Sudan University of Science and Technology

College of Graduate Studies

Preparation and Thermodynamic Characterization of Some Hydroxamic Acids and Their Complexes

تحضير وتوصيف خواص الديناميكا الحرارية لبعض أحماض الهيدروكسيميك و معقداتها

A Thesis Submitted in Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Chemistry

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الاستهلال

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

اقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ (1) خَلَقَ الْإِنْسَانَ مِنْ عَلَقٍ (2) اقْرَأْ وَرَبُّكَ

الْأَكْرَمُ (3) الَّذِي عَلَّمَ بِالْقَلَمِ (4) عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ (5)

صدق الله العظيم

سورة العلق الايات (1-5)

Dedication

I dedicate this work to my

Parents,Husband,Children

Brothers and Sisters.

Acknowledgements

Praise to Allah Almighty who gave me health, patience and ability to complete this research.

My deepest gratitude is due to my supervisors, Prof. Elmugdad Ahmed Ali and Dr. Mohammed Suliman, Department of chemistry, College of Science, Sudan University of Science and Technology for their useful guidance, patience, encouragement and helpful suggestions throughout this work.

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Abstract

Benzohydroxamic acid(BHA) and Salicylohydroxamic acid (SHA)were prepared by reacting Benzoic and salicylic acids esters withfree hydroxylamine and recrystallizing them using hot water/acetic acid.characterized by their standard color test with vanadium (V)and iron (III) solution, themelting point resultswere128$\mathbf{C}^0$, and 169$\mathbf{C}^0$for BHA and SHA respectively. The IR. spectra show characteristic stretching frequencies of acid functional groups, OH (BHA 3065,SHA 3288.), C=O (BHA 1687.38SHA 1614.64),C-N (BHA 1289, SHA 1353) N-O (BHA 903, SHA 907) cm^{-1} . H^1 NMR spectra shows an(Ar-H's) band at(7.4-7.7) δ (ppm) for BHA and 6.83 –7.832 δ (ppm) for SHA. An NH absorption at 3.1 , 3.3 for BHA and 3.1-3.9 for SHA and an OH absorption at 6.1for BHA and 6.9 for SHA and a Mass spectra of 137for BHA and 153forSHA. Complexes with Zn (II) gavea white complex for both acids. Cu(II) gave a blue complex for BHA and a dark green complex for SHA, Fe(III) gave a reddish brown complex for both acids. Co(II) complexes were pink for both acids. Mn(II) ions gave a white complex with BHA and pale browm complex with SHA. Ni(II) complexes were green for both acids.

The complexes were recrystallized with ethanol and characterized by I.R. spectra, SHA showed bands at 1597- 1601 $cm^{-1}$for(C=O) and 915-925 $cm^{-1}$for(N-O), BHA showed bands at1598- 1608 $cm^{-1}$for(C=O) and 918-1035 $cm^{-1}$for(N-O). Magnetic susceptibility proposes an Octahedral,tetrahedral and square pyramidal geometry for$[Fe(SHA_2).Cl_2]$ $2H_2O$, $[Co(SHA)_2]$ H_2O and a Square pyramidal geometry for $[Mn(SHA)Cl.H_2O]H_2O$ respectively.TGA results displayed three distinct degradation stages at 100 C^0 , 240 $C^0$and 900 C^0 TGA thermogram of all complexes show three characteristics mass loss and residue massas metal oxide. The spectral study reveals that all complexes coordinated to the metal via oxygen atoms (O,O).Stoichiometric measurements

of complexes were carried at 15 -25C. The stoichiometric ratio of both acids complexes show that the mole ratio(M:L) was 1:2 for Fe and Co 1:1 for Cu, Zn, Mn and 1:3 for V- hydroxamates. Solution stability constants (K) show an inverse relationship with temperature for both acids complexes and they were in the order Cu$< Zn < Mn < C0 < Fe < V$.Metal complexes (K)values for benzohydroxamate were Zn $(1.7\times 10^{2}), \mathrm{Cu}\ (59.1), \mathrm{Fe}(3{,}7 \times 10^{3}), \mathrm{Co}\ (2.7 \times 10^{3}), \mathrm{Mn}\ (94), \mathrm{V}\ (2.6 \times 10^{4})$ and for salicylohydroxamates Zn$(1.7\times 10^{2}), \mathrm{Cu}\ (1.5 \times 10^{2}), \mathrm{Fe}\ (5{,}9 \times 10^{3}), \mathrm{Co}\ (5.2 \times 10^{3}), \mathrm{Mn}\ (1.3 \times 10^{3}), \mathrm{V}\ (2.8 \times 10^{4})$K values, at 15 and 25°**C**, were used to derive the thermodynamic parameters($\Delta G^{o,}$ ΔH^{o}, ΔS) , ΔG^{o} values is negative which indicates that the reactions are spontaneous ,While the positive values of (ΔH^{o}, ΔS) indicate that the reaction is spontaneous and endothermic.

المستخلص

تم تحضيرالبنزوهيدروكسيمك والسالسيلو هيدروكسيمك عن طريق تفاعل استرات حمض البنزويك والسالسليك مع الهيدروكسيل أمين الحر. تمت إعادة بلورة الاحماض المحضرة بواسطة الماء الساخن / حمض الأسيتيك. تم تشخيص الأحماض الهيدروكسيمية المحضرة باختبار اللالوان المميزة مع الفاناديوم (V) والحديد (III) ، وايضا بتحديد نقاط الانصهارفكانت نقاط الانصهار 128، و169 درجة مئوية لحمض البنزوهيدروكسيمك والسالسيلوهيدروكسيمك على التوالى. تم عرض اطياف أكثر النطاقات المميزة المرتبطة بالمجموعة الوظيفية لأحماض الهيدروكساميك والتي ترجع إلى(3288 - 3065) OH ، (1687-614.64) C = O (1348 C-N–1353)(907 -903) NO لحمض السالسيلو والبنزو هيدروكسيمك على التوالى سم$^{-1}$. تظهر أطياف الرنين النووى المغناطيسى للأحماض الهيدروكساميكية المحضرة (جزء في المليون) ،(7.777-7.411 ، 7.832 –6.83) بسبب (Ar-H's) ، (3.1- 3.3 ، 3.1-3.9) ببسب إلى (6.1 NH، 6.9) بسبب – OH لحمض البنزوهيدروكسيمك و السالسيلوهيدروكسيميك على التوالى. أطياف الكتلة137لحمض البنزوهيدروكسيمك و153لحمض لسالسيلوهيدروكسيميك. تم تعقيد أحماض الهيدروكساميك المحضرة مع الخارصين II للحصول على معقدات بيضاء مع الحمضين ، مع النحاس II للحصول على معقد حمض البنزوهيدروكسيميك ازرق وحمض السالسيلو هيدروكسيميك أخضر غامق) ، مع الحديدIII للحصول على معقد بني محمرللحمضيين ومع الكوبالت IIللحصول على معقد ملون لحمض البنزوهيدروكسيميك زهرى للحمضين ، مع المنجنيز للحصول على معقدات بيضاء اللون للحمضين ، مع النيكل للحصول على معقدات خضراء شاحبة للحمضيين تم إعادة بلورتهما بالإيثانول ثم تم تمييزهما بالأشعة تحت الحمراء الأطياف ، لمعقدات السالسيلو هيدروكسيمك أظهر الحزم عند 1597-1601 سم$^{-1}$ (C = O) و 915-925 سم$^{-1}$ (NO) ، أظهرت االحزم عند 1598-1608 سم$^{-1}$ (C = O) و 918-1035)NO سم$^{-1}$ لمعقدات البنزوهيدروكسيميك والتحليل الدقيق للعناصر ، القابلية المغناطيسية واشارت لمعقد الحديد والكوبالت والمنجنيزلحمض السالسيلو هيدروكسيمك بثمانى السطوح ورباعى السطوح ومربع هرمى على التوالى ، أظهرت نتائج التحليل الحراري الوزني ثلاث مراحل تحلل مميزة عند 100 درجة مئوية و 240 درجة مئوية و 900 درجة مئوية أظهر مخطط التحليل الوزنى الحراري لجميع المعقدات ثلاث مراحل لفقدان الكتلة و وكانت الكتلة المتبقية كأكسيد فلز. اثبت الدراسة الطيفية أن جميع المعقدات متناسقة مع المعدن عبر ذرات الأكسجين (O، O). تم متابعةالحسابات الكمية اللمعقدات عند درجات حرارة 25 - 15 درجة مئويةوعند درجات حموضة مختلفة عند الطول الموجى الاعظم في محلول للحمض البنزوهيدروكسيميك وحمض السالسيلو هيدروكسيميك مع المعادن

الزنك،النحاس،الحديد،الكوبالت،المنجنيزوالفانيديوم (باستخدام طريقة المتغيرات المستمره (طريقة جوب) وتم تحديد النسبة المولية للمعقدات ، ووجد أنها بنسبة 1: 2 للحديد والكوبالت ، و 1 : 1 لـنحاس والزنك ، المنجنيز و 1: 3 للفانيديوم. تم حساب قيم ثوابت الاستقرار عند درجات حرارة مختلفة في المحلول ووجدت في كلا الاثنين من احماض الهيدروكساميك ، ثوابت الاستقرار تزداد مع انخفاض درجة الحرارة ، يتم ترتيب قيمها على النحو التالي. الفانيديوم> الحديد> الكوبالت> المنجنيز> الزنك >النحاس للمعقدات المعدنية ثم تم حساب ثوابت الاستقرار لمعقدات حمض البنزوهيدروكسيمك وكانت القيم المتحصل عليها كالاتى:الزنك10^2 ×1.7،النحاس59.1،الحديد10^3 × 3,7،الكوبالت× 2,7 10^3المنجنيز94 ،الفانيديوم10^4 × 2.6 وكانت قيم ثوابت الاستقرار لمعقدات حمض السالسيلوهيدروكسيك

كالاتى:الزنك10^2 ×1.7،النحاس.51$10^2$ ×،الحديد10^3 × 5,9،الكوبالت10^3 × 5,2المنجنيز× 1.3 10^3،الفانيديوم10^4 × 2.8. تم استخدام قيمة ثابت الاستقرارعند 25-15 درجة مئوية في اشتقاق الدوال الديناميكية الحرارية (التغير فى الطاقة الحرة والانثالبى والانتروبى)،قيم التغير فى الطالقة الحرة سالبة وهذا يشير إلى أن التفاعلات تلقائية بينما تشير القيم الموجبة للانثالبى والانتروبى ان التفاعلات تلقائية وماصة للحرارة.

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Abbreviations

Abbreviation	Meaning of the abbreviation
BHA	Benzohydroxamic acid
SHA	Salicylohydroxamic acid
IR	Infrared spectroscopy
^{1}H NMR	Proton nuclear magnetic resonance
TGA	Thermal gravimetric analysis
CH N	Elemental anlysis of C, H, N

Chapter 1

1-Introduction and Literature Review

1.1Thermodynamic Study:

is concerned with energy changes and transformations of its various forms(Thermo, mechanical, electrical, magnetic, chemical, etc.) from one to another, and on The basis of the cosmic applications of these laws thermodynamic finds use not only in Chemistry but also in other fields such as engineering, physics, and biology.The goal of thermodynamics is to establish a function that is expressed in terms of the properties of the system.

The ability of the system to change its condition automatically and the will to make physical transformations or Chemical imposed, and also in the thermodynamics, the equilibrium constants of a reaction are the measure of the heat released in the reaction and entropy change during reaction .The greater amount of heat evolved in the reaction, the most stable are there action products Secondly, the greater the increase in entropy during the reaction , greater is the stability of product.(Rossottie,1960)

An stability constant is related to the standard Gibbs free energy change for the reaction

$\Delta G = -2.303\ RT \ln K$.

R is the gas constant and T is the absolute temperature. At 25 Cº, $\Delta G = (-5.708\ kJmol^{-1}) \cdot \log k$. Free energy is made up of an enthalpy term and an entropy term. $\Delta G = \Delta H - T\Delta S$

1.2 Enthalpy and Entropy of Complex Formation

The thermodynamic parameters ΔH and ΔS of complex formation can be obtained from the temperature dependence of the complexation constant (K). A wide variety of experimental methods have been employed in the

determination of these quantities for the complexation reaction of hydroxamic acid (Rekharsky etal, 1998).like van't Hoff plots of ln K against 1/T are usually utilized for the estimation of ΔH and ΔS.(Weying etal, 2005)

1.3 Estimation of thermodynamic parameters :

1.3.1Van't Hoff Equation

The van't Hoff equation relates the change in temperature (*T*) to the change in the equilibrium constant (*K*) given the standard enthalpy change (ΔH^o) for the process.

$$\mathrm{d}\frac{\ln k}{\mathrm{d}T} = \frac{\Delta H}{RT_2} \quad \ldots\ldots\ldots\ldots\ldots 1$$

This can also be written

$$\mathrm{d}\frac{\ln K}{\mathrm{d}\frac{1}{T_2}} = \frac{\Delta H}{R} \ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

If the enthalpy change of reaction is assumed to be constant with temperature, the definite integral of this differential equation between temperatures T_1 and T_2 given by

$$ln\left(\frac{k_2}{k_1}\right) = \frac{-\Delta H}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

In this equation $K_1$is the equilibrium constant at absolute temperatureT_1equilibrium constant at absolute temperature T_2. $\Delta H^\circ$is the standard enthalpy change and *R* is the gas constant. Therefore, a plot of the natural logarithm of the equilibrium constant versus the reciprocal

temperature gives a straight line. The slope of the line is equal to minus the standard enthalpy change divided by the gas constant,

$$\text{Slope} = -\frac{\Delta H^{\circ}}{R} \ldots\ldots\ldots\ldots\ldots 4$$

and the intercept is equal to the standard entropy change divided by the gas constant

$$\text{Slope} = \frac{\Delta S^{\circ}}{R} \ldots\ldots\ldots\ldots\ldots 5$$

Differentiation of this expression yields the van 't Hoff equation (Laidler and Meiser, 1999).

1.4 Enthalpy-Entropy Compensation (Extrathermodynamic Relationship)

If ΔH is plotted against ΔS for a set of different guest molecules, a linear relationship (compensation) is often observed (Lee, etal, 1973).Moreover, an "isoequilibrium" temperature can be determined from the slope of the resulting line. At the isoequilibrium temperature, it is surmised that the rate or equilibrium constant is entirely independent of the enthalpic change caused by any alternations in substituents, solvent, and so on(Grunwald etal, 1995). The compensatory enthalpy-entropy relationship has often been empirically observed in both activation and thermodynamic quantities determined for a very wide variety of reactions and equilibria (Rekharsky etal, 1998).

1.5 Stability constant:

The stability of complexes is indicated in solutions to one degree or by the amount of interference between molecules (metal - ligand).

Involved in equilibrium after overcoming all the forces in the solution that are trying to hinder interference between them. In quantitative terms, the greater the interference, the more stable the complex formed.

The amount of interference (metal-lindane) is expressed with a value known as the stability constant or the formation constant below certain circumstances, for example, if we had the following reaction:

M + 4 L = 4 ML

Where: M is metal ions , L is ligand

In solution. Rarely, there are ions (ML), the higher the stability value, the greater the presence ratio ML_4 Surrounded by solvent molecules that compete with the metal (M) molecules in bulk in solution and the metal So the latter alternately replaces the solvent particles. Ligand (L) (Quinuos,1982).

The stability constant equation for the total reaction can be written as:

$M + L \rightarrow ML$ $K = [ML] / [M] [L]$ ------- (1)

The values in the parentheses represent the molar concentrations involved in the reaction,and stability (K)

stability Constant of the reaction. while it is value Sometimes complexes are expressed in terms of the dissociation constant.

The value of the dissociation constant represents the inverted value of the formation constantwhen the formation of complexes in solution is studied, generaly there are two types of stabilities:

1.5.1Thermodynamic stability:

Thermodynamic stability is determind by the equilibrium constants of a reaction and is the measure of the heat released in the reaction and entropy change during a reaction. The greater amount of heat evolved in the reaction, the most stable are the reaction products. Secondly, greater the increase in entropy during the reaction, greater is the stability of products.

1.5.2 kinetic stability:

the kinetic stability of complexes refers to the speed with which transformation leading to the attainment of equilibrium occurs.

1.5.3Factors affecting the stability of complexes:

Many factors effecting of the stability of complexes .The basic factors are centreal metal and ligand.Nature ions;These metal ions mostly are the transition elements. For the determination of stability constant, some important characteristics of these metal.

a.Ionc charge:

The properties of stability depend on the size of the metal ion used in the complexes and the total charge there on. If the size of these metal ions is small and the total charge is high, then their complexes will be more stable. That is, their ratio will depend on the charge/radius. If the charge of the central metal ion is high and the size is small, the stability of the compound is high

b .Ionic size

If the sizes of these metal ions are increased, the stability of coordination compound defiantly decreased. Zn(II) metal ions are the central atoms in

their complexes, and due to their lower size (0.74A°) as compared to Cd(II) size (0.97A°), its metal ions are formed more stable.

c .Electronegativity

When an electron pair attracts a central ion toward itself, a strong stability complex is formed, and this is due to electron donation from ligand → metal ion. This donation process is increases the bond stability of metal complexes exerted the polarizing effect on certain metal ions, these atoms are O, N, F, Au, Hg, Ag, Pd, Pt, and Pb. Such type of ligands that contains P, S, At, Br and I atom form stable complex because the accepts electron from M → π-bonding.

d. Temperature and pressure:

Volatile ligands may be lost at higher temperature. This is exemplified by the loss of water by hydrates and ammonia.

e. Ligand nature

i)Size and charge

The size and charge are two factors that affect the production of metal complexes. The less charges and small sizes of ligands are more favorable for less stable bond formation with metal and ligand.

ii)Basic character

It is suggested by Calvin and Wilson that the metal complexes will be more stable if the basic character or strength of ligands is higher. It means that the donating power of ligands to central metal ions is high.It means that the donating power of ligands to central metal ions is high.

f. Chelat Effect:

Chelating agents or multidentate ligands , commonlly ,from more stable than monodentate ligands, this known as the Chelate effect ,and it is explained in term of the favorable entropy for the chelation process.

1.6 .Determination of stability constant of complexes:

1.6.1. Potentiometric titrations:

Potentiometric titrations are among the most accurate methods known, because the potential follows actual change in activity and therefore the end point coincide with the equivalent point (Louis, 1981) and (Gurdeep, 1986). The pH of the solution is directly affected by the complex formation, since all complexing agents are either base or acid. All metal complexes or chelates may be considered as being formed by displacement of one or more usually weakly acidic protons of the complexing or chelating agent by a metal ion in a solution, which result in pH drop (Cotton, 2006). When stability constants are determined from the pH data the experiment can be carried out in one of the following ways: the change of pH can be measured as function of the ligand concentration, or measured as a function of concentration of acid or alkali added to constant total metal and total ligand concentration, The magnitude of the observed pH changing may be employed to determine the stability constant of the metal complex by Calvin, Wilson or Bjerrum's method.

Although pH measurement has been widely used to determine stability constants there are number of limitation to the method:

(i) It cannot used under conditions of extreme pH, at high pH the concentration of the free ligand is insensitive to pH change.

(ii) The method is inapplicable at very low total concentrations.

1.6.2.Spectrometric titration:

i)Slope ratio:

In this method two series of solutions are perpared. In the time series different quantities of metal ions are added to a large excess of the reagent, whereas in the second series different quantities of reagent are added to a large excess of metal ion. The absorption of the solutions in each series is measured and plotted vs. the concentration of the variable component.The combined part ratio in the complex is equal to the two straight line slope ratio.

ii)Molar Ratio Method:

This methods was introduced by Yoe and Jones (1944), In case of successive complex formation more reliable information can be obtained by the Molar Ratio method. A series of solutions are prepared in which the total concentration of the metal is kept constant and concentration of the ligand is varied under similar conditions. A plot is prepared of absorbance as a function of the ratio of moles of ligand to moles of the metal. This is expected to give a straight line from the origin to the point where
equivalent amounts of the constituents are present. The curve will then become horizontal, if only one complex of high stability is formed. This is because all of one constituent is used up, and the addition of more of the other constituent can produce no more of the absorbing complex. If the constituent which is in excess itself absorbs at the same wavelength.

iii)Continuous variation :

This method was worked out by Denison in connection with his studies of compound formation in liquid mixture .

Later it was applied by Job(1928) to the spectrophotometeric determination of the formulae of the complexes formed in solutions by reaction of two components.

The formation of many complex ions can be represented by equation:

$A + nB \rightarrow ABn$

where A is a metallic ion, B may be either ion or molecule. To determine n solutionsof A and B of the same molar concentration are mixed in varying proportions and a suitable property of resulting solutions is measured. The monochromatic light is asuitable, property for this method. The absorption of light is proportional to the concentration of absorbing species which is one of the necessary conditions. The absorbance of each solution is measured and is then plotted against the mole fraction of the ligand (A/ A+B), at triangular shaped curve is obtained. The ratio of the metal:ligand is determined from the curve where the maximum absorbance is obtained (Warrenc. etal, 1941).

