quinazolinone.

*Corresponding author. E-mail: sadeek59@zu.edu.eg

Benzoxazinone derivatives are also used as antiphlogistic drugs, antifungal and antibacterial agent [13, 14]. If a vinyl or phosphate functional group is connected to an aromatic ring located at the position two of the heterocyclic, the resulting compounds possess antimuscular contraction properties and can be used as a hypnotic drug [15, 16]. For many years, quinazolinone derivatives and their metal complexes have been the subject of most structural and mechanical studies due to their potential biological value [17]. In recent years the chemistry of heterocyclic compounds are well known for their diverse therapeutic properties and exhibited antibacterial, anticancer, antiulcer, diuretics, anticonvulsant, antihypertensive, antitumor, antifungal, anti-AIDS and antiviral properties [18].

The present study describes the coordination behavior of novel 2-methyl-quinazolinone towards some transition elements, which may help in more understanding of the mode of chelation of them towards metals. For this purpose the complexes of Cr(III), Fe(III) and Cu(II) ions with 2-methyl-quinazolinone are studied in the solid state. The structure of the studied complexes is characterized using elemental analysis, infrared spectra and thermal analyses (TGA and DTG) measurements. The biological activity of the parent, 2-methyl-quinazolinone and its metal complexes has been tested against antifungal screening, *Fusarium solani*, *Rizoctonia solani*, *Sclortium rolfsii* and *Botryodiplodia*.

EXPERIMENTAL

Chemicals

All chemicals used for the synthesis of compounds were of the analytical reagent grade and of highest purity available. Copper acetate dihydrate was purchased from Sigma, chromium chloride and ferric chloride were purchased from Prolabo. Solvents were dried by the standard procedures [19].

Instruments

Elemental microanalysis of the solid complexes for C, H, N and halogen was carried out on a Perkin-Elmer CHN 2400 and performed at the Micro-analytical Center, Cairo University. The analysis was repeated twice to check the accuracy of the analyzed data. The percentage of the metal ions were determined gravimetrically by transforming the solid products into oxide and also determined by using atomic absorption method. Spectrometer model PYE-UNICAM SP 1900 fitted with the corresponding lamp was used for this purposed. Infrared spectra of the three solid complexes, $[\text{CrCl}_3(\text{L})_3] \cdot 6\text{H}_2\text{O}$, $[\text{FeCl}_3(\text{L})_3] \cdot 6\text{H}_2\text{O}$, $[\text{Cu}(\text{CH}_3\text{COO})_2(\text{L})_3] \cdot 2\text{H}_2\text{O}$, 2-methyl-quinazolinone and the final products of the thermogravimetric analysis were recorded on a Perkin-Elmer FT-IR type 1650 spectrophotometer in wave number region $4000\text{--}400\text{ cm}^{-1}$. The spectra were recorded as KBr pellets. The thermal analyses (TGA and DTG) were carried out in dynamic nitrogen atmosphere ($20\text{ mL}\cdot\text{min}^{-1}$) with a heating rate of $10\text{ }^\circ\text{C min}^{-1}$ using Shimadzu TGA-50H thermal analyzer within the temperature range from room temperature to $1200\text{ }^\circ\text{C}$. Molar conductivities of the solution of the ligand and metal complexes in DMSO at $1 \times 10^{-3}\text{ M}$ were measured on CONSORT k410. All measurements were carried out at ambient temperature with freshly prepared solution.

Synthesis of 2-methyl-quinazolinone

The pale brown of 2-methyl-quinazolinone was prepared according to published method [20, 21] by heating of 10 mmol 2-methyl-3,1-(4H)-benzoxazin-4-one and 25 mL of formamide for 3

h in oil bath and the reaction mixture was left aside at room temperature until the precipitation occurs, the solution was filtered under vacuum and the solid product was recrystallized from suitable solvent (ethanol).

Synthesis of metal complexes

The black solid complex $[\text{CrCl}_3(\text{L})_3]\cdot 6\text{H}_2\text{O}$ was prepared by adding 2 mmol (0.533 g) of chromium chloride ($\text{CrCl}_3\cdot 6\text{H}_2\text{O}$) in 25 mL mixture of an ethanol-water (1:1) drop wisely to a stirred hot solution (60 °C) of 6 mmol (0.966 g) of 2-methyl-quinazolinone in 25 mL of the same mixture in 1:3 molar ratio. The reaction mixture was stirred under heating for four hours where upon the complex precipitated. The black solid complex collected by filtration and purified by washing with an ethanol-water mixture and diethyl ether. The gray and light green solid complexes of $[\text{FeCl}_3(\text{L})_3]\cdot 6\text{H}_2\text{O}$ and $[\text{Cu}(\text{CH}_3\text{COO})_2(\text{L})_3]\cdot 2\text{H}_2\text{O}$, respectively, were prepared in a similar manner described above by using $\text{FeCl}_3\cdot 6\text{H}_2\text{O}$ or $\text{Cu}(\text{CH}_3\text{COO})_2\cdot 2\text{H}_2\text{O}$, respectively, in 1:3 molar ratio. The three complexes were characterized by their elemental analysis, infrared spectra as well as thermal analyses.