1.7.Coordination compounds :

are molecules that posess a metal center that is bound to ligands (atoms, ions, or molecules that donate electrons to the metal). These complexes can be neutral or charged. When the complex is charged, it is stabilized by neighboring counter-ions.

After the formation of complex . In the inner coordination sphere, which is also referred to as the first sphere, ligands are directly bound to the central metal. In the outercoordination sphere, sometimes referred to as the second sphere, other ions are attached to the complex ion (Kleinberg, 1960).

Metal-ligand bonds are typically thought of Lewis acid-base interactions. The metal atom acts as an electron pair acceptor (Lewis acid), while the

ligands act as electron pair donors (Lewis base). The nature of the bond between metal and ligand is stronger than intermolecular forces because they form directional bonds between the metal ion and the ligand, but are weaker than covalent bonds and ionic bonds.

1.7.1 Ligand types:

Monodentate ligands donate one pair of electrons to the central metal atoms. bidentate. ligands donate two pair of electrons to the central metal atoms. Polydentate ligands, also called chelates or chelating agents, donate more than one pair of electrons to the metal atom forming a stronger bond and a more stable complex.There are complexes that contain more than one central atom and are called di nuclear complexes and are linked together by a bridge bond either through an oxygen atom or a hydroxyl group the term "hydroxo-bridge" means that a hydroxo group, instead of being coordinated to only one metal ion through the oxygen atom, is coordinated to two metal ions through the oxygen atom. Examples of structures having one, two, or three hydroxo bridging groups between two metal ions, in which the hydroxo group links or bridges the two metal ions together in a single structural unit.

1.7.2.Linkage isomers:

This rise from ambidentate ligands which define as: ligands with two or more different donor cites only one of which is attached to single metal atom at a given time.(Hala,1995)

Examples:For NO_2: M-NO_2 nitro attached through N.

M-ONO nitrito attached through O .

1.8. Hydroxamic Acids:

The chemistry of hydroxamic acid began in1869 separated oxalohydroxamic acid from production of alkyl oxalate and hydroxylamine (Lossen , 1869), when W Lossen obtained a mixture of mono-, di-, and tribenzoyl derivatives from the reaction of hydroxylamine with benzoyl chloride, Considerable progress was achieved., Jones and Sneed(1917) prepared glycine hydroxamic acid from ethycinate and hydroxylamine. Phenylglycinehydroxamic acid is another a-amino- hydroxamic acid which was prepared later by Dunn and coworkers .

but studies on these compounds did not start until 1980's. Hydroxamic acids fulfill a variety of roles in biology and medicine. These compounds possess antibacterial and antifungal properties and are selective inhibitors of enzymes such as peroxidases (Tsukamoto etal,1999), ureases (Arnold etal, 1998), matrix metalloproteases which degrades the barriers holding cells in place and are involved in tumor growth (Botos et al, 1996), hydrolases (Brown etal., 2004), cyclooxygenases (Connonlley et al, 1999), lipooxygenases (Muri etal., 2002), and peptide deformilases (Chen etal, 2004). The mentioned biological properties make hydroxamic acids ideal drug candidates. Hydroxamic acids also represent a wide spectrum of bioactive compounds that have a hypotensive (Gupta, 2013)(Zamora et al., 1995), anticancer (Apfel etal, 2000), and anti tuberclosis (Miller etal, 1989)

In recent years the preparation, characterization of hydroxamic acid metal complexes had been extensively sutdied because these compounds possess antibacterial and antifungal properties. complexes

Randa, (2017) synthesized hydroxamic acid ligand from (methyl salicylate) with hydroxaylamine and chelating (Fe(III), and V(V)) from aqueous media, Their purity was tested by their linear relationship of concentration and

absorbance. Stoichiometry of iron and vanadium with the ligand is measured at different pH values. The results show 1:1, 1:2, 1:3 for iron and 1:2, 1:3 for vanadium. Nehal,(2020) prepared poly acrylamide (HPAAM) by coupling reaction of polyacrylamide (PAAm) and free hydroxylamine in alkaline solution (pH>12) at 70˚C. The synthesized HPAAM was characterized by CHN elemental analysis, Fourier-transform infrared spectroscopy (FTIR),proton nuclear magnetic resonance (1HNMR) and thermogravimetric analysis (TGA) in the last 30 years in understanding the chemistry of acyl derivatives of hydrxylamine, particularly with the evolution of spectral methods. containing compounds are ubiquitous and recyclable separations and extractions individual been achieved. They soul also received a considerable work as reagents for measurement and spectrophotometric reasoning of metals(Exner, and etal1963)

1.8.1Hydroxamic Acids of Natural Origin:

In I960 the first hydroxamic acids of natural origin, ferri- chrome and ferrioxamine B (Emery etal (I960). were identified and shown to contain three hydroxamic acid groups coordinated to a central ferric ion (Figs. 1.1 and 1.2). Since this time over three dozen ,naturally occurring hydroxamic acids or ferric hydroxamates have been found in fungi, actinomycetes, yeast, bacteria, and green plants.(Neilands, 1967). Some mono- and dihydroxamic acids have been found but most of the naturally occurring hydroxamic acids are trihydroxamic acids and all of the naturally occurring hydroxamic acids are of the N-substituted variety. The monohydroxamic acids may occur in the uncomplexed form, but the di- and tri- hydroxamic acids form extremely strong chelates with iron(III) and occur, at least partially, as the ferric derivatives. The term. siderochromes has been given. to this large class of ferric trihydroxamates. Examples of the many diverse structural types of naturally occurring hydroxamic acids are shown in Figures 1.1 and 1.2.

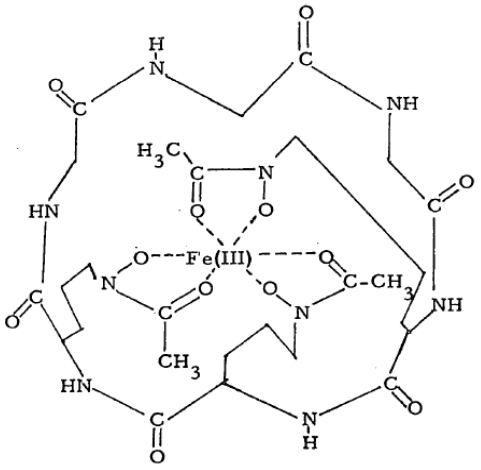


Figure1:1 Ferrochrome

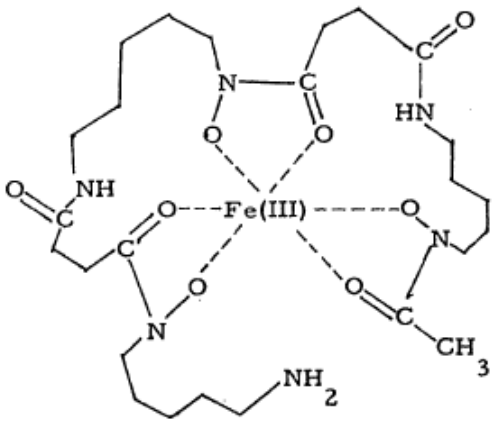


Figure1: **2 FerrioxamineB**

1.8.2Nomenclature:

Hydroxamicacid are derivatives from carboxylic acids, thus the nomenclature system is based on the naming of these carboxylic acids. In naming specific compound,the practice is drop the (-ic) of the related carboxylic acid and substitute the letter (O),followed by hydroxamic acids(Wolf,1972) example :Benzoic acid — Benzohydroxamic acid Salicylic acid — Salicylohydroxamic acid

1.8.3.Structure of hydroxamic acids:

Hydroxamic acids exist in two forms(Exner, and et al(1963)

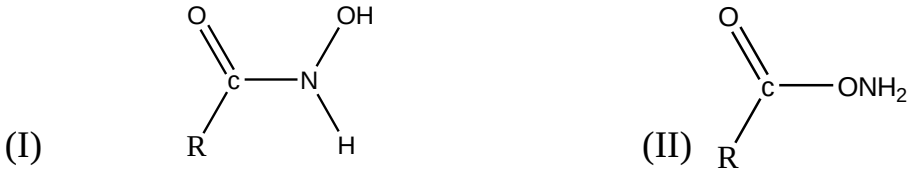


Figure 1.3(I) N-acyl derivative and (II) O-acyl derivatives

N-acyl are found in two tautomeric forms, keto-and enolforms (I) and (II) respectively.

Keto form(I) Enolform(II)

Figure 1.4:keto-and enol forms of hydroxamic acid

where (I) is hydroxyamide or hydroxamic acid and (II) is hydroxyimine or hydroximica cid. When an acyl group replaces one of the nitrogen bonded hydrogen in hydroxylamine molecule, a monohydroxamic acid, R-CO-NHOH, is formed and whenanother hydrogen of hydroxylamine is substituted by an aryl group, the N-arylhydroxamic acid formed. If there is restricted rotation about C -N bond, the Z and E isomers of theketo form exist, as do the enole form.

Figure 1.5 Z and E isomers of hydroxamic acid

The calculations show that the Z –ketoisomers become the more stable due to H-bonding.The crystals are stabilized by a network of intermolecular hydrogen bonds.Bond distance and bond angles as well as conformational parameters of hydroxamic acids have been analyzed, (Barbara. And Henryk. 1992)

1.8.4 Site of ionization on hydroxamic acids:

though the ionization behavior of hydroxamic acids has been studied by many groups,(Exner et al, 1965)(Steinberg, and Swidler, 1965), it is still not completely understood. The possibility for the existence of different isomeric forms of hydroxamic acids, as illustrated in Figure 1.6, provides several possibilities for the mode of proton dissociation from the ligand. However, so far the on evidence is in favor of the Z-keto isomer. (Brown, etal. 1988),(Exner etal. 1965)(Steinberg, and Swidler,. 1965) This isomer can behave as a N-acid or an O-acid, can dissociate to form an anionic species.Possible structures for ahydroxamic acid anion are reported in Scheme:

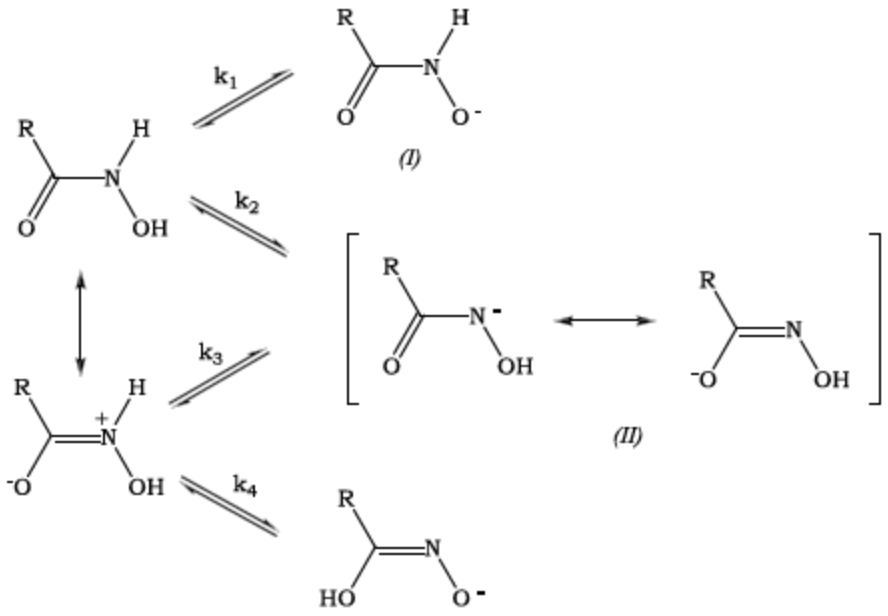


Figure 1.6 possible structures for ahydroxamic acid anion

Exner et al. concluded from UV and IR data, that in dioxane as well as in 50% methanol-water solutions, benzohydroxamic acid and its alkyl derivatives exclusively exist as N-acids in Figure 1.6. However, the investigations of(Stinberg et al.1965) show that in aqueous solutions they exist as O-acids, consisting of two species in equal concentration (structures in Figure 1.6). These findings are supported by the abinitio MO calculations performed by Dann enbergetal (Ventura, et al, 1993)that suggest that in aqueous solutions hydroxamic acids are more prone to behave as O-acids rather than N-acids. Further evidence for the O-acid behavior of hydroxamic acids in aqueous solution comes from studies of the temperature-dependent acid dissociation constant of these compounds and NMR investigations. (Bagno, and et al, 1994) .According to Exner, the existence of different monoionic forms of hydroxamic acids is a property of the ligand as well as the solvent.(Exner, and et al. 1993) Decreased acid strength of the ligand, and high-polarity solvents, favor O-acidity. On the other hand, increased acid strength of the ligand and low polarity solvents, favor N-acidity.

1.8.5Properties of Hydroxamic acids:

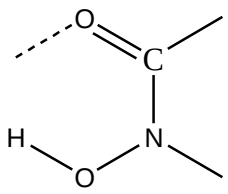
1.8.5.1 physical properties:

All the hydroxamic acids are white crystalline solids except the nitro and the iodo substituted acid which are yellow and pink respectively (Mohamed,1999) . the solid reagent are very stable to the action of heat light and air .

1.8.5.1.1Solublity of hyroxamic acid:

They are sparingly soluble In water , but long carbon chains of more than C12. these are insoluble in water and soluble in organic solvent like benzene,diethyl ether, ethylalcohol, carbon tetra chloride and chlorofrom hydroxamic acid are very weak acids, however, they are several times stronger than phenols

(Smith, 1966). The acidity of hydroxamic acid may be attributed essentially to the inductive effect of the (O-H) hydroxyl group and the suppression of the basic character of the central nitrogen due to its conjugation with acyl group. Suppression of acidic character maybe attributed to intramolecular hydrogen bonding as shown below:



1.8.5.1.2Detection of hydroxamic acids:

The reaction of hydroxamic acids evolve red violed colouration with ferric ion in acid media .Agrawal reported a method which based on two supposition, that all hydroxamic acids are soluble in chloroform and that the violet complex with all the hydroxamic acids formed with vanadium (V) can be extracted into chloroform, this method be unsuccessful to detect certain hydroxamic acids in which the complexes are insoluble in chloroform .

1.8.5.1.3 The Infra-red spectra of hydroxamic acids:

The most characteristic bands associated with the hydroxamic acids functional

groups to be due to (O–H), (C = O), and (N – O) stretching vibrations.

The frequencies are generally assigned in the regions 3200 cm^{-1}, 1600cm^{-1} and 910 cm^{-1} respectively. (Agrawal and Tandon (1971) .Noted that the site of the carbonyl and the hydroxyl infrared absorption bands vary differ from one hydroxamic acid to the next. An inter molecularly hydrogen-bonded carbonyl group absorbs infrared radiation at a higher frequency than the

corresponding intra molecularly hydrogen-bonded carbonyl. In addition, when hydrogen bonding is intermolecular, the O-H stretching band is usually sharp broad, where as a broad hydroxyl absorption is obtained when hydrogen bonding is intramolecular.Earlier results in hydroxamic acids showed that the O-H stretching of the free unconjugated hydroxyl group of-N-O-H in region 3195-3170cm^{-1} is very strong band, The O-H stretching vibration of the hydroxyl group in the hydrogen bonding with the carbonyl group is observed to be medium to high on the low frequency side of the central O-H band in the region of 2910-2850 cm^{-1} Likewise, the O-H deformation vibration is observed to be powerful and sharp in the region of 1100-1000 cm^{-1}.over and above all three bands disappearance upon coordination with a metal ion, this explain as evidence that the ligands co-ordinate through hydroxyl oxygen, and that on co-ordination of the acid the hydroxyl proton is replaced by the metal ion .In the case of salicyiohydroxamic acid SHA the spectra is some what complicated due to the presence of additional phenolic O-H group .This low frequency suggests both conjugation and hydrogen bonding in the SHA range 1700-1400cm^{-1}.

1.8.5.1.4 Ultra-violet spectra:

For arylhydroxamic acids and their N and O- substituted derivatives show intense absorption at the 220-260 nm wavelength associated with the aryl ring , hower, Hearn and Ward have drawn attention to the existence of an absorption band max.(205-210) which is comparable with that of amides ascribed to the $\pi \rightarrow \pi^*$ transition of the carbonyl.(Agrawal and Tandon., 1971)

1.9Physico- chemical properties of complexes:

1.9.1 Infrared spectroscopy:

is the Spectroscopy that is deals with the infrared region of electromagnetic spectrum,that is light with longer wavelength and lower frequency than

visible light.it covers range of techniques , mostly based on absorption Spectroscopy. all spectroscopy techniques, it can be used to identify and study chemical.Infrared portion Electromagnetic spectrum is usually divided into three regions; mid- and far- infrared, name for their a relation to the visible spectrum.the higher - energy near IR,Approximately 14000-4000 cm^{-1} can excite Overtounaur harmonic vibration. the mid infrared approximately 4000-400 cm may be use to study the fundamental vibration and Associated rotational- vibrational structure. the far Infrared approximately 400-10 cm^{-1}, has low energy and may be used for rotational spectroscopy the infrared spectrum of a sample is recorded by passing a beam Infrared light through the sample .when the Frequency of IR is the same as vibration frequency of a band, absorption occurs, examination of the transmitted light reveals how much energy was observed at each wavelength. Analysis of the position, shape and intensity of peaks in this Spectrum reveals details about the molecular Structure of the sample .IR spectroscopy measure the vibrations of atoms, on this it is possible to determine functional groups.Infrared light causes the band in molecules.to vibrate. Fundamentally, each type band in molecule will absorb characteristics frequency of IR might as it vibrate, and frequencies can often be us to determine which type of band molecule actually contains. Vibration fall into several different categories such as,symmetric stretching, antisymmetric stretching and scissoring . the study of IR Spectra of complexes and free ligand can be used to determine whether complex formation has occurred or not . This is spectra give the most information about the complex structure and also give valuable information reading the and nature of the donor atoms.

1.9. 2 Ultraviolet and visible absorption spectroscopy:

Ultraviolet and visible provides information about compounds with conjugated double bonds.Ultraviolet light and visible light have enough

energy to cause an electronic transitions (the promotion an electron from one orbital to another of higher energy).Depending on the needed for the electoronic transition, a molecule will absorb either Ultraviolet or visible light .Ultraviolet light is electromagnetic radiation with wavelengths raining from180 to 400 nm ; visible light has wavelengths ranging from400 to 780 nm. (Bruce, and Tyler.1985)

many types of transition between quantized energy levels account for molecular (UV –visible) spectra (fig) electron transfer may tacke place during excitations (Kunkely and Vogler 1995) between various types of orbitals the most important electronic transiton are ;

(a)$n \rightarrow \pi^*$in which the electron of an unshared pair goes to an unstable (antibonding) π orbital.

(b)$\pi \rightarrow \pi^*$in which the electron goes from astable (bonding) πorbital to an unstable (antibonding)π^* orbital , the approximate wavelength ranges for these absorptions,as well as par list of bands , functional group, or molecules that give rise to these transition is shown in table(1.1) the specific bonds or functional group of organic compounds(ketones, amine , ..)

The moleculeresponsible for the absorption of aparticular wavelengths of light in UV\Vis are called chromophores, (Harvey, 2000).

Table 1.1 Electronic transition involving n,s, and p molecular orbitals

Transition	Wavelenghth (nm)	Example
$\sigma \rightarrow \sigma^*$	200	C- C,C-H
$n \rightarrow \sigma^*$	160 -260	H_2O, CH_3OH, CH_3Cl
$\pi \rightarrow \pi^*$	200 -500	C=C, C=O, C=N,C$\equiv C$
$n \rightarrow \pi^*$	250 -600	C=O, C=N,N=N, N=O

The basis of spectrophotometric methods is the simple relationship between the color of a substances and its electronic structure ,a molecule or an ion exhibits absorption in the visible or ultra-violet region when the radiation couses an electronic transition in molecules.containing one or more chromophoric groups. The color determining factors in many molecules is the introduction ofconjugated double bonds by means of electron donor or electron acceptor groups(Blaedel and Meloche, 1964).

The quantitative applicability of the absorption method is based on the fact that the number of photons absorbed is directly proportional to the number or concentration of atoms, ions or molecules.Absorption spectroscopy is one of the most useful tools available, to the chemist, for quantitative analysis.

1.9.3 X-ray analysis:

X-ray crystallography is a tool used for identifying the atomic and molecular structure of crystal in which the crystalline atoms cause a beam of incident x-ray to diffract into many specific directions. by measuring the angle and in tensities of these diffracted beam ,acrystallographer can produce athree- dimensional picture of the density of electron with in the crystal.When X-ray fall on solids, they are diffracted to produce pattern ,formed on a photographic film since , x-ray are diffracted mainly by the orbital electron of the atoms,the diffraction will be function of the atomic number.Two proplems are involved in the interpretation of x- ray diffraction patterns, the dimensions of unit cell and the position of the individual atoms in molecule.the position of the diffracted beams depend on the dimensions of the unit cell. Intensities of the different beam depend on the position of the atom is a unit cell. A knowledge of these relative intensities leads to the following applications

1. determination of bond lengths, Valency angles, and general electron distribution in molecules

2. determination of molecule symmetry this offer means of distingueishing between geometrical isomers, and also of ascertaining the shape of molecule . molecule

3.Determination of structure this application was orginally use for compounds knows structure .

Trial models now structure:

Trial models based on the structure of the molecule were compared with the x-ray and if they fitted ,confirmed structure already accepted, if the patterns,did not fit, it then was necessary to look for another structural formula, more recently, however x-rayanylsis has been applied to compounds of unknown or,partially known structure.

x-ray analysis has been used to elucidate conformation of rotational isomer, also to determine the absolute Configuration of enantiomorphs

1.9.4Magetic susceptibility:

Quantitative measure of the extent to which a material may by magnetized in relation to given applied magneticfield.The magnetic properties of complexes in terms unpaired electrons and their magnetic or spin properties are useful in determining Structural features in transition metal compounds . Complexes that contain in unpaired electrons are paramagnetic and attracted in to magnetic field. Diamagnetic compound are those no unpaired electrons are repelled by magnetic field. the number of unpaired electrons can be determined by magnitude of the interaction of the metal compounds with magnetic field. Di and paramagnetism are often affected by the presence of coordination complexes, which by transition metals readily from (d- block).(Johnson ,and ,Basolo ,1964), magnetic susceptibility can determined by using a Gouy balance at room temperature. the Johnson - Matthey magnetic susceptibility balance is very similar to the traditional Gouy balance but, instead of measuring the force that a magnet exerts on a

sample, the opposite force that the sample exerts on a suspended permanent magnet is observed .

1.9.5 Nuclear magnetic resonance spectroscopy

NMR is commonly used in organic and organometallic chemistry to elucidate molecular structures and conformation by studying H^1 and C^{13}nuclei. The difference in resonance frequency is called the chemical shift, the chemical shift provides information about the structure of the molecule in study of hydroxamic acid chemical shift appear in spectra of acetohydroxamic acids exhibit the signals of both NH and OH a protons while in case of sodium acetohydroxanate only the NH proton observed in spectrum (Agrawal et al., 2010)

1.9. 6 A Mass spectra:

Spectrometry (MS) is an analytical chemistry technique that helps identify amount and type of chemicals present in a sample by measuring the mass to charge ratio and abundance of gas-phase ions, specifically used as means of elucidating the structure of compounds. Thus, it is possible to determine molecular weights, molecular formulae, Mass spectrometry works by ionizing chemical compounds to generate charged molecules or molecule fragments and measuring their to -charge ratios. There are three essential functionof mass spectrometer,and the associated components are:

1-a small sample is ionized, usually to cations by loss of an electron (ion source).

2-The ions are sorted and separated according to their mass and charge (Mass Analyzer).

3- The separated ions are then measured, and the results displayed on a chart (Detector) .

1.9. 7 Thermo Gravimetric Analysis(ATG):

TGA: is a method of thermal analysis in which change in physical and chemical properties of materials are measured inof increasing temperature, (Coats ,and Redfern .1963). TGA allowed stablishing the temperature at which the complexes decompositions begun, the weight loss allowed to estimate the decomposition stoichiometrey and the amount of crystallization or coordination water within the complexes, the common applications of TGA are:

(1) materials characterization through analysis. Of characteristic composition patterns

(2)studies of degradation mechanisms and reaction kinetics.

(3) determination of organic content in a sample

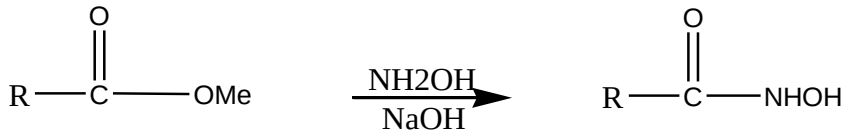
(4)determination of inorganic (eg, ash) content in a sample, which may be useful for corroborating predicted material structures or simply used as chemical analysis.

1.10 Preparation of Hydroxamic:

There are more than one method for preparation of hydroxamicacid like free carboxylic acids, carboxylic esters, acid chlorides and acid anhydrides. The reaction is generally carried out in basic condition, (Banton, and Ollis, 1979)

1.10.1The reaction between an ester and hydroxylamine:

In this method was hydroxamic acid prepared by reacrts an alkyl or aryl ester with hydroxylamine in the presence of alkali, the free acid obtained by addition of mineral acid (H-X) in cold solution, accordinig to these eqution:



Dutta used sodium methoxide instead of potassium hydroxide in preparing nictinohydroxamicacid.Wise and Brand, (Wise, and et al.1955).Methanol passing potassium hydroxamate solution prepared by Blatt's passing method, the cation exchanger hydrogen form (R-H) and removal of the access solvent under vacuum, (Wise, 1955).

1.10.2The reaction between acid chloride and hydroxylamine:

In this method the N-substituted ' hydroxylamine is acylated by acid chloride to produce a monohydroxamic acid, a derivative which is undesired is also produced. Tandon improved this method by using equimolar proportion of N substituted hydroxylamine and acid chloride at low temperature diethyl ether medium, (Tandon, and Bhattacharyya 1992) .

1.11.Reactions of hydroxamic acids:

1.11.1 Alkation and acelation:

There are three potential replacement sites, (N , N-O and C = O. AlkyIhydroxamates are the main products arising from the action of an alkylating agent on the hydroxamate ion, (Johnson, and et al.1971) Its reactivity to electrophiles was due to the α- effect of adjacent nitrogen atoms which increases oxygen atom availability.

The One alkylation reactions are usually performed by treating alkyl halide hydroxamic acid in the presence of sodium methoxide to give the mono-alkyl (acyl) product in any yield, along with a small amount of dialkyl

derivatives.Much investigation has been carried out into the structure of those dialkyl derivatives. There are three possible products, namely the N-alkyl hydroxamate and the O-alkyl hydroximate isomers (E) and (Z). The product ratio depends in large measure on the solvent, the nature of the accompanying cation and the alkylating agent's carbonium ion electrophilicity.(Johnson, etal 1971).

More reactive acid halides, such as sulfonyl or phosphoryl halides, induce a near spontaneous rearrangement of Lossen. Many less common types of acylation include isocyanates, ketene and acetals. (Mukaiyama, and Nohiro, 1961).

1.11.2 Hydrolysis:

Hydrolysis of hydroxamic acids and their producesa carboxylic acids and hydroxylaminesmaybe effected by both acidic and alkaline conditions. (Brendet, and Fuller, 1966).

Kinetic studies indicate that those of amides are detected by the acid mechanism and basecatalyzed hydrolysis of hydroxamic acids. Dependence of first order on hydronium ion suggests the mechanism involves a tetrahedral intermediate that yields the final products.

1.11.2.1Acid catalysed hydrolysis:

Two mechanisms have been proposed (Figure 1.7), although pathway B is preferred. In this mechanism, protonation at N occurs in the first step, followed by slow hydrolysis to yield an intermediate which rapidly decomposes to the free acid and hydroxylamine. The mechanisms for acid-

dependent and acid-independent dissociation also shown, in Figures 1.7 and 1.8 (Caudle and Crumbliss, 1994)

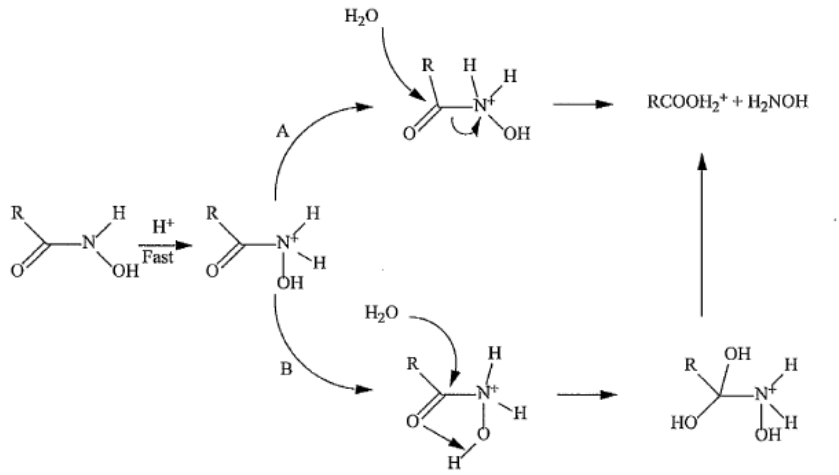


Figure 1.7 Acid Catalysed Hydrolysis of Hydroxamic Acids

1.11.2.2The base-catalyzed:

hydrolysis is less known except that, as with some amides,

There is dependence of first and second order on. This is proposed to occur through deprotonation of the -OH functional group, in agreement with NMR data which indicates this to be the most acidic proton.

Deprotonation is rapid and the rate determining step is hydrolysis of the resultant anion which rapidly decomposes to yield the carboxylate anion and hydroxylamine, .(Brendet, and Fuller, 1966).

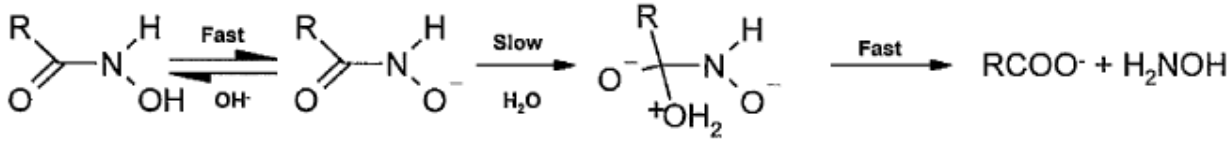
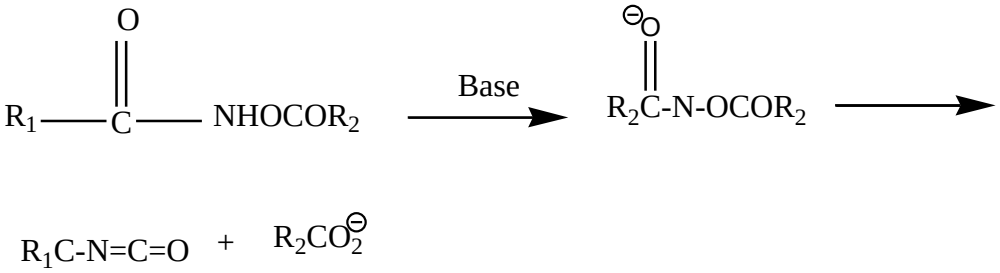


Figure 1.8 base-catalyzed hydrolysis

1.11.3The Lossen rearrangement:

As a result of the thermal decomposition of hydroxamic acids, Lossen rearrangement of hydroxamic acids occurs. The reaction mechanism comprises (N – O) bond fission with synchronous alkyl or acyl group migration from carbon to nitrogen.(Smith, (1963).



1.11.4 Inorganic acylating

agents, such as phosphoryl and sulfonly chlorides are every effective in inducing (N – O) bond fission (Samuel, and Silver, (1963).

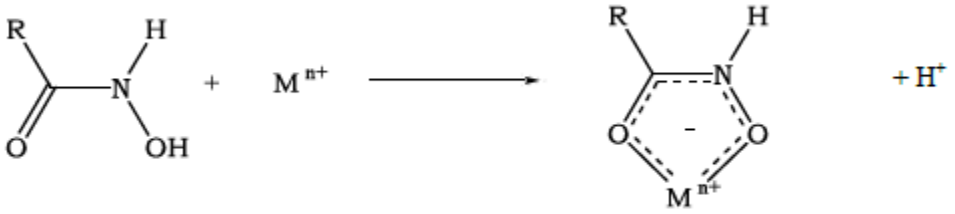
The rate of the reaction depends upon the electronic nature of R_1 and R_2. The rate of the reaction increases as both the electron releasing power of R_1 and the electron attracting power of R_2 increase.(Bright, and Hauser,(1939).

1.12Metal complex formation:

Complexes of monohydroxamic acids behave as bidentate donors towards various metal ions.(Anderegg, and et al 1963,).Spectroscopic studies indicate that the metal-ligand coordination takes place via two oxygen atoms.(Brown, and et al 1979)(Brown,. 1983)-The IR spectrum of monohydroxamic acid complexes of Cu(II), Fe(IH) and Ni(II) shows bands for the metal-oxygen in the region of 250-600 cm' 1 which compare with the calculated values. (Brown, and et al 1979) The NMR spectra of acetohydroxamic acid exhibits signals for both NH and OH protons, whereas the sodium complex of this compound displays the signal for only the NH

proton. These results indicate that the sodium ion replaces the proton on the oxygen atom. The X-ray structures of the complexes of benzohydroxamic acid with Fe(III) and Cr(III) show coordination of the oxygen atoms of the ligand in a bidentate fashion .

Abu-Dari,and et al 1979. It is thus probable that most hydroxamic acid metal complexes have the following structure



Metal ion (M^{n+}) {O,O} coordination by a generic hydroxamic acid.

1.13Stability constant of hydroxmate:

the term stable and unstable is often used in general for the purposes of describing the term compound reactivity. These terms have specific references in the case of metal complexes Significance which relates to complex formation thermodynamics. Stable complexes could be defined as those with constant gravity overall stability greater than one, and those unstable would then have overall stability constant less than one. Complexes with five –and six membered chelate rings are most stable .Chelate complexes with four-membered rings are rare while chelate rings with more than six-membered or generally less stable. of the former two, aliphatic chelate complexes with five-membered rings appear tobe owing to favorable entropy changes .The six membered chelate rings with conjugated double bonds or aromatic ligands are some time more stable compared to five –membered rings, perhaps because of the release in strain by wider bond angles and resonance. (five-and six component chelate rings are complexes

most stable, four-membered complexes of.chelate are special though .Less than six-membered or commnlly less stable chelate rings. Of that Former two, five-membered aliphatic chelate complexes appeartobe owing to favorable entropy changes The six memberedchelate rings with conjugated double bonds or aromatic ligands are often more stable than five -membered rings, maybe because of wider bond angles and resonance release into strain. metal complexes are stable, depending on the following: type of metalion and donor atom, adjusts the base power and the number coordination locations of the ligand, chelate ring size and steric, and the effects of resonances.The stability constant for complexes of the (d)divalent cation with nitrogen donor ligands increases in the series:Mn (II),<Fe(II),<Co(II),<Ni(II),<Cu(II)<Zn(II).The stability constants for the transition metal complexes of a wide variety of hydroxamic acids have been summarized, (Chatteijee, 1978). The complexes of hydroxamic acids with transition metals are fairly strong (Farkas,et al,2017). It is interesting to note that the stability constants for the nickel(II)hydroxamate complexes are about the same or somewhat lower than those of the respective Zn(II) species which is in contrast to the trend predicted by Irving and Williams.(Irving, and Williams, 1975)

1.14. Biologigcal activity of hydroxamic acid:

Hydroxamic acids have been the source of much biochemical interest in recent years due to the fact that they show a wide range of biological activities. (Emery, 1971 Coutts, 1967). much of the activity of these compounds is due to the presence of the hydroxamic acid grouping which allows them to chelate to metal ions. Some hydroxamic acids are effective antimicrobial agents against bacterium, fungus, and other microbes. Aspergillic acid and the sodium salt of salicylohydroxamic acid as well as many mono- and di-substituted derivatives of salicylohyaroxamic acid have

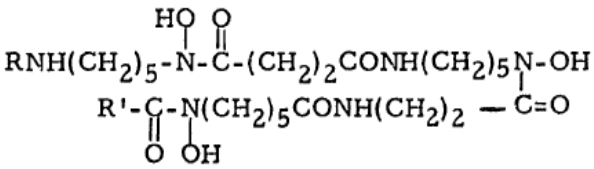
been tested and found to be effective against my cobacterium tuberculosis(Coutts, 1967).

Most antitubercular hydroxamic acids possess antifungal properties as well. Benzohydroxamic acid, salicylohydroxamic acid and its sodium salt, and 2-hydroxy-3-naphthohydroxamic acid, for example, inhibit the growth of Trichophytonrubrum, T. violaceum, T. gypseum, and Achorionschoenlein.(CIBA, Ltd , (1962).Arylthioacetohydroxamic acids, RC_6H_4-S-CH_2-C(O)-N(OH)H, are good antifungal agents, but the corresponding aryl sulfonyl acetohydroxamic acids, RC_6H_4-S-CH_2-C(O)-N(OH)H, are promoters of fungal growth(Coutts, 1967).Sorbohydroxamic acid has been found to be such an effective fungal growth inhibitor that its use as a food preservative has been studied. This compound was found to be m ore effective, over a wider pH range, than sorbic acid, a widely used food preservative. Hydroxamic acid esters of the type $RC(O)N(H)OCH_2CH_2NR_2$ have bactericidal properties and also enhance the formation of antibodies.The antimicrobial action of hydroxamic acids is believed to be due to their ability to coordinate to metal ions and thus make the ions unavailable for metabolism and the subsequent growth of the microorganism(Coutts, 1967).

Mycobactins and sideramines, naturally occurring growth factors in microorganisms, are hydroxamic acids coordinated to iron(III) ions.(Snow, 1970).Mycobactins, the growth factors from mycobacteria, contain a ring structure bound as a hexadentate ligand to iron(III) by coordination through two hydroxamic acid groups, a cyclic amine group, and a hydroxy group. The sideramines, which are similar to the mycobactins in physiological function, differ in that chelation to the iron occurs through three hydroxamic groups. The function of these naturally occurring compounds is to provide iron for metabolism by chelating available iron outside the cell and

transporting it through the cell wall. The process of iron transport and the involvement in the metabolism within the cell is believed to occur by the following mechanism: The hydroxamic acids are produced within the cell,the amount produced depending on the cell's need for iron, and are secreted through the walls of the cell. Iron in the environment around the cell is chelated by the hydroxamic acids and is transported back into the cell. The hydroxamic acid with its chelated iron then comes into contact with an enzyme involved in iron metabolism. At this point, reduction of the iron to the +2 state occurs and the hydroxamic acid, which has little affinity for the iron(II), releases the iron to the enzyme. The hydroxamic acids are then free again to migrate out of the cell to find more iron.

This proposed mechanism for behavior of the naturally occurring hydroxamic acids is supported by the exceptionally high affinity and selectivity for ferric ion. Also these compounds are almost universal in microorganisms and may occur in plants. (they do not appear in animal cells). The most convincing evidence for this action lies in the fact that the microorganism's release of hydroxamic acid to the environment, and the amount released, depends on the organism's need for iron .(Neilands, 1957). It has been shown. that increased production occurs when cultures of the microorganisms are grown under low iron conditions and reduction of hydroxamic acid release occurs in an iron-rich environment.Hydroxamic acids also exhibit herbicidal and insecticidal properties. (Neighbors, (1968). Compounds of the type Cl_n $–C_6H_5$ -n-$N(OH)C(O)N(CH_3)_2$ have exhibited herbicidal properties and much time has been devoted to the syntheses of these compounds in recent years by industry Trihydroxamic acids of the type have been reported.(Gale, and et all (1970).



as effective agents in preventing the accumulation of iron-containing pigments in tissues. One such compound, desferrioxamine (R=H, R' = $COCH_3$) is available commercially under the trade name "Desferal" for removal of excess iron from the body hydroxamic acids show activity in inhibiting the production of nucleosides and nucleic acids or in chemically modifying these substances(Neilands, 1957). Propiohydroxamic acid has been shown to producemodification of RNA .(Kochetkov, and Shibaeva, 1964). And sorbohydroxamic acid inhibits synthesis of DNA. (Gale, and et al 1970).