Antifungal activity

The effect of the prepared compound 2-methyl-quinazolinone and its metal complexes on the linear growth of tested soil fungi, such as *Fusarium solani*, *Rizoctonia solani*, *Sclerotium rolfsii* and *Botryodiplodia* on potatoes dextrose agar (PDA) medium was evaluated by a previously reported modified method [22]. The medium was prepared as usual using 50 mL of PDA and transferred to a conical flask (150 mL) and autoclaved.

Adequate drops of 25% of lactic acid were added on PDA after sterilization and before pouring in Petri dishes to prevent bacterial growth. Appropriate amounts of each prepared compound were added to flasks containing PDA medium just before solidifying and shaken before pouring to obtain the required concentrations of the prepared compounds (1000 µg/mL). The different preparations of each compound were then poured in Petri dishes. Four dishes were used as replicates for each compound. Agar disks 6 mm in diameter of growth cultures of each tested fungus on PDA medium were seeded on center of each amended PDA plate with tested compounds. Other four dishes that were not treated with any chemical were incubated with fungal disks and used as control. All dishes were incubated at $25\pm 1^\circ\text{C}$. The linear growth of fungal mycelium was measured in mm when any of the colonies covered the plate. The data of linear growth of fungi as affected by prepared compounds are recorded.

RESULTS AND DISCUSSION

The prepared solid complexes were subjected to elemental analysis (C, H N, halogen and metal content), infrared spectral studies (IR), and thermal analyses (TGA and DTG), to identify their tentative formula in a trial to elucidate their molecular structures. All these complexes were colored and hydrates with a metal to ligand ratio amounting to 1:3 for three complexes and the metal ions complete the coordination number to six for Cr(III) and Fe(III) or five for Cu(II) with chloride or acetate ions, respectively. The structures of the complexes suggested from the elemental analysis agreed well with their proposed formula (Table 1). The magnetic moment of Fe(III) complex at room temperature was found to be at 2.42 B.M., which indicated for low spin paramagnetic Fe(III) in octahedral geometry [23, 24]. For Cu(II) complex the measured magnetic moment value was 1.77 B.M., which is very close to that of the spin only value (1.71 B.M.) expected for a complex having one Cu(II) with a single unpaired electron [25]. Also, the

magnetic moment for Cr(III) complex was found at 3.82 B.M. [24]. Molar conductance values of 2-methyl-quinazolinone and all complexes were found to be in the range 8.11-12.50 S cm² mol⁻¹ suggesting their non-elyctrolytic nature. Qualitative reactions revealed the presence of chloride and acetate as ligand (inside the complex sphere for the three complexes). The biological activity of the ligands and their metal chelates were studied against antifungal organisms *Fusarium solani*, *Rizoctonia solani*, *Sclortium rolfsii* and *Botryodiplodia*.

Table 1. Analytical, physical and elemental analysis data for L* and their metal complexes.

Compounds M.Wt. (M.F.)	Color (yield) %	M.p. (°C)	% found (calcd.)			
			C	H	N	M
L 160(C ₉ H ₈ N ₂ O)	Pale brown (85)	132	67.5 (67.5)	4.95 (5.00)	17.35 (17.50)	-
[CrCl ₃ (L) ₃]·6H ₂ O 746.5 (CrC ₂₇ H ₃₆ Cl ₃ N ₆ O ₉)	Black (75)	>300	43.49 (43.40)	4.84 (4.82)	11.28 (11.25)	6.87 (6.96)
[FeCl ₃ (L) ₃]·6H ₂ O 750.34 (FeC ₂₇ H ₃₆ Cl ₃ N ₆ O ₉)	Gray (71)	>300	42.99 (43.17)	4.76 (4.79)	11.07 (11.19)	7.39 (7.44)
[Cu(CH ₃ COO) ₂ (L) ₃]·2H ₂ O 697.54 (CuC ₃₁ H ₃₄ N ₆ O ₉)	Light green (75)	>300	53.29 (53.33)	4.84 (4.87)	12.00 (12.04)	8.98 (9.10)

* = 2-methyl-quinazolinone.

IR spectral studies

The infrared spectra of 2-methyl-quinazolinone, [CrCl₃(L)₃]·6H₂O, [FeCl₃(L)₃]·6H₂O and [Cu(CH₃COO)₂(L)₃]·2H₂O are listed in Table 2. The infrared spectra of the three complexes were compared with those of the free ligands in order to determine the coordination sites that may involved in chelation. There were some guide peaks, in the spectra of the ligand, which were a good help for achieving this goal. These peaks were expected to be involved in chelation. The position and/or the intensities of these peaks were expected to be changed upon chelation. The presence of the spectral absorption bands in the region 3475-3395 cm⁻¹ indicated the presence of water molecules in the obtained complexes [26, 27]. The characteristic ν(N-H) stretching frequencies, appeared in the region 3362-3210 cm⁻¹. The stretching vibrations ν(C-H) of phenyl groups in all complexes occurred as a number of bands in the range 3182-3000 cm⁻¹, while that the corresponding vibrations ν(C-H) of -CH₃ unit was observed in the range 2981-2914 cm⁻¹. The assignments of all the C-H stretching vibrations agreed quite well with the expected in literature [28]. The ν(C=O) stretching vibration of free L was found at 1670 cm⁻¹. The shift of ν(C=O) to a lower wave numbers in the three complexes at 1621 cm⁻¹ for Cr(III), at 1664 cm⁻¹ for Fe(III) and at 1659 cm⁻¹ for Cu(II) indicated the participation of 2-methyl-quinazolinone in coordination and the formation of a bond between the oxygen of L with the central metal ions, and that nitrogen atom was not the donor atom. For [Cu(CH₃COO)₂(L)₃]·2H₂O complex the stretching asymmetric (ν_{as}) of carboxylate group for acetate ion found at around 1689 cm⁻¹ and of the symmetric vibrations (ν_s) at 1442 cm⁻¹ confirmed the donation of acetate as monodentate. Unidentate carboxylate complexes exhibited Δν values at > 200 cm⁻¹ + Δν = ν_{as}(COO⁻) - ν_s(COO⁻) [29].