Cinnamohydroxamic acid has been demonstrated to exhibit antihypertensive action in animals, but derivatives of 3,4,5,tri-methoxybenzohydroxamic acid act as mental tonics. (Nordmann and Swierkot, (1965). The inhibition of enzymes, especially urease, by hydroxamic acids has received considerable attention. series of sixty-one hydroxamic acids, including sorbo-, glutaro-, benzo-, 4-fluoro- benzo-, isonicotino- and 2, 3-dichlorophenoxyacetohydroxamic acid, were tested (Gale, 1969) and twenty-one were found effective in inhibiting the enzyme from jack bean and from Proteus morganii and P. mirablis. Two reviews on the effects of hydroxamic acids . And hydroxamates as inhibitors of urease have been published with discussions of the mechanism of their inhibitory binding, toxicity, and possible clinical uses. Inhibition of urease by hydroxamic acids Urease is known to contain two Ni(II) ions in its active site. It is believed that the inhibition of urease by hydroxamic acids is caused by complexation of one or both of these metal ions. Several groups have investigated the reactions of urease with hydroxamic acids, has concluded that the inhibitory

powers of these compounds are due to the presence of the hydroxamic acid group. (Muehlemann, 1971)

The reaction of acetohydroxamic acid (AHA) with urease was observed to be biphasic in nature, (Dixon,and et al 1980), (Dominey, and Kustin. 1984)The two processes are assigned to: (i) formation of an initial urease-AHA complex and (ii) slow transformation of the intermediate to give the final product. The second order rate constant for process(i) was measured to be$17M^{-1}s^{-1}$. The value of this rate constant is much smaller than the value of the rate constant for the complexation of AHA with free aquo-nickel which was measured to be$717M^{-1}s^{-1}$. The difference in the values of these rate constants may be because of the following reasons: (i) the amino acid residue(s) on the Ni(II) center in urease have to dissociate for the ligand to bind, (ii) the incoming ligand faces electrostatic repulsions or steric hinderance that may be caused by the charged amino acid residues present at the active site and/or (iii) the ligand may bridge between the two nickel ions in which case the reaction mechanism is quite different than the mechanism of ligand binding with aquo Ni(II) Inhibition of the urease has been found (Eisai Co , Ltd , (1973) to decrease the fecal ammonia content in cows, swine, and poultry as a result of im proved nitrogen utilization, and incorporation of compounds such as capro-, aceto-, and benzo-hydroxamic acids into the feeds of these animals has produced dramatic increases in their rate of growth. (Morimoto and Naito 1972)

for example, daily administration for forty-two days of caprohydroxamic acid (3 mg/kg body weight) in the feed to five day old shoats produced an average 23% weight promotion. Hydroxamic acids have also been found to exhibit antidepressant and antiinflammatory.(Wang, 1970). (Hayman,1970).action, to be effective antimalarial and antileukemic. (Coutts, (1970), agents and chemotherapeutic agents for rheumatoid

diseases, to function as antibiotics and antibiotic antagonists, to lower the cholesterol level in the blood of animals,). and to function as herbicides. One interesting non- biological use that might be mentioned here is the effect that hydroxamic acids have in prolonging the shelf life of photographic developing solutions.(Kasman, 1971).

Hydroxamic acids which have been shown to exhibit some type of biological or pharmocological activity are structurally diverse. They may be prim ary or secondary, acyclic or cyclic, aromatic or aliphatic, or mono-, di-, or trihydroxamic acids. The only feature common to all is the hydroxamic acid group itself.For those compounds which exhibit biological activity through a coordination mechanism, adefinite correlation should exist between the metal-binding ability of the compounds and the extent of their biological activity. Such a relationship has been found 01-substituted hydroxyureas(Harmon, etal 1970). and tetracycline. (Doluisio and Martin, 1963.Kohn, 1961).

The therapeutic activity of these compounds is directly related to their metal- binding ability. In those compounds which showed little or no tendency to coordinate to metal ions, very little or no antibacterio- logical activity was found, but those compounds that coordinated strongly exhibited high activity. The degree of activity of these compounds was also affected by the presence or absence of metal ions. That is, for those compounds which coordinated readily, the activity was removed when no metal ions were available for coordination. For the analogs which were not therapeutically active, the presence or absence of metal ions made no difference. It was concluded that the action of these compounds was a result of their coordination to a metal ion and the attachment of the resulting complex to an active site in another compound through the coordinated metal ion. Thus, for these compounds the ability to coordinate is very important to their

biological activity, and a similar situation is believed to exist for the hydroxamic acids. Therefore, the conclusion, is that the biological activity of the hydroxamicacidsis due to the presence of the hydroxamic group and more specially to its ability to chelate metal iron(III).

1.15.Spectrophotometric Determinations of hydroxamic acid:

Hydroxamic acidsve received considerable attention as reagents inanalytical chemistry for spectrophotometric determination of metals. Then intense colouration given by many metal ions with hydroxamic acids makes the latter often useful as colourimetric reagents (Agrawal,1977). The most characteristic reaction of the hydroxamic acid is red-violet colouration develops with ferric ion in acid medium below PH_2 and the orange complexes which develop gradually above pH_3 and the orange complexes which develop gradually above pH_3. Vanadium reacts with certain hydroxamic acids specially with those having another functional group attached to the side chain yielding complexes with differentcolours at different pH. In 1959, Shome determined spectrophotometrically the red compound formed by Vanadium witlibenzophenylhydroxamic acid, the coloured compound formed in presence of ethanol at pH 2.5 shows maximum absorbance at 480 nm. N-acetylsalicyloyl-N-phenylhydroxylamine used by Joseph and Savarior fordetermination of Ti (IV) spectrophotometrically and gravimeterically. Spectrophotometrically is highly selective, the deep yellow colour shows maximum absorbance at 390 nm. In gravimetry, the yellow precipitate formed in 1-2 M HCi can be weigheddirectly after drying at 105°-l 15°C. Agrawal in 1973 determined U (VI) spectrophotometrically at pH 4.0-4.5 in 0.1 M N-phenyl-2-naphthohydroxamic acid in chloroform, the absorption maximum at515 nm.(Agrawal , 1973) In 1980 , V (V) was determined spectrophotmetrically by Koshy and Tandon with N-p-chlorophenyl-2-naphthohydroxamic acid.

The violet complex was extractedfrom 3 - 8.4 M HC1. Uranium (VI) and benzohydroxamic acid was developed for spectropholometric determination by Meloan, the colour of complex is dependent, on (Moloan, and et al, 1960)

1.16 Objecctives of the study :

The objectives of this research can be summaries as follow :

1. To prepare two hydroxamic acid ligands by the esterification reaction
2. To characterization the prepared acids using instrumental techniques to assure their identity and structure.
3. To synsties complexes between the ligands and the Zn^{+2}, Cu^{+2} ,Fe^{+3} ,Co^{+2} ,Mn^{+2} ,Ni^{+2}cations .
4. To identifiy the prepared complexes ,using infrared , elemental analysis, and thermo gravimetric analysis.
5. To study the Stability of prepared hydroxamic metals complexes using continuos variation.

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Chapter Two

2 .Materials and Methods

2 .1 Materials

2.1.1 Chemicals:

Chemicals used in this research were of analytical grade type and general reageants and include:

Salicylic acid (LD Reagent),Benzoic acid (CDH Reagent),Sulphuric acid(H_2SO_4, BDH Analar Grade) ,Methanol(MeOH 99%) (BDH Analar Grade) Ethanol(EtOH 99% ,BDH Analar Grade)

Hydroxylamine hydrochloride($NH_2OH.HCl$, BDH Reagent). Sodium hydrogen carbonate. Magnesium sulfate.,Sodium hydroxide, Analar Grade),Acetic acid(ACOH)(CDH Reagent),Ferric chloride (AC Reagent),Copper sulfate penta hydrate ($CuSO4.5H_2O$, AC Reagent) , cobalt nitrite, zinc chloride,manganese chloride, nickl chloride , and Distilled water.

2.1. 2 Instruments

- Griffin Melting point Apparatus model 9100.

- Elemental Analyzer FLASH EA1112 series , CHNS-O.

- Perkin Elmer Lambda 25UV-visible Spectrophotometer.

- On NICOLET 6700 FT-IR model, Spectrophotometer.

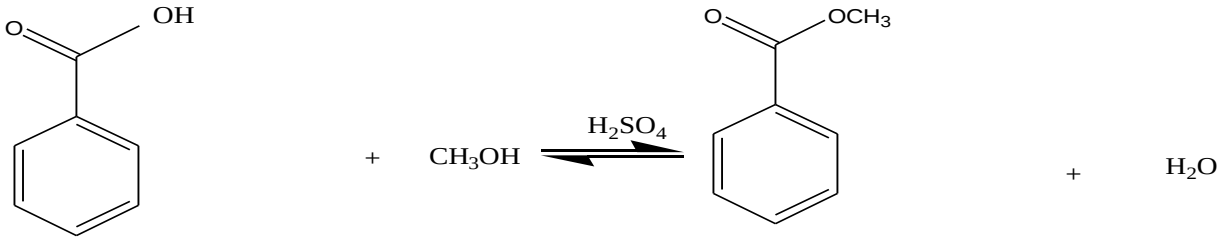
-Bruker AMX-300 NMR spectrometer.

- Shimadzu Thermogravimetric Analyzer(TGA-50).

2 .2 Method

2.2.1 Preparation methyl Benzoate: (Fisher esterification)

10 g of benzoic acid and 25 ml Methanol were placed in 125 ml ,round bottomflask, the mixture was cooled then 3 ml ,of concentrated sulfuric acid are slowly and carefully added , The mixture was mixed and refluxed for one hour in a water bath, it was then cooled and decant into a separatory funnel containing 50 ml of water and 35 ml of ether are shaked thoroughly and drain off the water layer, then ether layer in the seperatory funnel was washed with 256 ml of water, followed by 25 ml of 0.5 M sodium ,bicarbonate to remove unreacted Benzoic acid, shaked and the bicarbonate layer was drained, then the ether layer in separatory funnel was washed with saturated sodium chloride solution and drained off the ether layer in the flask, and the ether was removed by simple distillation. Finally 2-3 g of magnesium sulfate are added, and the methyl benzoate decanted(product 1)



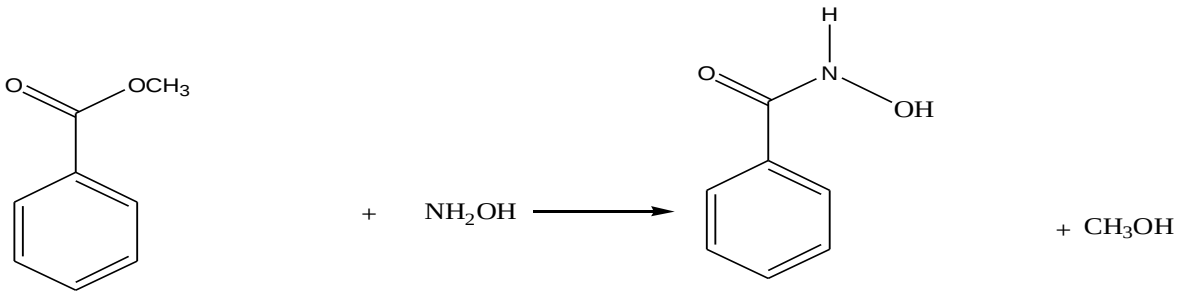
Scheme (1) represents the equation of the preparation of methyl benzoate

2.2.2 Preparation of hydroxylamine:

6.9 g (0.1 mol.) of hydroxylamine hydrochloride are added to 24g sodium hydroxide in 100cm^3 distilled water. the mixture was cooled (at room temperature) filtered form sodium chloride(product 2) .

2.2.3 Coupling reaction of methyl benzoate and hydroxylamine:

hydroxylamine was added to (product 1) and , the mixture was allowed to stand over of 36 hours. Hydrochloric acid solution (3M) was added gradually until the solution became acidified litmus paper and cooled in an ice bath at 0C. the precipitate was filtered and recrystallized from hot water containing a drop of acetic acid . the hot solution was filtered, cooled again in an ice bath at 0℃ .the white precipitate was collected.

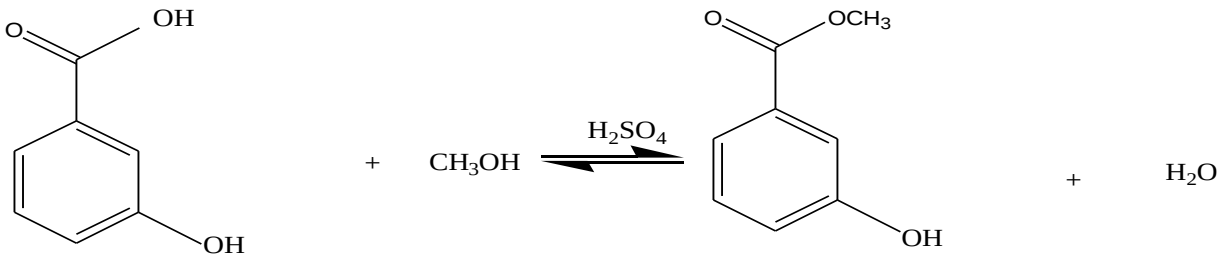


Scheme (2) represents the equation of the preparation method of benzohydroxamic acid

2.2.4 Preparation of methyl salicylate

Methyl salicylate was prepared by the esterification of salicylic acid with methanol in this reaction 28g (0.2 mol.) of salicylic acid , 64g 81cm^3, (2 mol) and 8 cm^3 of concentrated sulfuric acid were mixed and a few ,small chips of porous porcelain were add , and the mixture was boiled gently to reflex 5 hours . Excess of alcohol was distilled off on a water bath and allowed to cool. The residue was poured into about (250 cm^3) of water contained in a separatory funnel and the flask was rinsed with a few cm of water which were also poured into the separatory funnel . 15 cm^3 of carbon tetra chloride was added, and the mixture was shaken in funnel vigorously , upon standing . Methyl salicylate in carbon tetra chloride separated. The lower layer was run off carfully , the upper aqueous layer was rejected ,and the methyl

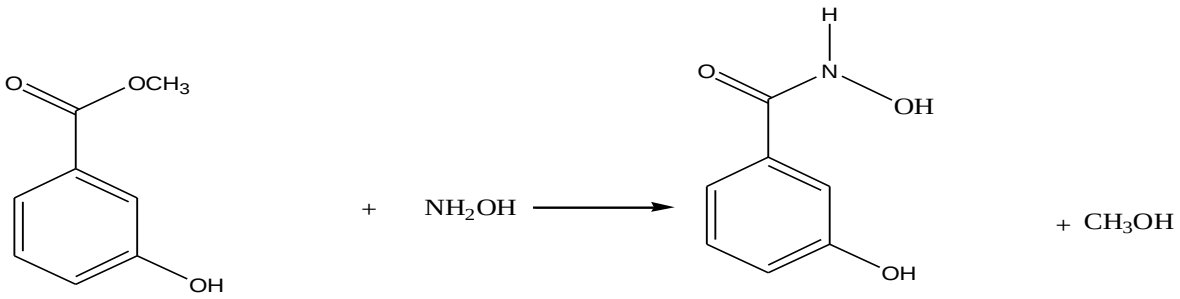
salicylate was returned to the funnel which was then shaked with a strong solution of sodium hydrogen carbonate until all free acid was removed and further evolution of carbon dioxide occurred . the mixture was washed once with water , and dried using small dry conical flask containing 5g of magnesium sulfate . the flask was stopped , shake for 5 minutes and allowed to stand for at least half an hour with occasional shaking . Methyl salicylate solution was left for one day .then neutralized with methanolic potassium hydroxide cooled and the sulfate was filtered off and the methyl salicylate is obtained.



Scheme (3)represents the equation of the preparation method of Methyl salicylate

2.2.5 Coupling reaction of methyl salicylate and hyrroxylamine

14g (0.2 mol) hydroxylamine were added to 200 cm of 12% solution of sodium hydroxide and cooled at room temperature . then 15.2g (0.1mol) of methyl salicylate were added in small portions with vigorous shaking, to ensure complete dissolution .The mixture was allowed to stand for two days until it became straw brown .Sulfuric acid solution 2M was added gradually until the solution became acidified litmus paper and cooled in an ice path at 0C. the precipitate was filtered and recrystallized from hot water containing a drop of acetic acid . The hot solution was filtered, cooled in an ice bath at 0C and the white precipitate was collected.



Scheme (4) represents the equation of the preparation method of salicylohydroxamic acid

2. 3 Characterization of the hydroxamic acids:

2. 3.1 Color test:

Ethanlic solutions of benzohydroxamic, salicylohydroxamic, were added to an aqueous solution of (ferric chloride and vanadium salt). The two solutions of each hydroxamic acids were mixed and transferred to a watch glass for air dryness.

2. 3.2 The melting point:

In this technique involves placing the sample in a capillary tube and was used to determine the melting point of benzohydroxamic and salicylohydroxamic.

2. 3.3 FT-IR Spectra (IR):

The infrared spectroscopy was carried out for benzohydroxamic , salicylohydroxamic acids using JENWAY FTIR instrument with potassium bromide disc with the solid samples in the 400- 4000 cm^{-1} range.

2. 3.4. Nuclear Magnetic Resonance spectra (NMR):

^{1}H NMR spectra of the benzohydroxamic , salicylobenzohydroxamic were carried out with the NMR spectrometer .

2. 3.5. Mass spectra:

The mass spectra of benzohydroxamic , salicylobenzohydroxamic were recorded using the mass Spectrometer.

2. 4 preparation of metal hydroxamate complexes :

2.4.1preparation of Zinc (II) salicylohydroxamate complexe

1.53g of salicylohydroxamic acid dissolved in $5cm^3$ ethanol we mixed with 1.4g of $Zncl_2$ dissolved in distilled water , then 10% $NaHCO_3$ was added to raise the pH ,the white precipitate of complex was formed were filtered and washed with ethanol.

2.4.2 preparation of copper (II) salicylohydroxamate complexe

1.53g of salicylohydroxamic acid dissolved in $5cm^3$ ethanol we mixed with 1.7 g of $Cucl_2.(H_2O)$ dissolved in distilled water , then 10% $NaHCO_3$ was added to raise the pH ,the green precipitate of complex was formed were filtered and washed with ethanol.

2. 4 . 3 preparation of iron (III) salicylohydroxamate complexe

1.53g of salicylohydroxamic acid dissolved in $5cm^3$ ethanol we mixed with 1.6g of $Fecl_3$ dissolved in distilled water , then 10% $NaHCO_3$ was added to raise the pH ,the riddish brown precipitate of complex was formed were filtered and washed with ethanol.

2. 4.4 preparation of cobalt (II) salicylohydroxamate complexe

1.53g of salicylohydroxamic acid dissolved in $5cm^3$ ethanol we mixed with 2.9 g of $CO(NO_3)_2.6H_2O$ dissolved in distilled water , then 10% $NaHCO_3$ was added to raise the pH ,the pink precipitate of complex was formed were filtered and washed with ethanol.

2. 4.5 preparation of manganese (II) salicylohydroxamate complexe

1.53g of salicylohydroxamic acid dissolved in $5cm^3$ ethanol we mixed with 1.9 g of $Mncl_2.4H_2O$ dissolved in distilled water , then 10% $NaHCO_3$ was

added to raise the pH ,the white precipitate of complex was formed were filtered and washed with ethanol.

2.4.6 preparation of nickl (II) salicylohydroxamate hydroxamate complexe

1.53g of salicylohydroxamic acid dissolved in $5cm^3$ ethanol we mixed with g of $NiCl_2.6H_2O$ dissolved in distilled water , then 10% $NaHCO_3$ was added to raise the pH ,the pale green precipitate of complex was formed were filtered and washed with ethanol.

2.5preparation of metal benzohydroxamate complexes :

2.5.1preparation of Zinc (II) benzohydroxamate complexe

1.37g of benzohydroxamic acid dissolved in $5cm^3$ ethanol we mixed with1.4 g of $ZnCl_2$ dissolved in distilled water , then 10% $NaHCO_3$ was added to raise the pH ,the white precipitate of complex was formed were filtered and washed with ethanol.

2.5.2preparation of copper (II) benzohydroxamate complexe

1.37g of benzohydroxamic acid dissolved in $5cm^3$ ethanol we mixed with 1.7 g of $Cucl_2.(H_2o)$ dissolved in distilled water , then 10% $NaHCO_3$ was added to raise the pH ,the bluish green precipitate of complex was formed were filtered and washed with ethanol.

2.5.3 preparation of iron (III) benzohydroxamate complexe

1.37g of benzohydroxamic acid dissolved in $5cm^3$ ethanol we mixed with1.6 g of $Fecl_3$ dissolved in distilled water , then 10% $NaHCO_3$ was added to raise the pH ,the riddish brown precipitate of complex was formed were filtered and washed with ethanol.

2.5.4 preparation of cobalt (II) benzohydroxamate complexe

1.37g of benzohydroxamic acid dissolved in $5cm^3$ ethanol we mixed with 2.9g of $CO(NO_3)_2.6H_2O$ dissolved in distilled water , then 10% $NaHCO_3$ was added to raise the pH ,the pink precipitate of complex was formed were filtered and washed with ethanol.

2.5.5 preparation of manganese (II) benzohydroxamate complexe

1.37g of benzohydroxamic acid dissolved in $5cm^3$ ethanol we mixed with 1.9g of $MnCl_2.4H_2O$ dissolved in distilled water , then 10% $NaHCO_3$ was added to raise the pH ,the white precipitate of complex was formed were filtered and washed with ethanol.

2.5.6preparation of nickl (II) benzohydroxamate complexe

1.37g of benzohydroxamic acid dissolved in $5cm^3$ ethanol we mixed with g of $NiCl_2.6H_2O$ dissolved in distilled water , then 10% $NaHCO_3$ was added to raise the pH ,the pale green precipitate of complex was formed were filtered and washed with ethanol.