The phenyl breathing vibration, ν(C=N) and ν(C=C) in all complexes occurred as a group of medium to very strong bands lying in the range 1601-1401 cm⁻¹ (Table 2). The CH deformation motions of the -CH₃ group occurred as a medium band at 1381 and 1337 cm⁻¹ for L and as a weak or medium bands at 1346 and 1301 cm⁻¹ for Cr(III), at 1395 cm⁻¹ for Fe(III) and at 1383 cm⁻¹ for Cu(II) complexes. The ν(C-O), ν(C-N) and ν(C-C) stretching vibrations in all compounds are assigned to a large number of bands lying in the 1299-1000 cm⁻¹ region. The CH

bending vibrations of the three complexes and free ligand were assigned to the group of bands of varying intensities in the range 976-704 cm^{-1} . The assignments of these bands agree quite well with the literature [30].

The coordination of the metal ions via oxygen of L is also confirmed by the $\nu(\text{M-O})$ bands at 571 and 510 cm^{-1} for Cr(III), 546 and 525 cm^{-1} for Fe(III) and at 557 and 485 for Cu(III). Therefore, from the infrared spectra, it was concluded that the 2-methyl-quinazolinone behaved as a neutral monodentate ligand with oxygen donor site involved in the coordination sphere.

Table 2. Infrared frequencies (cm^{-1}) and tentative assignments, (A) 2-methyl-quinazolinone; (B) $[\text{CrCl}_3(\text{L})_3] \cdot 6\text{H}_2\text{O}$; (C) $[\text{FeCl}_3(\text{L})_3] \cdot 6\text{H}_2\text{O}$ and (D) $[\text{Cu}(\text{CH}_3\text{COO})_2(\text{L})_3] \cdot 2\text{H}_2\text{O}$.

A	B	C	D	Assignments
3424br	3468wbr	3475w	3395mbr	$\nu(\text{OH}); \text{H}_2\text{O}$
3307w 3210w	3362mbr	3308 br	3281 w 3218wbr	$\nu(\text{N-H})$
3093vw 3063vw	3182wbr 3093vw	3172vw 3078vw 3000w	3125wbr	$\nu(\text{C-H}); \text{C-H aromatic}$
2981 w, 2934w	2969vw 2922vw	2875w 2608br		$\nu(\text{C-H}); -\text{CH}_3$
1670s 1637s	1621s	1664ms 1615m	1689s 1659w	$\nu_{\text{as}}(\text{COO}); \text{acetate group}$ $\nu(\text{C=O})$
1601vs 1560m 1516w 1468ms 1428ms	1582s 1550m 1454s 1401vs	1589ms 1519s 1452s	1594s 1522s 1442s	$\nu(\text{C=N}),$ $\nu(\text{C=C})$ and phenyl breathing modes
1381 ms 1337m	1346w 1301m	1395vs	1383vs	$\delta(\text{C-H}), -\text{CH}_3$
1246m 1182m 1108m 1074ms 1011m	1257s 1172sh 1161s 1031m	1295s 1252s 1161s 1062vw 1047vw 1041ms 1000w	1299vs 1254s 1187vw 1153ms 1112w 1087w 1041ms 1014w	$\nu(\text{C-O}),$ $\nu(\text{C-N})$ and $\nu(\text{C-C})$
976w 924w 878m 828w 797w 773m 729w	961w 904vw 855m 804m 756vs 707m	966s 880w 854w 828w 810vw 790vw 757vs 704m	966s 879m 851m 817ms 756vs	$-\text{CH bend}; \text{phenyl} + \delta(\text{COO}')$
693m 604vw 577vw 520vw 473w 420w	663vs 571s 510s 435ms	651m 623m 546m 525w 484s 426m	699s 665m 600w 557w 529m 485m	$\nu(\text{M-O}) + \text{ring deformation}$

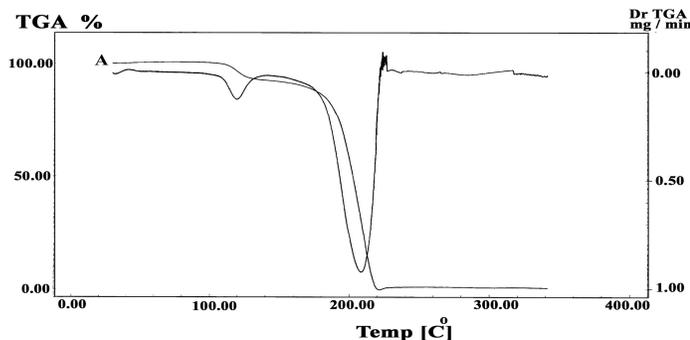
Key: s = strong, m = medium, br = broad, w = weak, v = stretching.

¹H NMR spectrum

The new ligand 2-methyl-quinazolinone was characterized using ¹H NMR spectrum. The ¹H NMR spectrum of 2-methyl-quinazolinone L, was carried out in DMSO-d₆ as a solvent. The ¹H NMR spectrum exhibit peaks in the range 7.4-7.9 ppm, which were assigned to -CH of benzene ring and the NH amide found at 8.00 ppm. Also, the methyl group observed at 0.9 ppm.

Thermal analyses

Thermogravimetric (TGA) and differential thermogravimetric (DTG) were carried out for the ligand 2-methyl-quinazolinone and the three solid complexes [CrCl₃(L)₃].6H₂O, [FeCl₃(L)₃].6H₂O and [Cu(CH₃COO)₂(L)₃].2H₂O under N₂ flow and heating rates were suitably controlled at 10 °C min⁻¹ and the weight loss was measured from the ambient temperature up to ~1200 °C. The TGA and DTG curves of the complexes were shown in Figure 1. Table 3 gives the maximum temperature values T_{max}/°C, species lost together with the corresponding weight loss for each step of the decomposition reaction. The data obtained strongly supported the proposed formulas of the ligand and the three complexes and indicate that the decomposition mode of the ligand occurred in one step at two maxima 119 and 209 °C. This step was associated with a weight loss value of 100% in a good agreement with the obtained value 99.33%. Thermogravimetric (TGA) curve for [CrCl₃(L)₃].6H₂O showed two weight loss events. The first step of decomposition occurred in the range 40-120 °C, with a maximum temperature at 72 °C corresponds to the loss of three water molecules of hydration. The second step of decomposition occurred in the range 120-1200 °C, with two maxima at 230 and 376 °C. The thermal decomposition of [Fe(L)₃Cl₃].6H₂O complex proceeds two degradation steps. The first step of decomposition occurred in the range 30-200 °C, with a maximum temperature at 169 °C corresponds to the loss of five water molecules. The second step of decomposition occurred in the range 200-1200 °C, with four maxima at 268, 321, 747 and 932 °C and was simultaneously decomposed to oxide with intermediate formation of very unstable products which were not identified [31] and is accompanied by a weight loss of 59.24%, corresponding to the loss 2CO+7C₂H₂+2N₂+0.5H₂O+H₂+HCl+2NH₄Cl. The actual weight loss from these two steps was 71.19%, close to the calculated value 71.75%. The TGA curve of [Cu(CH₃COO)₂(L)₃].2H₂O complex (Figure 2) and the data were listed in Table 3 exhibits two main degradation steps. The first step of decomposition occurred at maximum temperature of 71 °C and was accompanied by a weight loss of 13.35%, corresponding to the loss of 2H₂O+2CO+1.5H₂. The second step of decomposition occurred at one maximum 256 °C and is accompanied by a weight loss of 65.82%, corresponding to the loss of 12C₂H₂+4NO+NH₃+0.5N₂ giving CuO as a final product. Water of crystallization lost for the three complexes at a relatively low temperature may be indicated to a weak H-bonding involving the H₂O molecule and the complexes.