2.6Characterization of the metals hydroxamate Complexes:

2.6 .1 Infrared spectrum of metals hydroxamate Complexes

The infrared spectroscopy was carried out for(zinc(II), copper (II), iron(III), cobalt (II) ,manganese (II), nickel(II) (benzohydroxamate , salicylohydroxamate) using JENWAY FTIR with KBr disc.

2.6 .2 C , H , N percentage of metals hydroxamate Complexes:

Carbon, nitrogen, hydrogen content of the prepared complexes were determined using Elemental Analyzer (FlASH EA1112 series CHNS-O) .

2.6 .3Thermogravvimetric analysis :

The TGA instrument continuously weights sample as it is heated to temperatures of up to 1000 C. As the temperature increases ,various components of the sample are decomposed and the weight percentage of each resulting mass change can be measured. Results are plotted with temperature on the X-axis and mass loss on the Y –axis . in this research the different metal complexes were characterized using Shimadzu Thermogravimetric Analyzer(TGA-50).

2.7 Stoichiometric study of hydroxamate complexes using continuous variation method :

2.7.1 Preparation of hydroxamic acid stock solution

0.02g of hydroxamic acid were weighed and dissolved in 1.0 cm^3 ethanol ,then transferred to 100cm^3 volumetric flask,5$cm^3$of buffer solution PH (=) was added to the solution and was diluted to the volume mark with distilled water.

Preparation of cobalt nitrate stock solution

0.38 of cobalt nitrate was weighted and dissolved in small amount of distilled water ,then transferred to 100cm^3volumetric flask ,5cm^3 of buffer solution (PH= (7 for Co (SHA),and 5for (BHA)) was added to the solution and was diluted to the volume mark with distilled water.

Stoichiometry of cobalt hydroxamate complex

Aseries solution of different mole fraction of the two constituents were prepared 0:1, 1:9 , 2:8 , 3:7 , 4:6 , 5:5 , 6:4 , 7:3 , 8:2 , 9:1 , 10:1 cm^3 salicylohydroxamic acid (ligand) : cobalt ion respectively .The total volume of the prepared complex and the PH were kept constant .

2.7.2Preparation of copper sulphate stock solution

0.32g of copper sulphate was weighted and dissolved in small amount of distilled water ,then transferred to 100cm^{3}volumetric flask ,5cm^3 of buffer solution PH 6 for Cu (SHA),and (BHA)) was added to the solution and was diluted to the volume mark with distilled water.

Preparation of hydroxamic acid stock solution(0.013M (SHA)(0.014(BHA)

0.02g of hydroxamic acid were weighed and dissolved in 1.0 cm^3 ethanol, then transferred to 100cm^3 volumetric flask,5cm^{3}of buffer solution PH 6 for Cu (SHA),and (BHA) was added to the solution and was diluted to the volume mark with distilled water.

Stoichiometry of copper hydroxamate complex

Aseries solution of different mole fraction of the two constituents were prepared 0:1, 1:9 , 2:8 , 3:7 , 4:6 , 5:5 , 6:4 , 7:3 , 8:2 , 9:1 , 10:1 cm^3 salicylohydroxamic acid (ligand) : copper ion respectively .The total volume of the prepared complex and the PH were kept constant .

2.7.3Preparation of Zinc chloride stock solution

0.37g of Zinc chloride were weighted and dissolved in small amount of distilled water ,then transferred to 100cm^{3}volumetric flask ,5cm^3 of buffer solution PH4 for (SHA) , and 5 for(BHA) was added to the solution and was diluted to volume using distilled water.

Preparation of hydroxamic acid stock solution

0.02 of salicylohydroxamic acid were weighed and dissolved in 1.0 cm^3 ethanol ,then transferred to 100cm^3 volumetric flask,5cm^{3}of buffer solution

PH= (4) for Zn (SHA),and 5for (BHA) was added then diluted the solution to volume using distilled water.

Stoichiometry of Zinc salicylohydroxamate complex

Aseries solution of different mole fraction of the two constituents were prepared 0:1, 1:9 , 2:8 , 3:7 , 4:6 , 5:5 , 6:4 , 7:3 , 8:2 , 9:1 , 10:1 cm^3 hydroxamic acid (ligand) : Zinc ion . The total volume of the prepared complex and the pH were kept constant .

2.7.4Preparation of Manganese chloride stock solution

0.26g of Manganese chloride was weighted and dissolved in small amount of distilled water ,then transferred to 100cm^3volumetric flask ,5cm^3 of buffer solution PH 5 for Mn (SHA),and 5for (BHA) was added to the solution and was diluted to volume using distilled water.

Preparation of hydroxamic acid stock solution

0.02 of salicylohydroxamic acid were weighed and dissolved in 1.0 cm^3ethanol, then transferred to 100cm^3 volumetric flask,5$cm^3$of buffer solution PH= (5) for Mn (SHA),and 5for (BHA)was added to the solution and was diluted to volume using distilled water.

Stoichiometry of Manganese salicylohydroxamate complex

Aseries solution of different mole fraction of the two constituents were prepared 0:1, 1:9 , 2:8 , 3:7 , 4:6 , 5:5 , 6:4 , 7:3 , 8:2 , 9:1 , 10:1 cm^3 hydroxamic acid (ligand) : Manganese ion .the total volume of the prepared complex and the pH were kept constant .

2.7.5 Preparation of ferric chloride stock solution

0.21g of iron chloride was weighted and dissolved in small amount of distilled water ,then transferred to 100cm^{3}volumetric flask ,5cm^3 of buffer solution pH 3 for Fe (SHA),and 5for (BHA)) was added to the solution and was diluted to volume using distilled water.

Preparation of salicylohydroxamic acid stock solution

0.02 of hydroxamic acid were weighed and dissolved in 1.0 cm^3 ethanol, then transferred to 100cm^3 volumetric flask,5cm^{3}of buffer solution pH 3 for Fe (SHA),and 5 for (BHA) was added to solution and was diluted to the volume using distilled water.

Stoichiometry of iron hydroxamate complex

Aseries solution of different mole fraction of the two constituents were prepared 0:1, 1:9 , 2:8 , 3:7 , 4:6 , 5:5 , 6:4 , 7:3 , 8:2 , 9:1 , 10:1 cm^3 hydroxamic acid (ligand) : iron ion .the total volume of the prepared complex and the pH were kept constant .

2.7.6 Preparation of ammonium meta vanadate stock solution

0.152 of ammonium meta vanadate was weighted and dissolved in small amount of distilled water ,then transferred to 100cm^{3}volumetric flask ,5cm^3 of buffer solution PH 5 for V (SHA),and 7for (BHA) was added to the solution and was diluted to volume using distilled water.

Preparation of hydroxamic acid stock solution

0.02 of salicylohydroxamic acid were weighed and dissolved in 1.0 cm^3 ethanol, then transferred to 100cm^3 volumetric flask,5cm^{3}of buffer solution

pH 5 for V (SHA),and 7for (BHA) was added then diluted the solution to volume using distilled water.

Stoichiometry of vanadium hydroxamate complex

Aseries solution of different mole fraction of the two constituents were prepared ,0:1, 1:9 , 2:8 , 3:7 , 4:6 , 5:5 , 6:4 , 7:3 , 8:2 , 9:1 , 10:1 cm^3 salicylohydroxamic acid (ligand) : vanadium ion .the total volume of the prepared complex and the pH were kept constant .

Preparation of blank solution:

1cm^3 of 0.01M salicylohydroxamic and benzohydroxamic acids were taken, transferred to 10 cm^3 volumetric flasks and completed up to volume with distilled water.

Determination λmax:

1cm^3 of 0.01M hydroxamic acid was transfered into 10 cm^3 volumetric flasks, 1 cm^3 of (ZnCl2 .7H_2O, $FeCl_3$, CuSO4.5H_2O, $Co(NO_3)_2.6H_2O$,$MnCl_2.4H_2O$, NH_4VO_3) were added and completed up to the mark with distilled water. Then the λmax of each solution was recorded(1cm^3 of 0.01M (SHA(Zinc (λmax 430nm),(copper λmax 780nm), (iron (λmax 520nm), (cobalt(λmax 510nm),(mangenese λmax 440nm), (vanidum (λmax 420nm),). BHA(Zinc (λmax 430nm),(copper λmax 410nm), (iron (λmax 470nm), (cobalt(λmax 520nm),(mangenese λmax 420nm), (vanidum (λmax 460nm),

2.8 Preparation of buffer solution:

Buffer1 : 25$cm^3$of 0.2M potassium chloride was mixed with 48.5cm^3 of 0.2M hydrochloric acid then transferred to 100cm^3 volumetric flask, and completed to the mark with distilled water

Buffer 2: prepared by adding 65cm^3 of (0.2M)HCl to 250Cm^3 of (0.2M)KCl solution and diluting to the mark with water.

Buffer 3: prepared by adding 203.7 ml of (0.2M)KCl solution to 500 ml of potassium hydrogen phthalate solution(0.1M) and diluting to one liter with distilled water.

Buffer 4: prepared by adding 147 ml of potassium chloride solution (0.1M)to 500 ml of potassium hydrogen phthalate solution(0.1M) and diluting to one liter with distilled water.

Buffer 5: prepared by adding 226 ml sodium hydroxide solution(0.1M) to 500 ml of potassium hydrogen phthalate solution(0.1M) and diluting to one liter with distilled water.

Buffer 6: prepared by adding 764 ml of sodium acetate solution (0.05M) to36 ml of acetic acid solution(0.05M) and the volume was completed to one liter with distilled water.

Buffer 7: prepared by adding 291 ml sodium hydroxide solution (0.1M) to 500 ml of potassium hydrogen phthalate solution (0.1M) and diluting to one liter with distilled water. All buffer solutions were prepared were adjusted to their pH using a pH meter.

2.9 Preparation of standard metals solution

Preparation of 1000ppm iron (III) solution

2.9g of ferric chloride were weighted, dissolved in 200 cm^3 in small volume of water to which 10 $cm^3$of sulfuric acid were then added, cooled, transferred to 1-dm^3 volumetric flask and completed to volume with distilled water.

Preparation of 1000ppm copper (II) solution

3.93g of copper sulfate were weighted, dissolved in small volume of water, transferred quantitatively to 1-dm^3 volumetric flask and completed to the mark with distilled water.

Preparation of 1000ppm vanadium (V) solution

2.3g of ammonium metavanadium were weighted, dissolved in small volume of water on warming, cooled, transferred quantitatively to 1-dm^3 volumetric flask and completed to volume with distilled water.

Preparation of 1000ppm cobalt (II) solution

4.036g of cobalt nitrate were weighted, dissolved in 20 cm^3 of 2M hydrochloric acid on warming, cooled, transferred quantitatively to 1-dm^3 volumetric flask and completed to volume with distilled water.

Preparation of 1000ppm manganese (II) solution

3.93g of manganese chloride were weighted, dissolved in small volume of water, transferred quantitatively to 1-dm^3 volumetric flask and completed to volume with distilled water.

Preparation of 1000ppm Zinc (II) solution

3.93g of zinc chloride were weighted, dissolved in small volume of water, transferred quantitatively to 1-dm^3 volumetric flask and completed to volume with distilled water.

Chapter 3

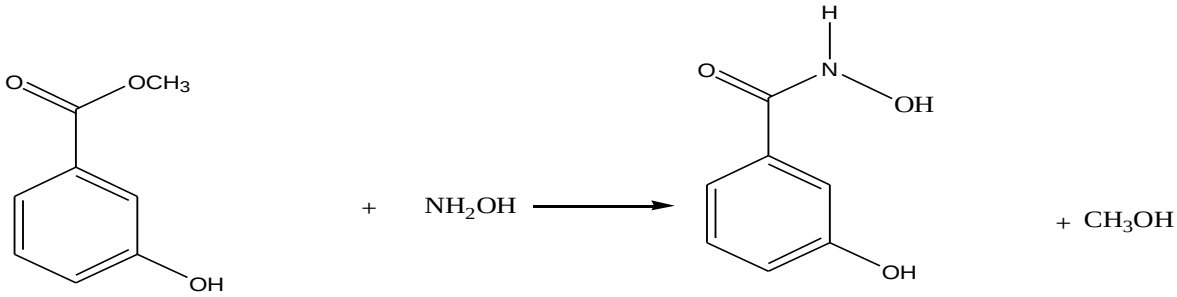
3 .Results and discussion

3.1Preparation of hydroxamic acids:

One of the most useful methods for the preparation of hydroxamic acids is by using Baltts method, reaction of ester and hydroxylamine in a basic medium

$RCO_2R + NH_2OH \rightarrow RCO - NHOH$

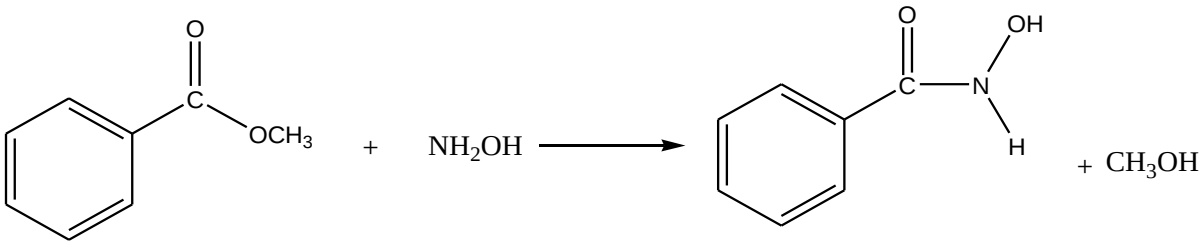
Firstly salicylohydroxamic acid were prepared by the reaction of methyl salicylate and hydroxylamine in a basic medium sodium hydroxide, which was added to neutralize the liberated hydrogen chloride, When hydroxylamine reacts with methyl salicylate hydrogen atoms attached to nitrogen and oxygen are attacked producing mono hydroxamic acids. the solution of mono hydroxamic acid acidified by sulfuric acid to obtained solid hydroxamic acid at least recrestalizes by littile acetic acid in a hot water . The full equation represent this preparation was shown in scheme



Scheme (1) The preparation of salicylohydroxamic acid

Secondly, benzohydroxamic acid were prepared by the reaction of methyl benzaoate and hydroxylamine in a basic medium sodium hydroxide, which was added to neutralize the liberated hydrogen chloride, When hydroxyl

amine reacts with methyl benzaoate hydrogen atoms attached to nitrogen and oxygen are attacked producing mono hydroxamic acids. The solution of mono hydroxamic acid acidified by hydrochloric acid to obtained solid hydroxamic acid at least recrestalizes by methanol. The two hydroxamic acids prepared are white crystalline solids. They are readily soluble in organic solvents such as alcohols, benzene, chloroform and ethyl acetate. The full equation represent this preparation was shown in scheme



Scheme (2) The preparation of benzohydroxamic acid

The hydroxamic acids, were prepared to study their complexing ablity towards Zn(II), Cu(II), Fe (III), Co(II),Mn(II) , V (V).

3.2. Characterization and identification of hydroxamic acids:

3.2.1 Color test

The hydroxamic acids prepared were characterized by their reaction with V (V) and Fe(III) solutions, which give violet and blood-red colors with V(V) and Fe(III) solutions respectively.

3.2.2Melting points

The melting points for a chemical compound is one of the characteristic the prepared qualitative parameter , the melting points for the prepared hydroxamic acids, BHA , SHA (128) and (169C°) respectively . Is found to agree with those reported in the literature for hydroxamic acid .

3.2.3. Infrared (FT-IR) analysis of hydroxamic acid

The vibrational frequencies for the infrared spectra of the two hydroxamic acids were shown by their characteristic functional groups C=O, O – H, N – O and C – N

Table (3.1) shows FTIR vibrational frequencies the characteristic functional groups of subistituted hydroxamic acids

Table (3.1) IR spectrum of hydroxamic acid

Hydroxamic acid	C=O	OH	N-O	C-N
Salicylohydroxamic Acid	1614	3288	907	1353
Benzohydroxamic Acid	1687	3065	903	1324

There is a strong peaks at 1687 and 1614cm^{1-} due to ν(C=O) and 3288 and 3065cm^{-1} due to ν(O–H). In general, the ν(C–N) peaks at ranges 1353, 1324 cm^{-1} and 903,907 due to ν(N–O) for BHA ,SHA respectively.

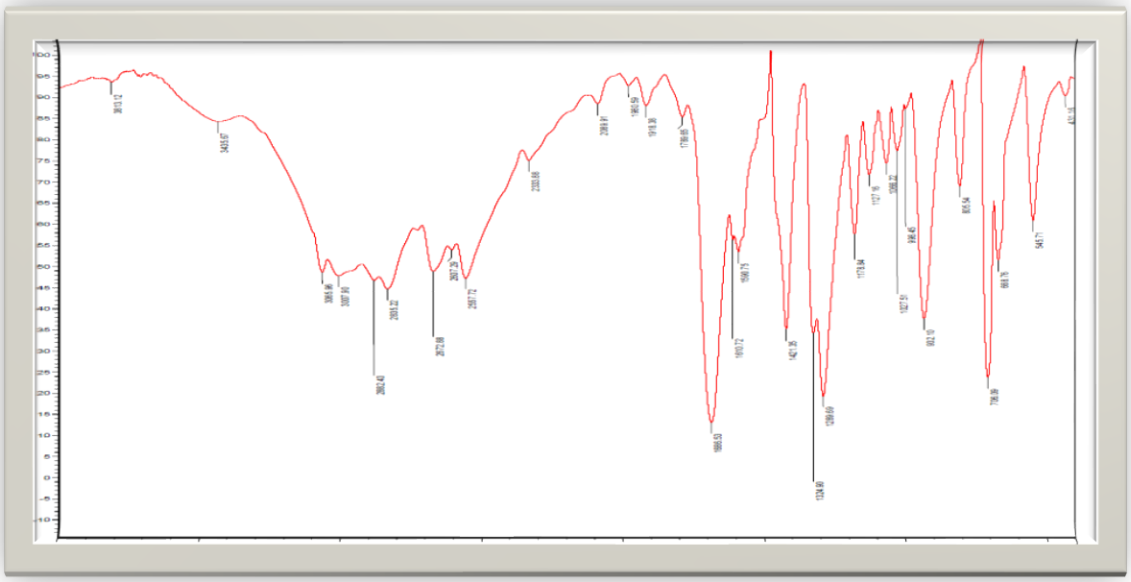


Figure 3.1: FT-IR spectrum of salicylohydroxamic acid

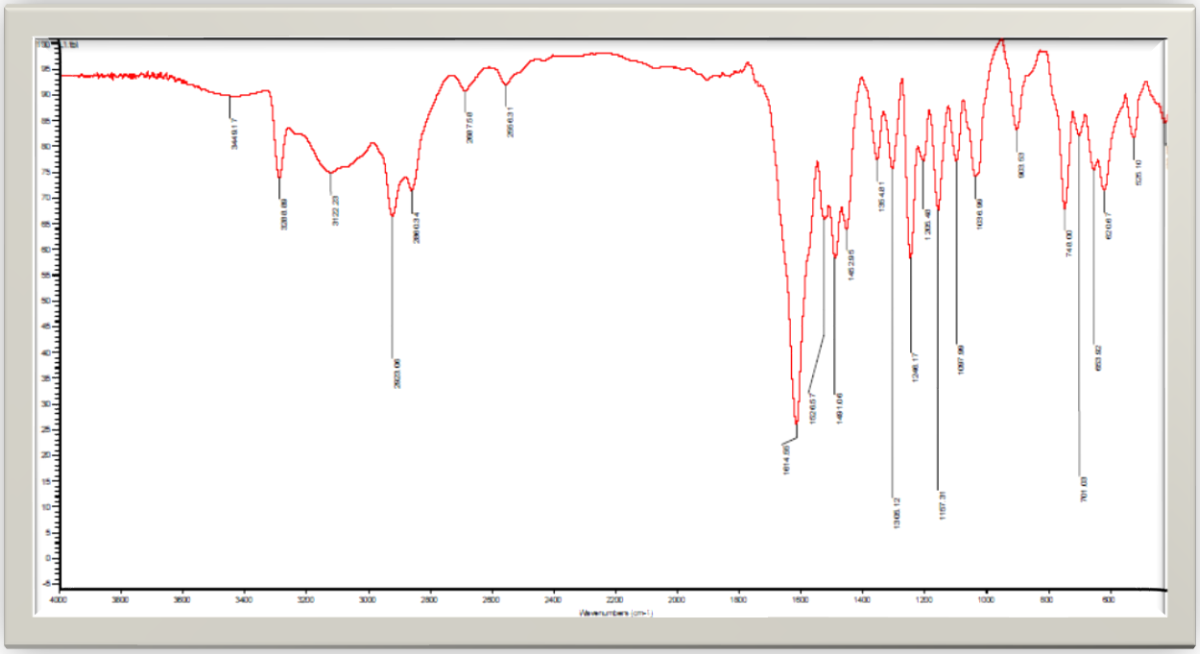


Figure 3.2: FT-IR spectrum of benzohydroxamic acid

3.2.4. Proton (^{1}H) Nuclear Magnetic resonance (^{1}H NMR)

The ^{1}H NMR spectra of the hydroxamic acid, Fig 3.3 and 3.4 shows that similarly δ(ppm) for (BHA 7.411-7.777 , SHA6.82 –7.83) due to proton of aromatic ring , for (BHA ,3.1 , 3.3 SHA ,3.1-3.9) attributed to NH , for (BHA 10-10.3 , SHA 11. 41 – 12.20) indicated to OH . The shifting of the resonance signal of hydroxyl proton to lower field supports intermolecular hydrogen bonding ,the phenolic hydrogen in SHA did not appear because it was replaced by Na(from Na_2Co_3) used to enhance its solubility in DO_2