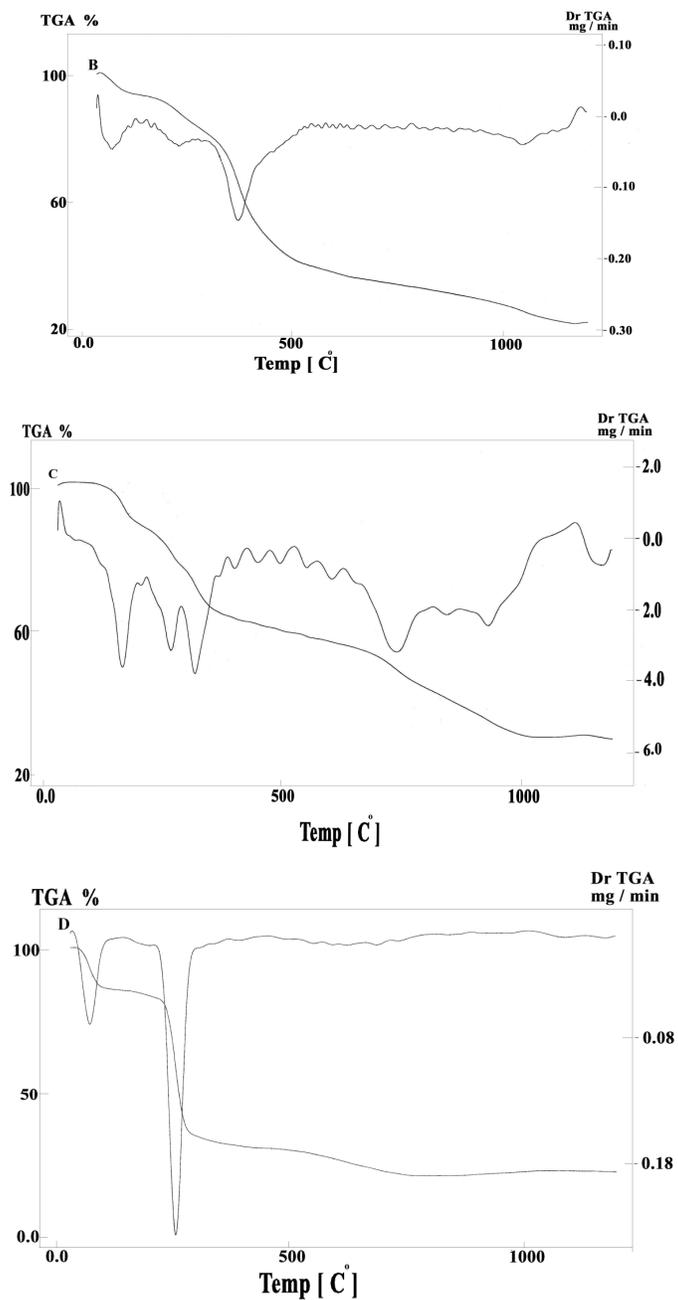
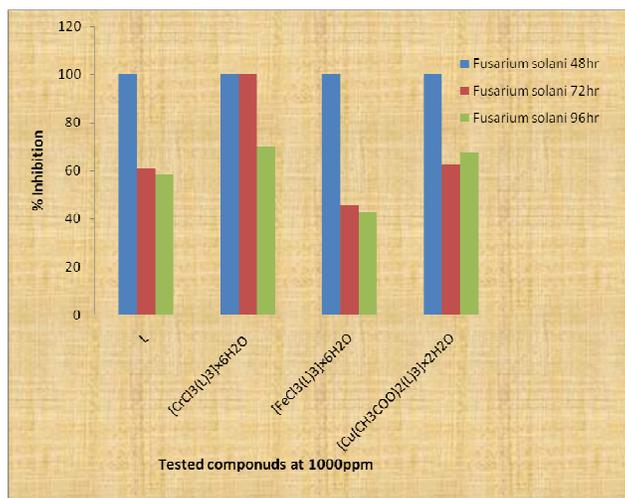
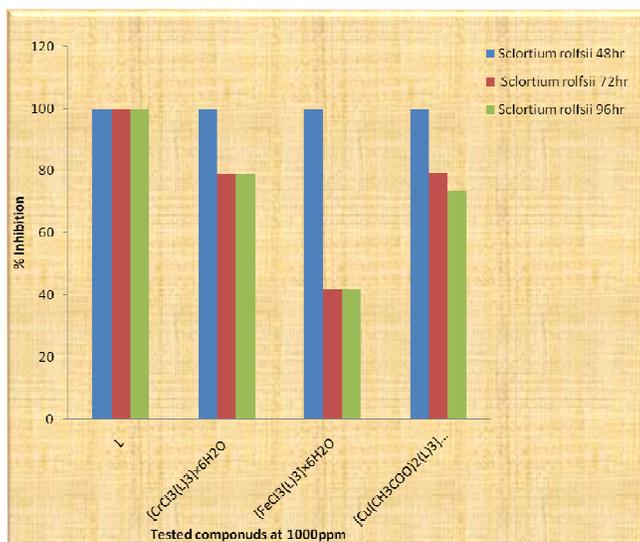


Figure 1. TGA and DTG diagram of (A) 2-methyl-quinazolinone (L), (B) $[\text{CrCl}_3(\text{L})_3] \cdot 6\text{H}_2\text{O}$, (C) $[\text{FeCl}_3(\text{L})_3] \cdot 6\text{H}_2\text{O}$ and (D) $[\text{Cu}(\text{CH}_3\text{COO})_2(\text{L})_3] \cdot 2\text{H}_2\text{O}$.

The decomposition mechanisms were only based on speculation hypothesis and the thermal analysis weren't connected with a complementary technique (gas chromatography) [31]. The suggested residues confirmed only on the basis weight loss percent calculation and the infrared spectra, which clearly shows the bands associated to the metal oxides and disappearance of the bands characteristic for the 2-methyl-quinazolinone and acetate ions Figure 2.



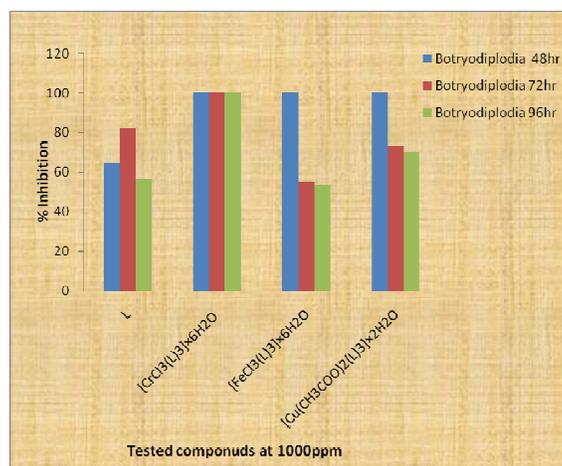
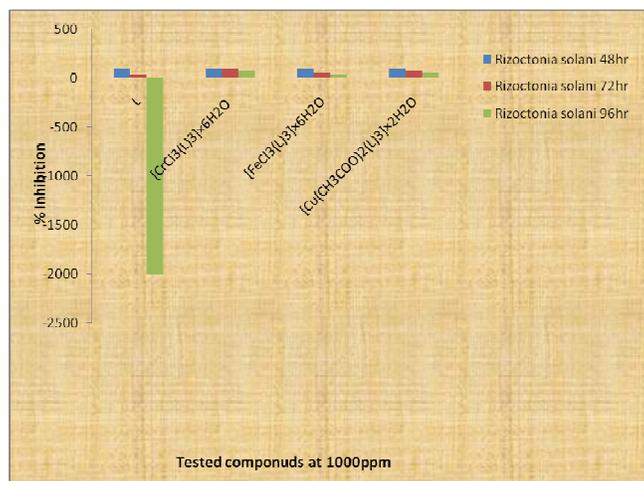
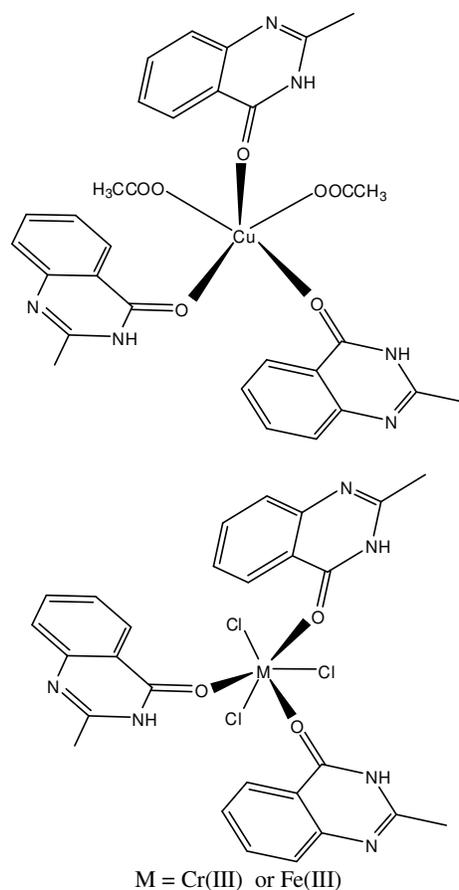


Figure 3. Statistical representation for antifungal activity of 2-methyl-quinazolinone and its complexes

The proposed structure formula (II) on the basis of the results discussed in this paper may be as follows:



Formula II. The coordination mode of Cu(II), Cr(III) and Fe(III) with 2-methyl-quinazolinone.

Biological activities

The fungicidal activity of 2-methyl-quinazolinone and the three prepared heterocyclic complexes were evaluated under laboratory conditions. The tested fungi were *Fusarium solani*, *Rhizoctonia solani*, *sclerotium rolfsii* and *Botryodiplodia* sp. Data presented in Table 4 reveals the antifungal potency of these compounds. The highest antifungal activity for the tested compounds was observed after 48 h of treatment, with obvious decreasing on their activities with prolongation of incubation time at 72 h or 96 h. However, the Cr(III) complex against the three fungi *Fusarium solani*, *Rhizoctonia solani* and *Botryodiplodia* gave the highest inhibition at 48 and 72 h and then the rate of inhibition was decreased to 96 h except for *Botryodiplodia*. Also, the 2-methyl-quinazolinone (L), completely inhibited the growth of *Sclerotium rolfsii* at the three tested incubation times.

Table 4. Evaluation of fungicidal activity of 2-methyl -quinazolinone (L) and its complexes against different soil fungi under laboratory conditions.

Test fungi	Tested compounds at 1000 µg/mL	% Inhibition		
		48	72	96
<i>Sclerotium</i>	L	100.0	100.0	100.0
	[CrCl ₃ (L) ₃].6H ₂ O	100.0	79.10	78.90
	[FeCl ₃ (L) ₃].6H ₂ O	100.0	42.00	42.00
	[Cu(CH ₃ COO) ₂ (L) ₃].2H ₂ O	100.0	79.50	73.70
<i>Fusarium</i>	L	100.0	60.80	58.40
	[CrCl ₃ (L) ₃].6H ₂ O	100.0	100.0	69.90
	[FeCl ₃ (L) ₃].6H ₂ O	100.0	45.50	42.40
	[Cu(CH ₃ COO) ₂ (L) ₃].2H ₂ O	100.0	62.50	67.50
<i>Rhizoctonia</i>	L	100.0	47.50	-2000
	[CrCl ₃ (L) ₃].6H ₂ O	100.0	100.0	76.10
	[FeCl ₃ (L) ₃].6H ₂ O	100.0	49.70	41.11
	[Cu(CH ₃ COO) ₂ (L) ₃].2H ₂ O	100.0	72.20	56.00
<i>Botryodiplodia</i>	L	64.50	82.20	56.70
	[CrCl ₃ (L) ₃].6H ₂ O	100.0	100.0	100.0
	[FeCl ₃ (L) ₃].6H ₂ O	100.0	55.00	53.30
	[Cu(CH ₃ COO) ₂ (L) ₃].2H ₂ O	100.0	73.20	70.00