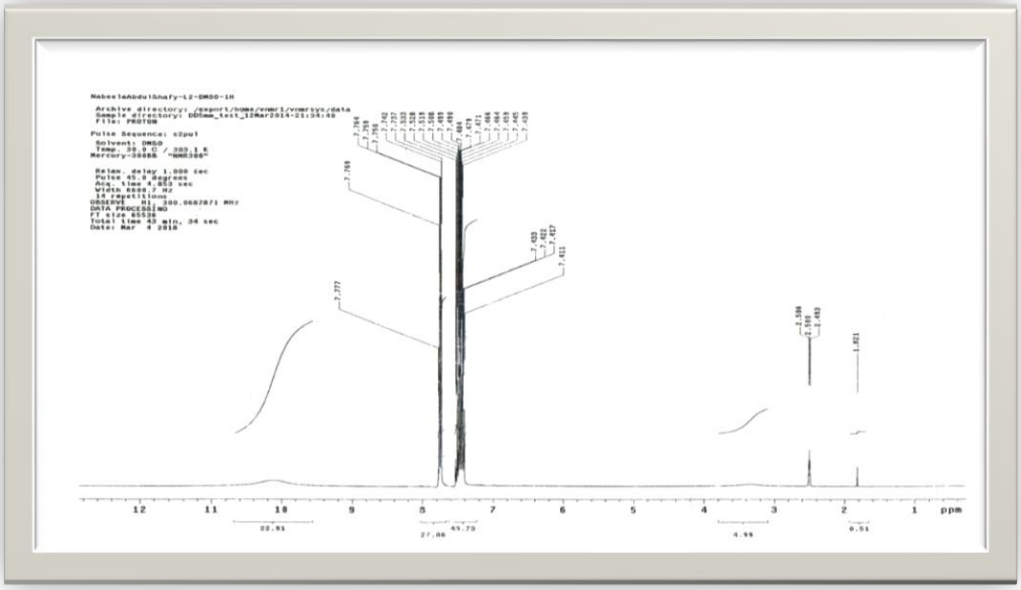


Figure 3.3: ^{1}H NMR spectrum of Salicylohydroxamic acid

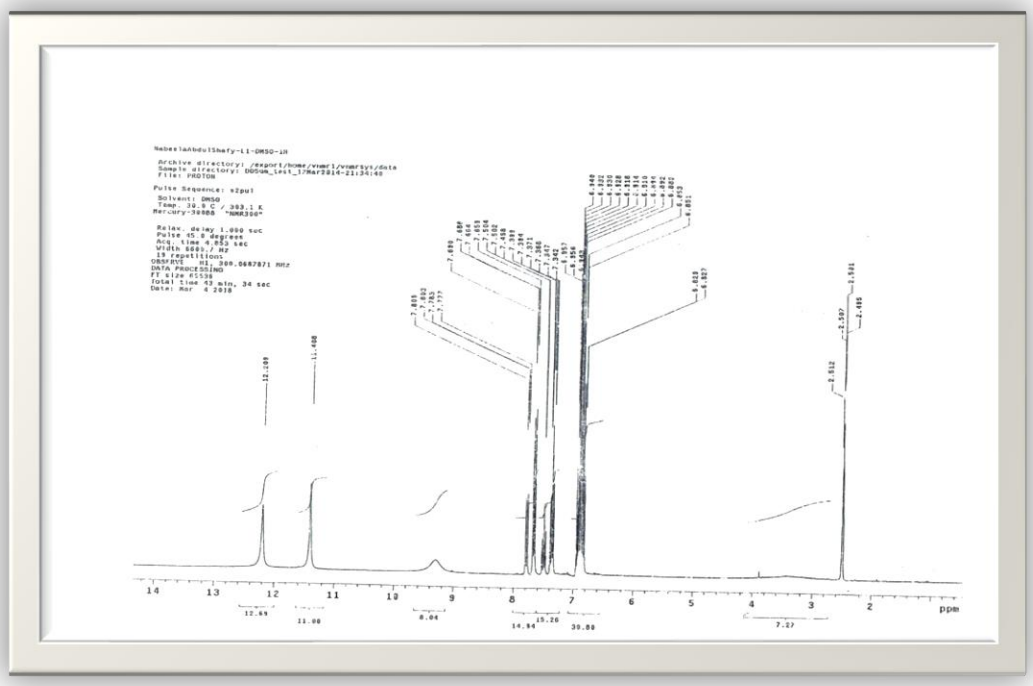


Figure 3.4: ^{1}H NMR spectrum of benzohydroxamic acid

3.2.5 Mass spectra of salicylohydroxamic acid

The Mass spectra of the salicylohydroxamic acid . The correct molecular mass of salicylohydroxamic acid(153) and fragment sequence of 135, 120, and 92.9corresponding to loss OH, NH, CO respectively and remaining C_6H_4OH

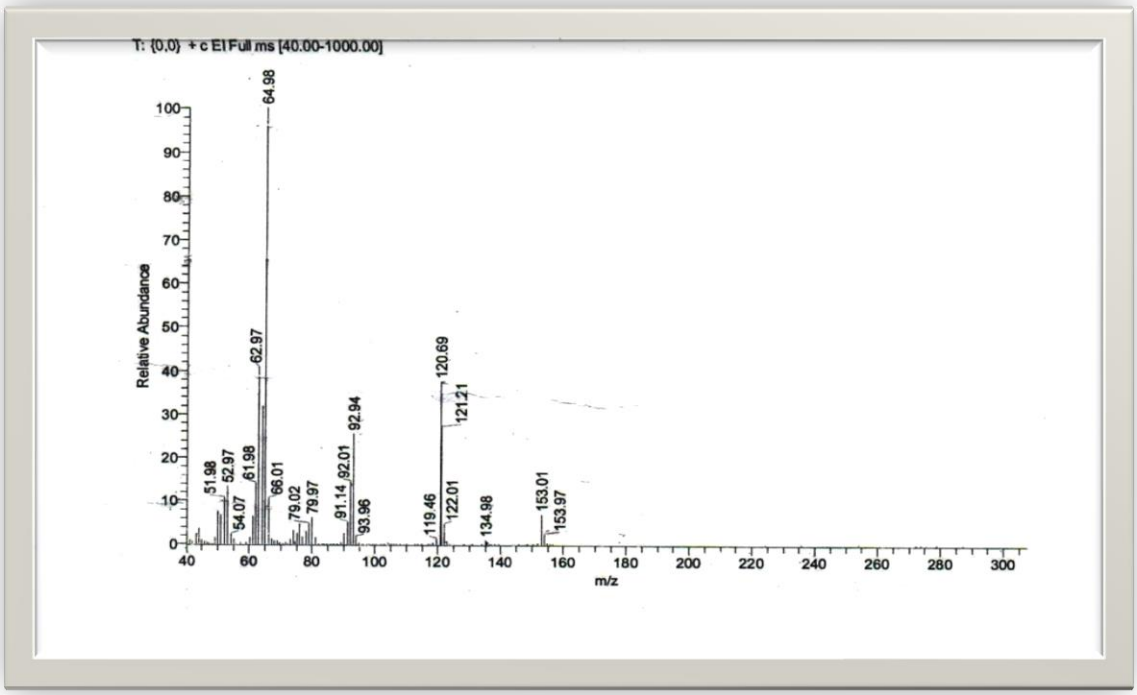


Figure 3.5:Mass spectrum of salicylohydroxamic acid

3.2.6 Mass spectra of benzohydroxamic acid

Mass spectra of the benzohydroxamic acid. The correct molecular mass benzohydroxamic acid (137.01) and fragment sequence of 104, corresponding to loss OH. NH, C:O respectively. And remaining 76 the remaing correspond aromatic ring.

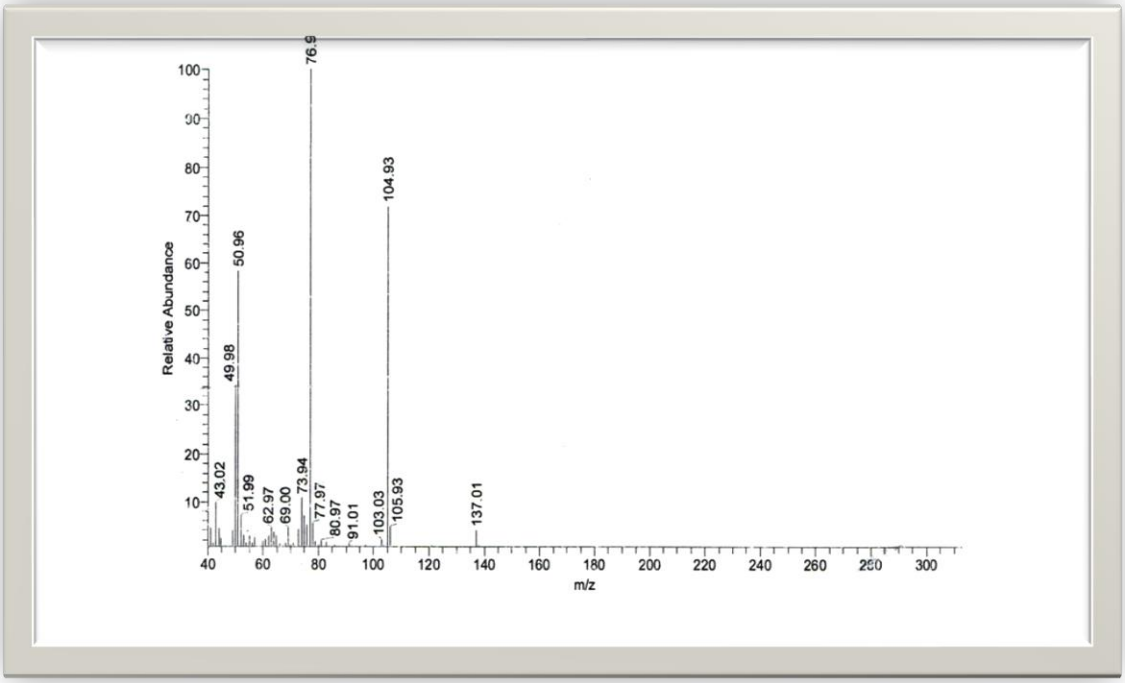


Figure 3.6:Mass spectrum of benzohydroxamic acid

3.3Characterization and identification of hydroxamic acids complexes:

3.3.1 carbon, hydrogen and nitrogen elemental analysis (CHN):

Chemical analysis for carbon, hydrogen and nitrogen were determined by microanalysis using FLASH EA 1112 SERIES CHNS O elemental analyzer. the elemental analysis of the some complexes are summarized in table(3.2) and(3.3).The results of elemental analysis agreed well with the proposed formula

Table (3.2): colours, yield, and elemental analysis of Salicylohydroxamic acid complexes:

Salicylhydroxamic complexes	Colour	Yield %	M.wt	%C Found (Calc.)	%H Found (Calc.)	%N Found (Calc.)
zinc salicylohydroxamate	white	55.4	435.58	17.95 (19.72)	1.74 (2.36)	2.11 (3.22)
Copper salicylohydroxamate	Green	56.3	386.059	23.45 (22.78)	2.08 (2.35)	3.25 (3.63)
Iron salicylohydroxamate	Reddish brown	60.6	469	32.37 (30.0)	3.05 (4.6)	5.33 (5.0)
Cobalt salicylohydroxamate	brown	56.3	383.226	44.65 (43.37)	4.36 (3.16)	7.52 (7.31)
Mangenese salicylohydroxamate	white	56.4	279.562	30.81 (30.07)	2.57 (3.6)	4.96 (5.01)
Nikel salicylohydroxamate	Pale green	50	283.332	29.67 (29.52)	3.55 (3.47)	4.94 (4.96)

Table (3.3) colours, yield, and elemental analysis, of Benzohydroxamic acid complexes:

benzohydroxamic complexes	Colour	Yield %	M.wt	%C Found (Calc.)	%H Found (Calc.)	%N Found (Calc.)
zinc benzohydroxamate	white	55.4	393.506	22.30 (21.36)	1.74 (3.07)	2.16 (3.56)
Copper benzohydroxamate	Green	56.3	472.18	36.25 (35.62)	2.59 (2.71)	6.089 (5.93)
Iron benzohydroxamate	Reddish brown	60.6	299.572	28.95 (28.06)	4.06 (3.36)	3.90 (4.67)
Cobalt benzohydroxamate	brown	56.3	389.074	22.58 (21.65)	2.24 (3.61)	6.53 (7.20)
Mangenese benzohydroxamate	white	56.4	472.61	35.93 (35.5)	3.26 (2.96)	6.02 (5.92)
Nikel benzohydroxamate	Pale green	50	512.845	14.76 (16.3)	3.05 (2.55)	4.94 (2.7)

3.3.2 Infrared spectrum of salicylhydroxamic acid complexes with

Table 3.5 and Figure 3.13 -3.18 shows FTIR spectrum of salicylohydroxamic acid complexes with Zn(II) , Cu(II) , Fe(III) , Co(II) , Mn(II) and Ni(II)

1- C=O frequencies for Zn(II) , Cu(II) , Fe(III) , Co(II) , Mn(II) and Ni(II) complexes were observed at range of 1601to 1572 cm^{-1} respectively .

2- N- O absorption appear at range of 947 to 915 cm^{-1} respectively . The shifting of to a lower wavenumber are indicating the involvement of C=O during complexation.

3- the peak at range of 1382 to1386 cm^{-1} were assigned to C-N frequencies

4- the complexes show band at 3300- 3400 cm^{-1}attributed to OH group.

Table (3.4) IR spectra of salicylhydroxamic complexes:

complexes	C=O	C-N	N-O	prH_2O
zinc salicylohydroxamate	1599	1416	947	3410
Copper salicylohydroxamate	1571	1384	946	3448
Iron salicylohydroxamate	1600	1388	923	3404
Cobalt salicylohydroxamate	1597	1384	915	3323
Mangenese salicylohydroxamate	1601	1388	925	3398
Nikel salicylohydroxamate	1572	1376	917	3339