Friebe *et al.* [3] found that, benzoxazinones and benzoxalinones have a strong inhibition to various phytopathogenic fungi including *Helminthosporium turcicum*, *Stagonospora nodorum*, *Microdochium nivale* and *Fusarium* sp. Some isolates of *Fusarium* sp. are able to transform benzoxazinone compounds to less inhibitory derivative. Also Niemeyer [32] indicates that the benzoxazinone and aglycones that found as natural compound in plants and their degradation products exhibit fungistatic and bacterostatic activity. Depending on the percent of inhibition at 96 h quinazolinone as a most active compound against *sclerotium* sp, where as Cl methylbenzoxazinone only was the most active compound against *Fusarium solani*, *Rhizoctonia* sp and *Botryodiplodia* sp. So, 2-methyl-quinazolinone is considered as quindidint compound and was used as ligand to prepare complexes. On contrary, *Fusarium* sp. was more sensitive to complexes [CrCl₃(L)₃].6H₂O and [Cu(CH₃COO)₂(L)₃].2H₂O than ligand itself (2-methyl-quinazolinone). On the other hand, all complexes [CrCl₃(L)₃].6H₂O, [FeCl₃(L)₃].6H₂O and [Cu(CH₃COO)₂(L)₃].2H₂O showed fungal activity more than quinazolinone in case of *Rhizoctonia* sp. Also the same indication was found with complexes [CrCl₃(L)₃].6H₂O and [Cu(CH₃COO)₂(L)₃].2H₂O against *Botryodiplodia* sp. From the above results, it could be concluded that the conjugation of metallic compounds with heterocyclic compounds in complexes changed the bioactivity of heterocyclic compounds against fungi in two forms: (i) no change in bioactivity and (ii) decrease the bioactivity less than ligand, or increase the bioactivity more than ligand these changes depending on sensitivity of tested fungi and type of metallic compounds that used in complex reaction

The physico-chemical properties of the tested active ingredient (complexes)

All complexes were insoluble in water and xylene where as [FeCl₃(L)₃].6H₂O complex showed a low solubility in acetone their solubility percentages was 14%. On the other hand the free acidity of all tested complexes were found in two forms (Table 5). (a) Moderate free acidity (4.60) found for [FeCl₃(L)₃].6H₂O complex. (b) The two complexes [CrCl₃(L)₃].6H₂O and [Cu(CH₃COO)₂(L)₃].2H₂O their free acidity are 7.25. From above results it could be concluded

that dustable powder formulation is the suitable formulation to these active ingredient because their physico properties are not soluble in water and xylene also it will be use in controlling the soil borne fungi.

Table 5. Physico-chemical properties of diluents.

Complex	Solubility			Acidity or alkalinity	
	Water	Acetone	Xylene	Acidity	Alkalinity
[CrCl ₃ (L) ₃]·6H ₂ O	Not soluble	Not soluble	Not soluble	7.25	-
[FeCl ₃ (L) ₃]·6H ₂ O	Not soluble	14%	Not soluble	4.60	-
[Cu(CH ₃ COO) ₂ (L) ₃]·2H ₂ O	Not soluble	Not soluble	Not soluble	7.25	-

L = 2-methyl-quinazolinone.

Calcium carbonate possessed an ionization constant pK_a higher than 3.3 (Table 6). Accordingly this carrier has slight acidic surface sites that are safe to mixed with our complexes. However talck has pK_a level >1.5 and <3.3. This means that talck has acidic sites less than calcium carbonate. On the other hand both tested carriers were slightly alkaline and varied in their pH values. Talck showed the highest pH value 8.33, while calcium carbonate possessed lower value 7.98

The tested inert varied considerably according to their bulk density. Calcium carbonate showed the highest bulk densities (loss and packed) (0.8, 1.14). According to the specifications of WHO (1979), the bulk density of powder after compacting (packed bulk density) should not exceed the value obtained before compacting by more than 60%, both tested inert confirmed these specification. On the other hand, calcium carbonate and talck have particle size range less than 40 microns.

Table 6. Physico-chemical properties of diluents.

Diluent	pK _a	pH at 25 °C	Alkalinity % as NaOH	Bulk density		Screening analysis less than microns			
				Before comp.	After comp.	53	40	30	96
Calcium-carbonate	>3.3	7.98	0.013	0.80	1.14	100	100	99	96
Talck powder	>1.5 < 3.3	8.33	0.0057	0.36	0.41	100	100	100	100

CONCLUSION

The new reaction of some transition metals Cr(III), Fe(III) and Cu(II) with 2-methyl-quinazolinone (L) has been studied. The results of the elemental analysis, molar conductivity, magnetic moment, infrared spectra and thermogravimetric analysis deduced the formation of 1:3 metal/ligand complexes in all cases. Antifungal studies were carried out against several species. The results showed significant increase in antifungal activity of some metal complexes as compared with uncomplexed ligand.

REFERENCES

1. Baket, E.A.; Smith, I M. *Ann. App. Biol.* **1977**, 87, 73.
2. Counture, R.M; Routley, D.G.; Dunn, G.M. *Physiol. Mol. Plant Pathol.* **1971**, 1, 515.
3. Friebe, A.; Vilich, V.; Hennig, L.; Kluge, M.; Sticker, D. *Appl. Environ. Microbiol.* **1998**, 64, 2386.
4. Richardson, M.D.; Bacon, C.W. *Mycologia* **1995**, 87, 510.

5. Yue, Q.; Bacon, C.W.W.; Richardson, M.D. *Phytochemistry* **1998**, 48, 451.
6. Walfe, J.F.; Rathman, T.L.; Sleevi, M.C.; Campbell, J.A.; Greenwood, T.D. *J. Med. Chem.* **1990**, 33, 161.
7. Padia, J.K.; Field, M.; Hinton, J.; Meecham, K.; Pablo, J.; Pinnock, R.; Roth, B.D.; Singh, L.; Suman-Chauhan, N.; Trivedi, B.K.; Webdale, L. *J. Med. Chem.* **1998**, 41, 1042.
8. Xia, Y.; Yang, Z.Y.; Hour, M.J.; Kuo, S.C.; Xia, P.; Bastow, K.F.; Nakanishi, Y.; Nampoothiri, P.; Hackl, T.; Hamel, E.; Lee, K.H. *Bioorg. Med. Chem. Lett.* **2001**, 11, 1193.
9. Kenichi, O.; Yoshihisa, Y.; Toyonari, O.; Toru, I.; Yoshio, I. *J. Med. Chem.* **1985**, 28, 568.
10. Buchanan, J.G.; Sable, H.Z. in *Selective Organic Transformations*; Thyagarajan B. (Ed.), 2nd ed., Wiley-Interscience: New York; **1972**; p 95.
11. Segarra, V.; Crespo, M.I.; Pujol, F.; Belata, J.; Domenech, T.; Miralpeix, M.; Palacios, J.M.; Castro, A.; Martinez, A. *Bioorg. Med. Chem. Lett.* **1998**, 8, 505.
12. Akazom, M.; Yamamoto, J.; Kondo, T.; Watanabe, Y. *J. Organomet. Chem.* **1995**, 494, 229.
13. Gupta, B.M.; Agrawal, U.; Khan, S. K. *Indian J. Exp. Biol.* **1963**, 7, 61.
14. Bouillant, M. L.; Farre-Bonvin, J.; Ricci, P. *Tetrahedron Lett.* **1983**, 24, 51.
15. Mayama, S.; Tani, T.; Mastura, Y. *J. Am. Oil Chem. Soc.* **1981**, 5, 697.
16. Bulluci, C.; Gualtieri, F.; Chiarini, A. *Eur. J. Med Chem.* **1987**, 22, 473.
17. Aly, M.M.; Mohamed, Y.A.; El-Bayouki, K.A.M.; Basyouni, W.M.; Abbas, S.Y. *Europ. J. of Med. Chem.* **2010**, 45, 3365.
18. Rashad, A.E.; Shamroukh, A.H.; El-Hashash, M.A.; El-Faragy, A.F.; Yousif, N.M.; Salama M.A.; Mostafa, A.; El-Shahat, M. *J. Heterocyclic Chem.* **2012**, 49, 1130.
19. Argarego, W.L.F.; Purrin, D.D. *Purification of Laboratory Chemicals*, 4th ed., Butterworth: Oxford; **1997**.
20. El-Faragy, A.F.; Hamad, M.M.; Said, S.A.; Sayed, Ahmed, A.F.; El-Gendy, G.M.; *Pak. J. Sci.* **1992**, 35, 19; Kim-Dong, H. *J. Heterocycl. Chem.* **1975**, 6, 1165.
21. Albertin, G.; Bordignon, E.; Orio, A.A. *Inorg. Chem.* **1975**, 14, 1411.
22. Fallik, E.; Klein, J.; Grinberg, S.; Lomaniee, C.E.; Lurie, S.; *Lalazar, A* **1993**, 77, 985.
23. Dutta, R.L.; Syamal, A. *Elements of Magnato Chemistry*, S. Chand and Company Ltd.: New Delhi; **1982**.
24. David, N. *Complexes and First-Row Transition Elements*, Macmillan Press: London; **1974**; p 104.
25. Castillo-Blum, S.E.; Barba-Behrens, N. *Coord. Chem. Rev.* **2000**, 3, 196.
26. Nakamoto, K. *Infrared and Raman Spectra of Inorganic and Coordination Compounds*, 4th ed., Wiley: New York; **1986**; p 230.
27. Sadeek, S.A.; El-Faragy, A.F.; El-Kady, A.M.A.; Genidy, G.; Abd El-Lattif, N.S. *Latvian J. Chem.* **2012**, 2, 66.
28. Almadfa, H.; Said, A.A.; Nour, E.M. *Bull. Soc. Chem. Fr.* **1991**, 128, 137.
29. Karlin, K.D.; Zubieta, J. (Eds.) *Copper Coordination Chemistry: Biochemical and Inorganic Perspectives*, Adenine Press; New York; **1983**; p 43.
30. Cotton, F.A.; Wilkinson, G.; Murillo, C.A.; Bochmann, M. *Advanced Inorganic Chemistry*, 6th ed., Wiley: New York; **1999**; p 857.
31. Nour, E.M.; AlKority, A.M.; Sadeek, S.A.; Teleb, S.M. *Synth. React. Inorg. Met. Org. Chem.* **1993**, 23, 39.
32. Niemeyer, H M. *Phytochemistry* **1988**, 27, 334.