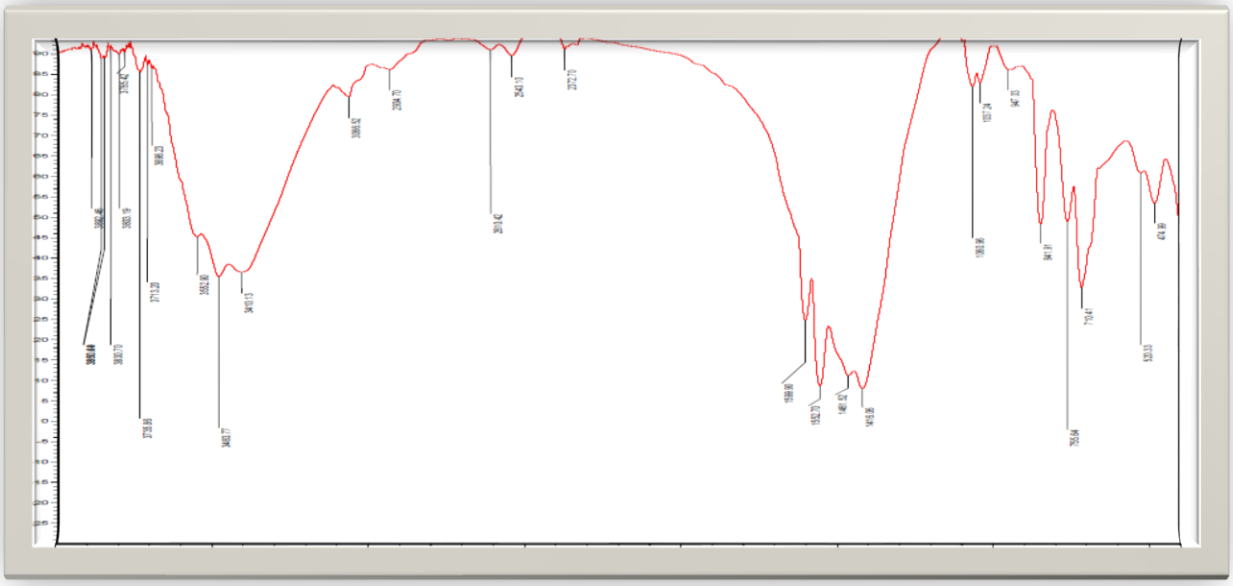


Figure 3.7: FT-IR spectrum of Zn-salicylohydroxamic acid

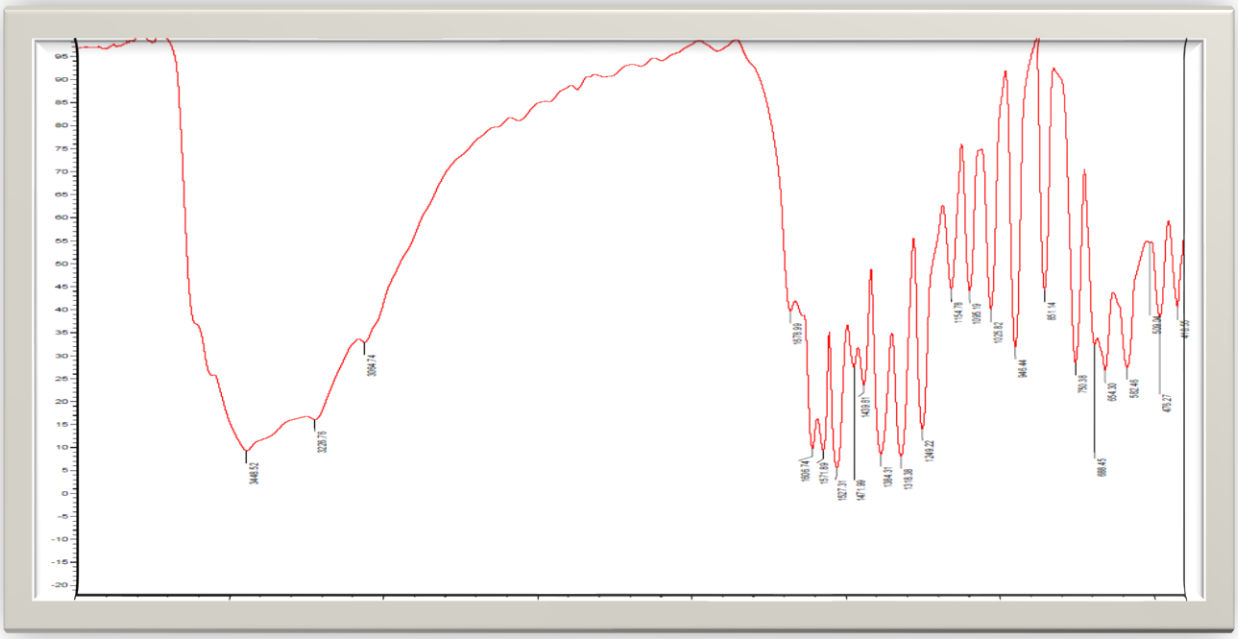


Figure 3.8: FT-IR spectrum of Cu-salicylohydroxamic acid

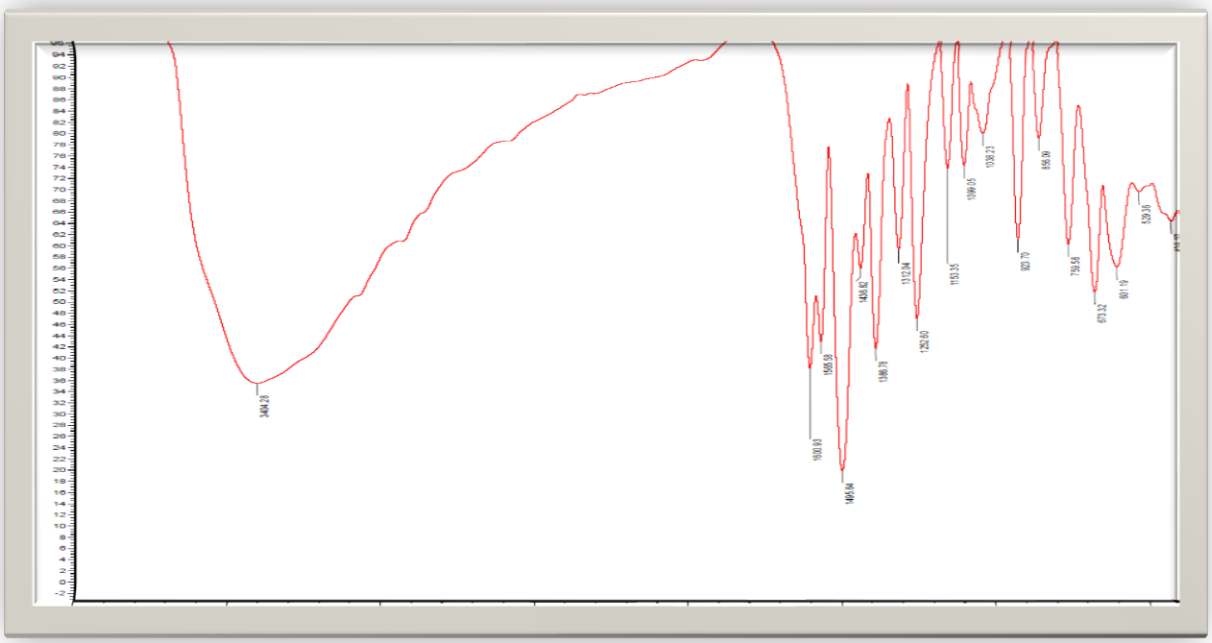


Figure 3.9: FT-IR spectrum of Fe-salicylohydroxamic acid

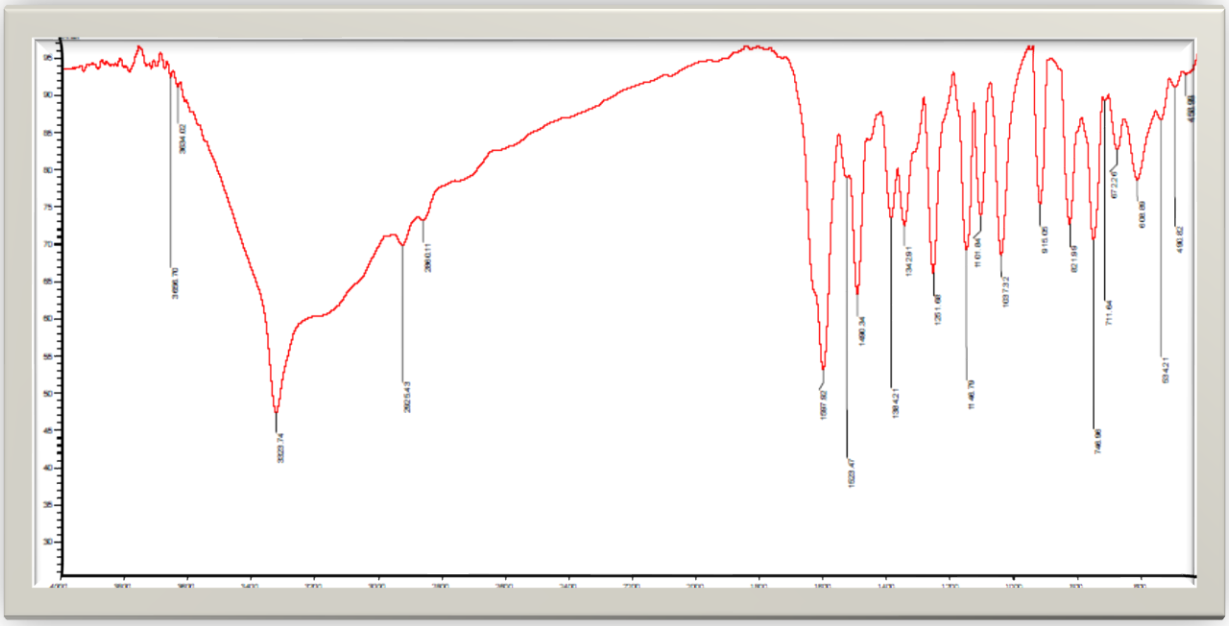


Figure 3.10: FT-IR spectrum of Co-salicylohydroxamic acid

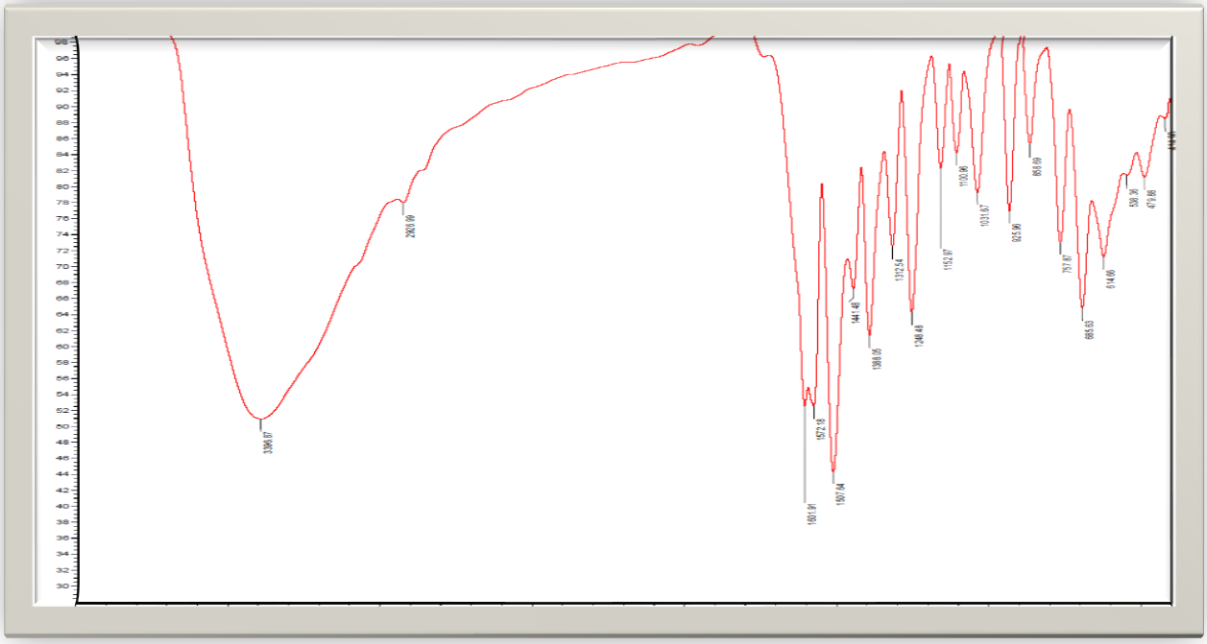


Figure 3.11: FT-IR spectrum of Mn-salicylohydroxamic acid

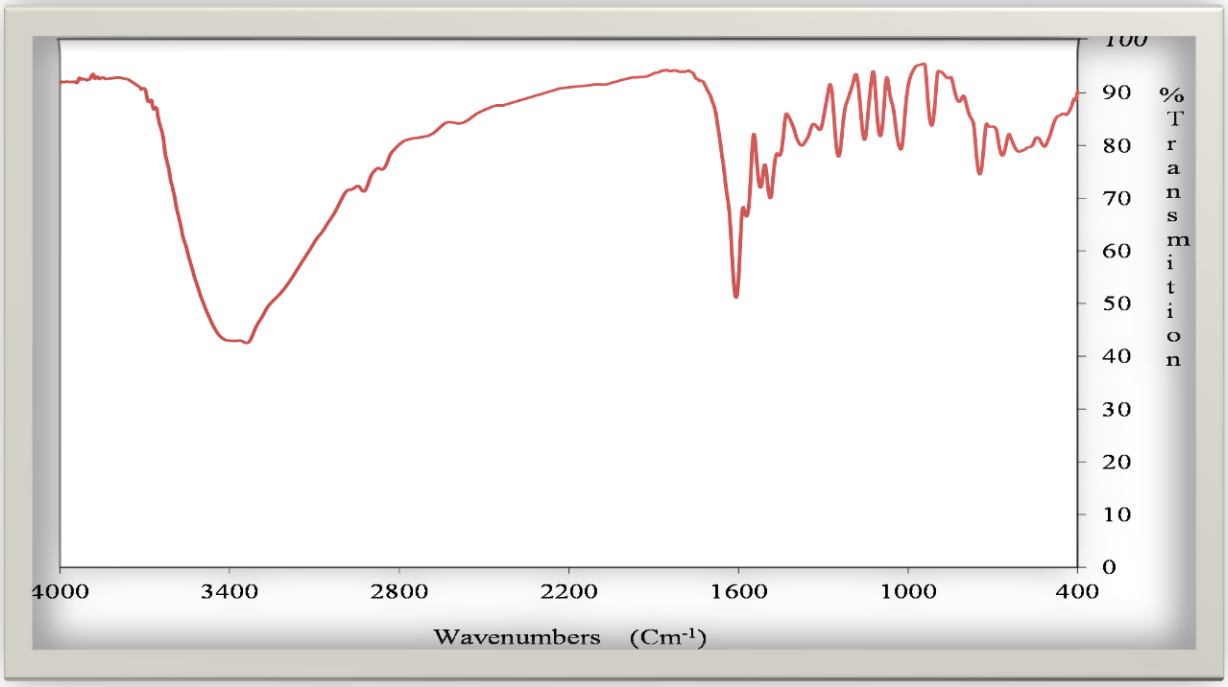


Figure 3.12: FT-IR spectrum of Ni-salicylohydroxamic acid

3.3.3 Infrared (FT-IR) analysis of benzohhydroxamic acid complexes

Table 3.4 and Figure 3.7 -3.12 shows FTIR spectrum of benzohhydroxamic acid complexes with Zn(II) , Cu(II) , Fe(III) , Co(II) , Mn(II) and Ni(II) : The infrared spectra of BHA and its metal complexes are quite different. The differences of the BHA and their metal complexes spectra are showed Figure (1). Hence, by comparing the ligand and the metal complexes spectrum

1- C=O frequencies for Zn(II) , Cu(II) , Fe(III) , Co(II) , Mn(II) , Ni(II) complexes were observed at range of 1608 to 1598 cm^{-1}. The shifting of to lower wave numbers indicates the involvement of C=O during complexation .

2- N- O absorption appear at range of 1035 to 918 cm^{-1} respectively .

3- the peak at range of 1382 to1386 cm^{-1} were assigned to C-N frequencies .

4- the complexes show band at range of 3300 to 3400 cm^{-1}attributed to OH group The shifting of ν(C=O) to lower wavenumber and disappearance of ν(O–H) in the metal complexes suggesting that the bonding of BHA to the metal salts via oxygen atoms of carbonyl and hydroxyl group

Table (3.5)IR spectra Absorption frequencies of benzohydroxamic metal complexes :

complexes	C=O	C-N	N-O	prH_2O
zinc benzohydroxamate	1598	1413	1029	3418
Copper benzohydroxamate	1600	1375	948	3427
Iron benzohydroxamate	1608	1376	1035	3481
Cobalt benzohydroxamate	1606	1387	1025	3415
Mangenese benzohydroxamate	1605	1383	918	3327
Nikel benzohydroxamate	1599	1395	989	3460

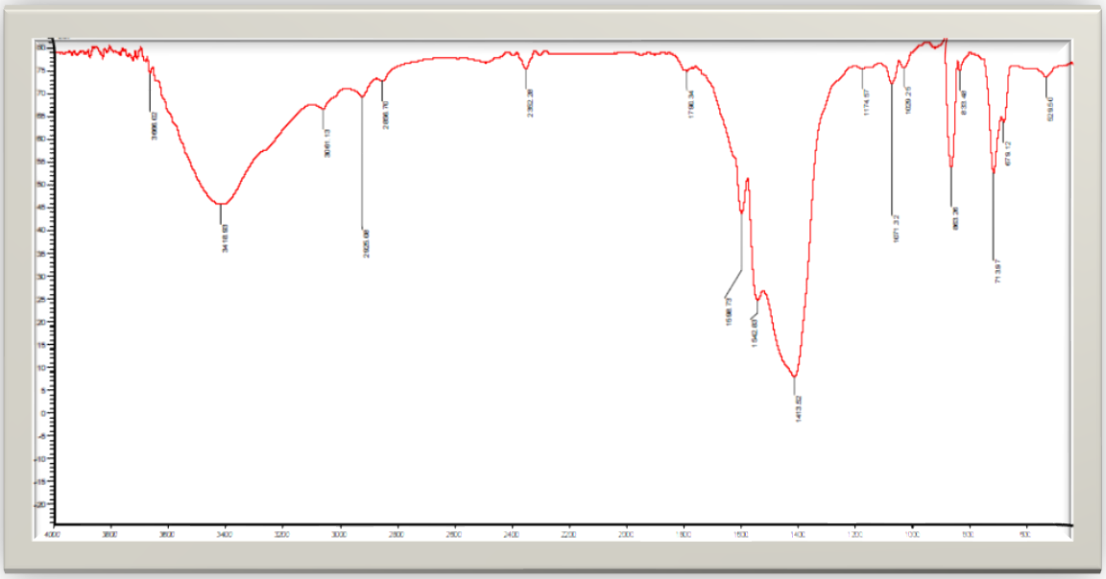


Figure 3.13: FT-IR spectrum of Zn-benzohydroxamic acid

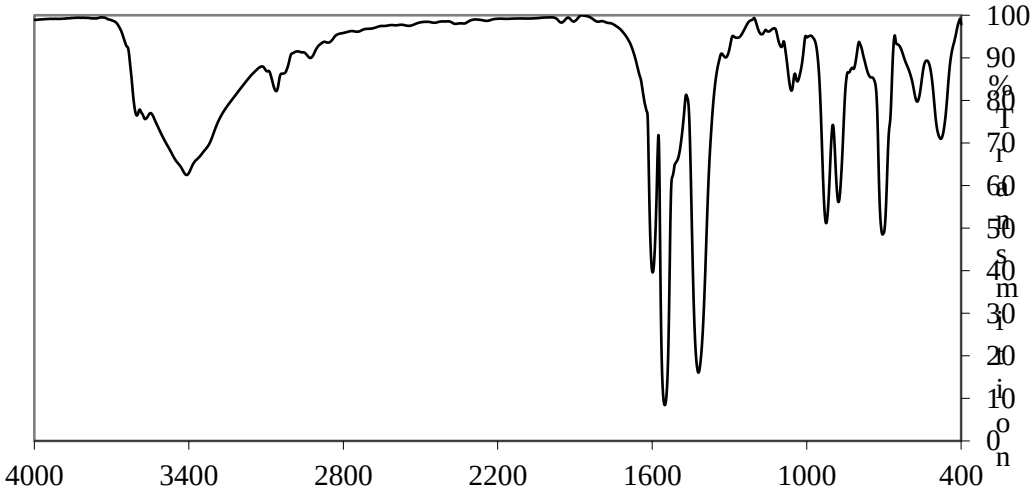


Figure 3.14: FT-IR spectrum of Cu-benzohydroxamic acid

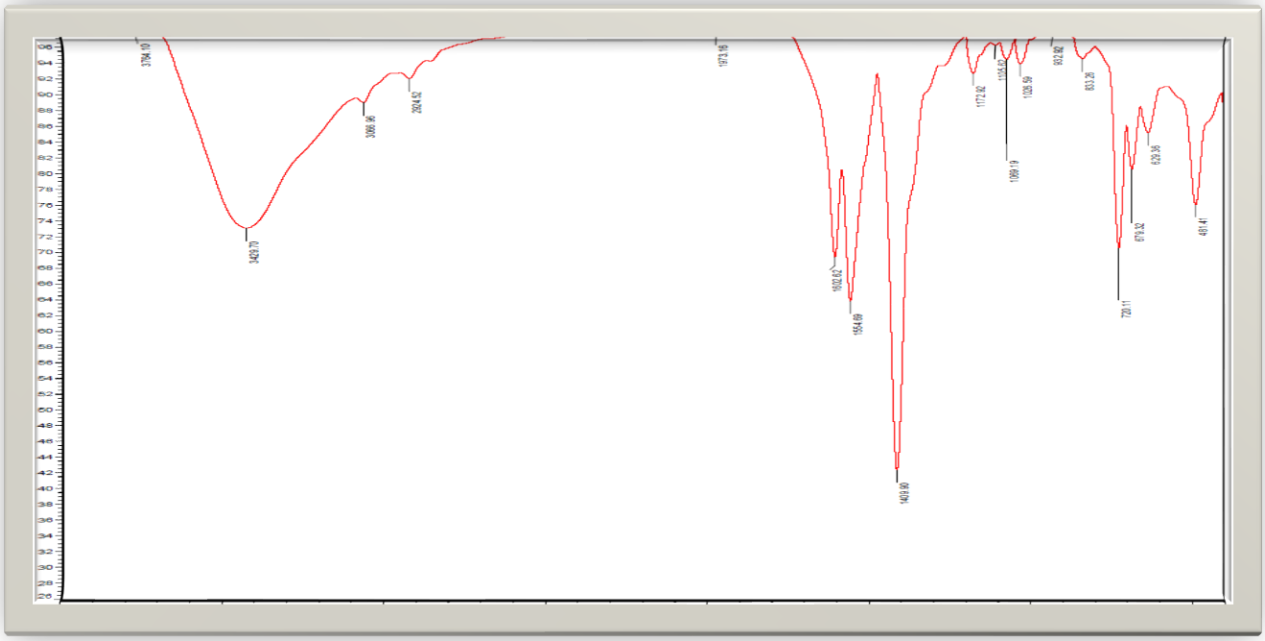


Figure 3.15: FT-IR spectrum of Fe-benzohydroxamic acid

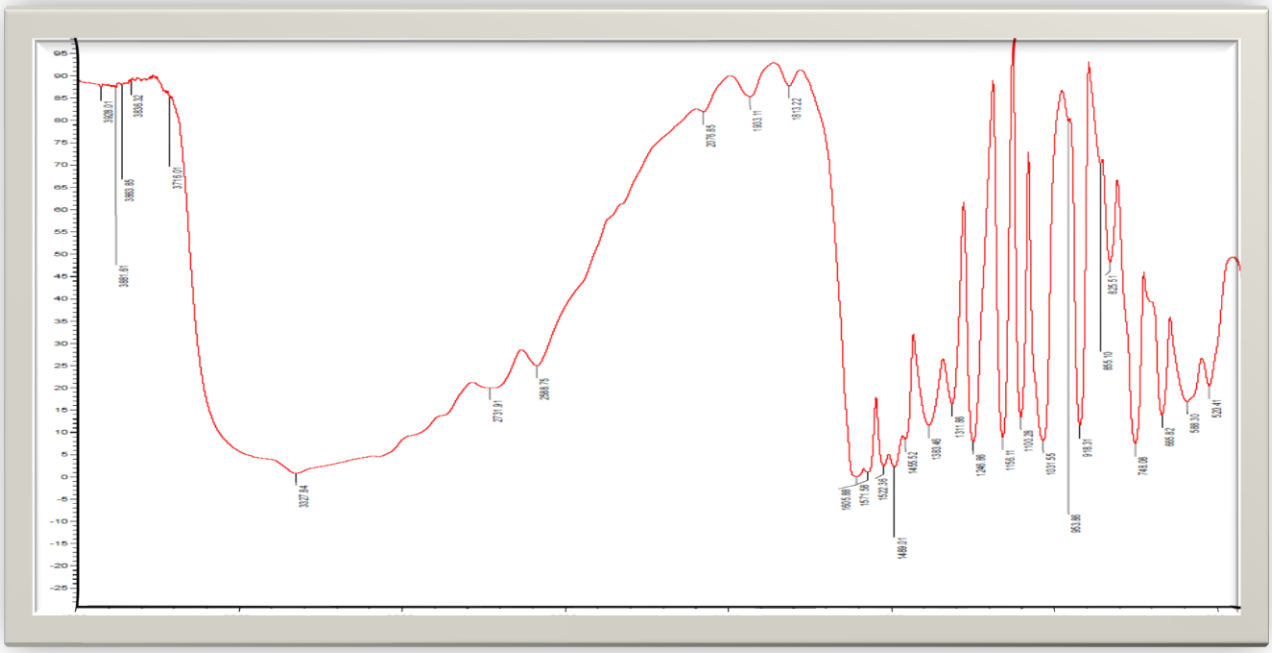


Figure 3.16: FT-IR spectrum of Mn-benzohydroxamic acid

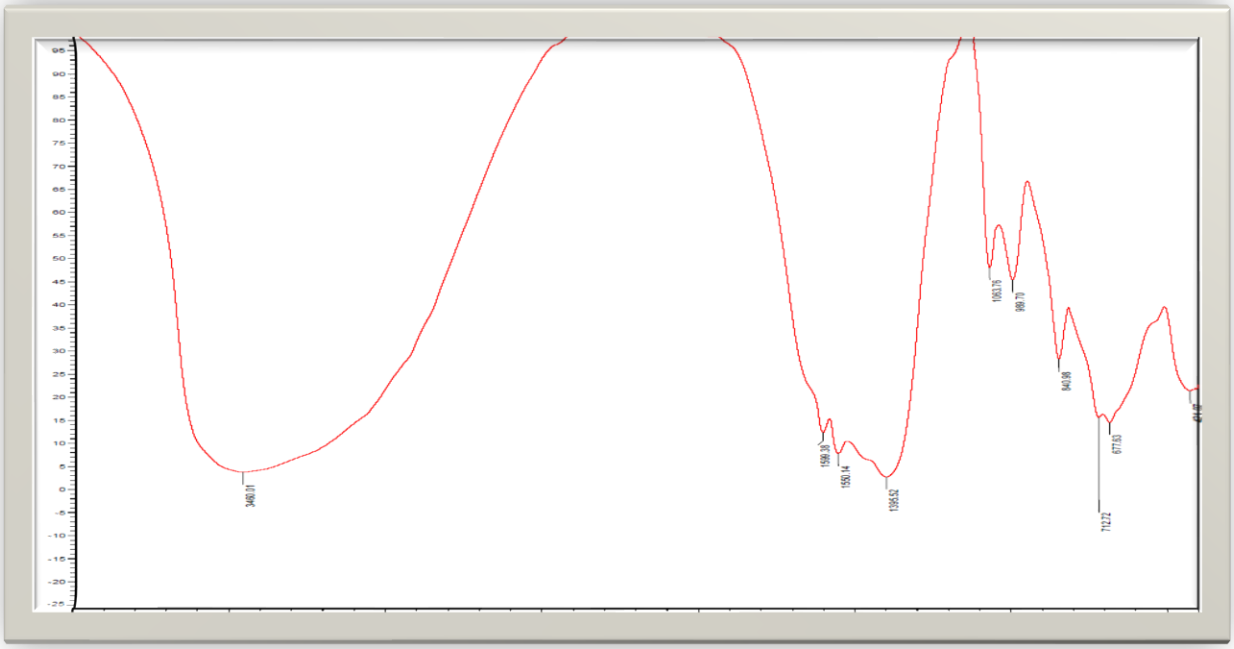


Figure 3.17: FT-IR spectrum of Ni-benzohydroxamic acid

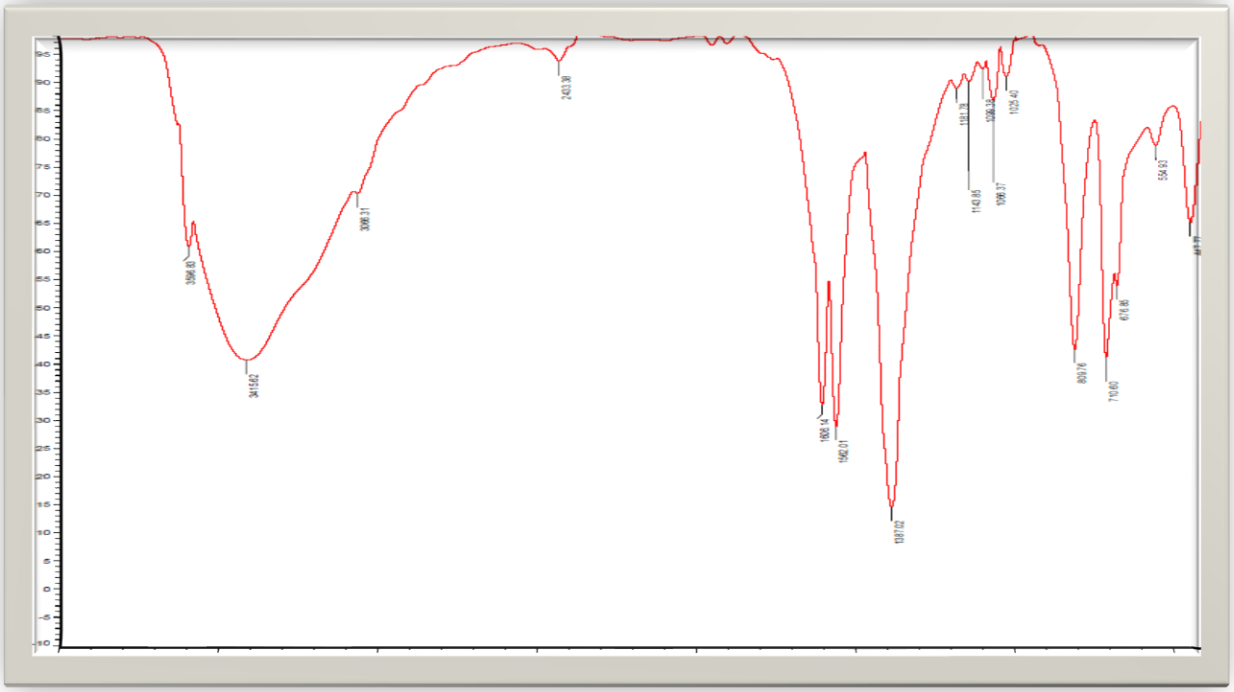


Figure 3.18: FT-IR spectrum Co-benzohydroxamic acid

3.3.4Thermogravimetric analysis (TGA) of hydroxamic acid complexes:

Thermogravimetric analysis (TGA) was carried out an a perkin – Elmer model TGS-2 instrument . Thermogravimetric analysis of some complexes were carried out to confirm the result obtained from other (elemental) analysis .The Thermogravimetric curves of complexes are shown in Fig (19 to 30) and the result obtained are summarized in table (6,7) . the simultaneous TGA analysis of Zn(II) , Cu(II) , Fe(III) , Co(II) , Mn(II) , Ni(II) complexes were invistigate from ambient temperature to 1000° .

The Thermogravimetric analysis result are similar for all the complexes , the mass loss occurred in two to three stage until the complexes are destroyed and the metal oxide is formed .

The first mass loss of complexes start around 50- 130 due to the loss of hydration water . De hydration take place and the molecules of crystallization water were eliminaed. for these complexes the second step took place around 130 -240C° due to loss of coordinated water .

The first decomposition step of complexes in the range of 240 – 500C° due to the deterioration of the hydroxamic acid molecule , and the second decomposition step of complexes in the range of 500 -990C° due to formation of corresponding oxide Cuo ,….etc

The TGA curve of complexes indicated the presence of water molecules outside and inside the coordination sphere. The proposed formula is [M-(L).(H_2O).]xH2O.

The result obtained are in good agreement with the theoretical formulae suggested from the elemental analysis. The TGA result summarized in Table (3.6) and (3.7)

Table (3.6)Thermogravimetric analysis (TGA) of salicylohydroxamic acid complexes

	Temprature		
Complexes	100- 240	240- 500	500-900
zinc salicylohydroxamate	Loss(5.944%) of hydration water	Deterioration(42.767%) of chloride and hydroxamic acid molecule.	Decomposition of all molecule and remaining Zno
Copper salicylohydroxamate	Loss(4.6%)of hydration water	Deterioration(54%) of chloride and hydroxamic acid molecule.	Decomposition of all molecule and remainingCuo
Iron salicylohydroxamate	Loss(13.53%)of molecule of hydration water	Deterioration(56%) of chloride and hydroxamic acid molecule.	Decomposition of all molecule and remainingFe_2O_3
Cobalt salicylohydroxamate	Loss(4%)of hydration water	Deterioration(79.56%) of hydroxamic acid molecule.	Decomposition of all molecule and remaining Cobalt oxide
Mangenese salicylohydroxamate	Loss(11.6%)of hydration water	Deterioration(50%) of chloride and hydroxamic acid molecule	Decomposition of all molecule and remainingMnO
Nikel salicylohydroxamate	Loss(17.36%)of two molecule of hydration water	Deterioration(66%) of chloride and hydroxamic acid.	Decomposition of all molecule and remainingNiO

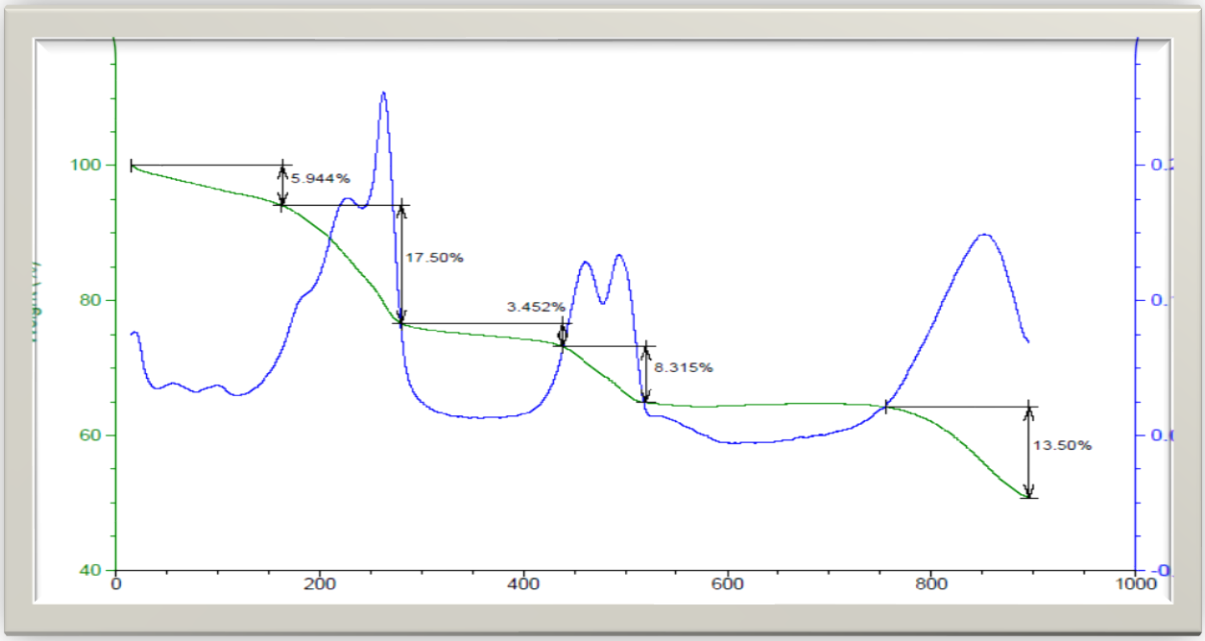


Figure 3.19: Thermogram of Zn-salicylohydroxamic acid

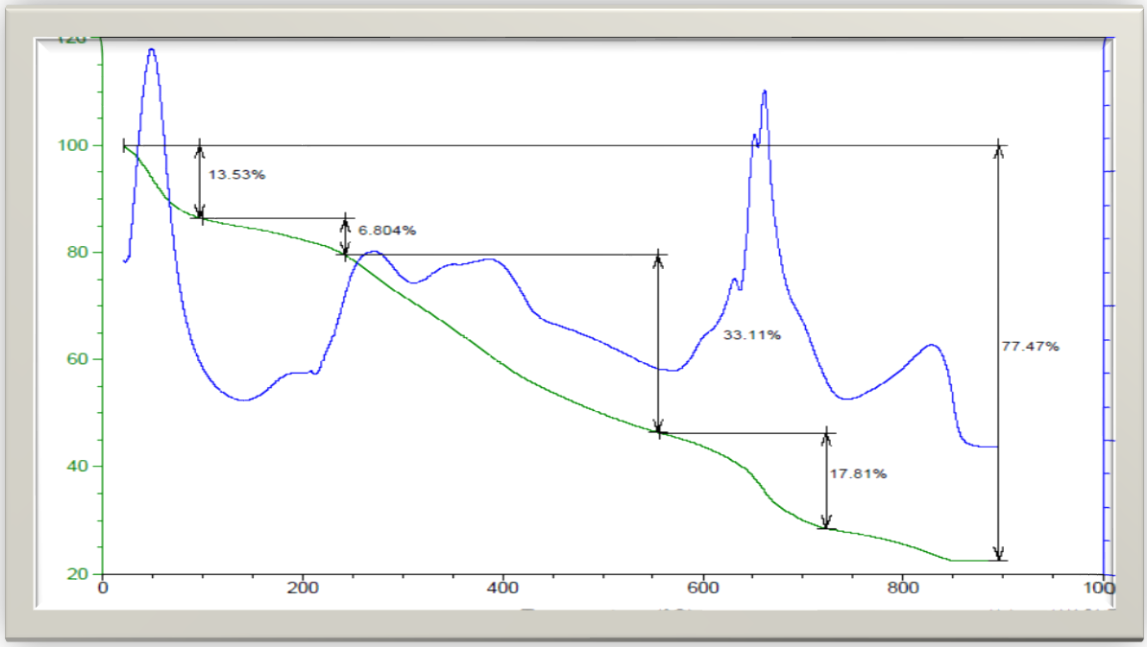


Figure 3.20: Thermogram Fe-salicylohydroxamic acid

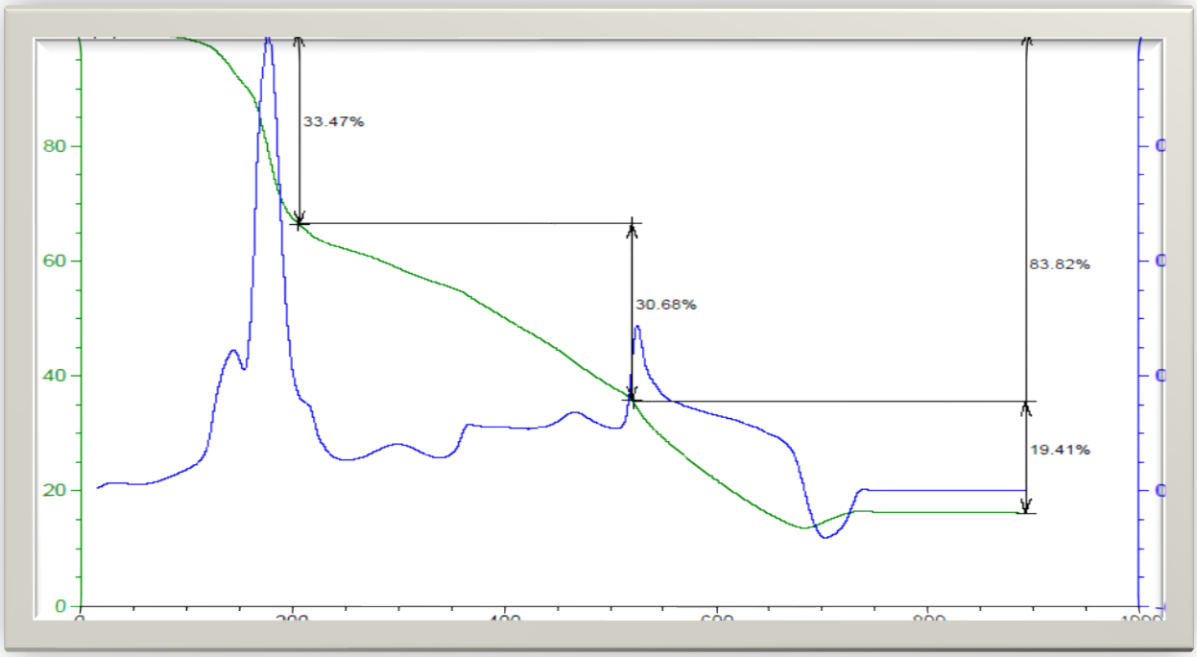


Figure 3.21: Thermogram of Co-salicylohydroxamic acid

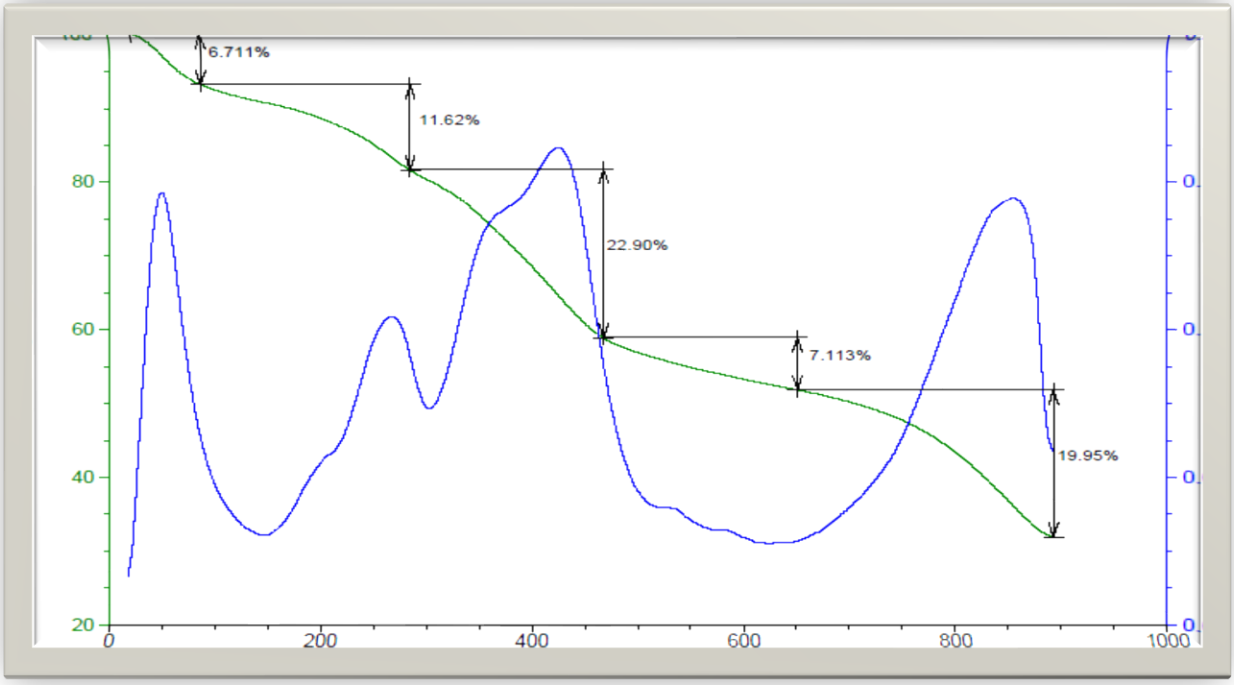


Figure 3.22: Thermogram of Mn-salicylohydroxamic acid

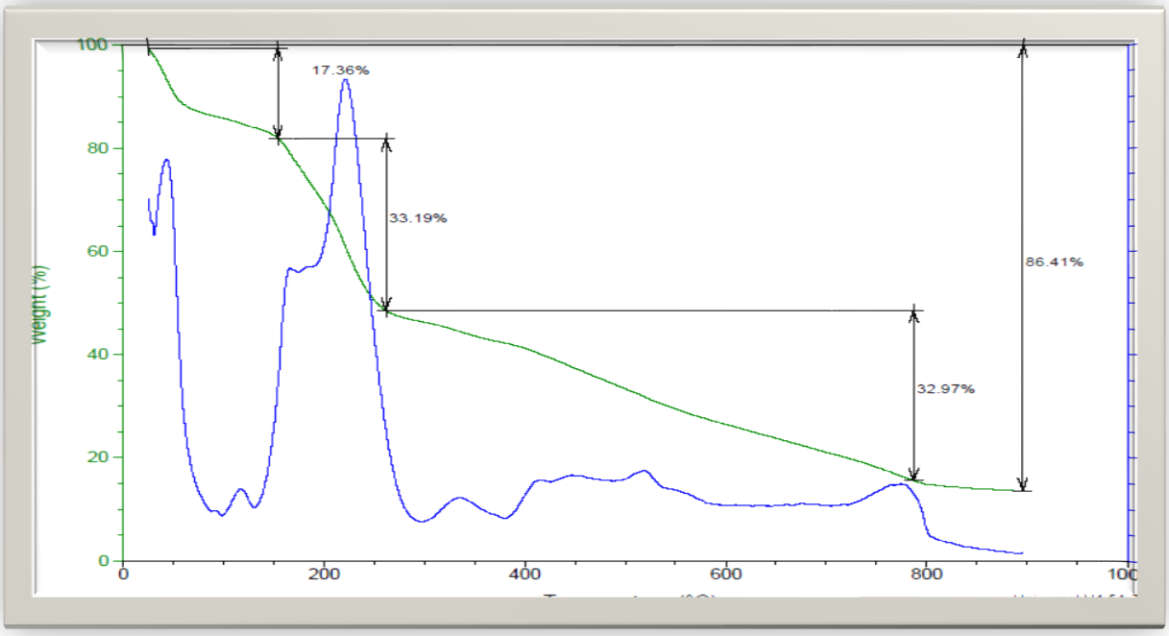


Figure 3.23: Thermogram of Ni-salicylohydroxamic acid

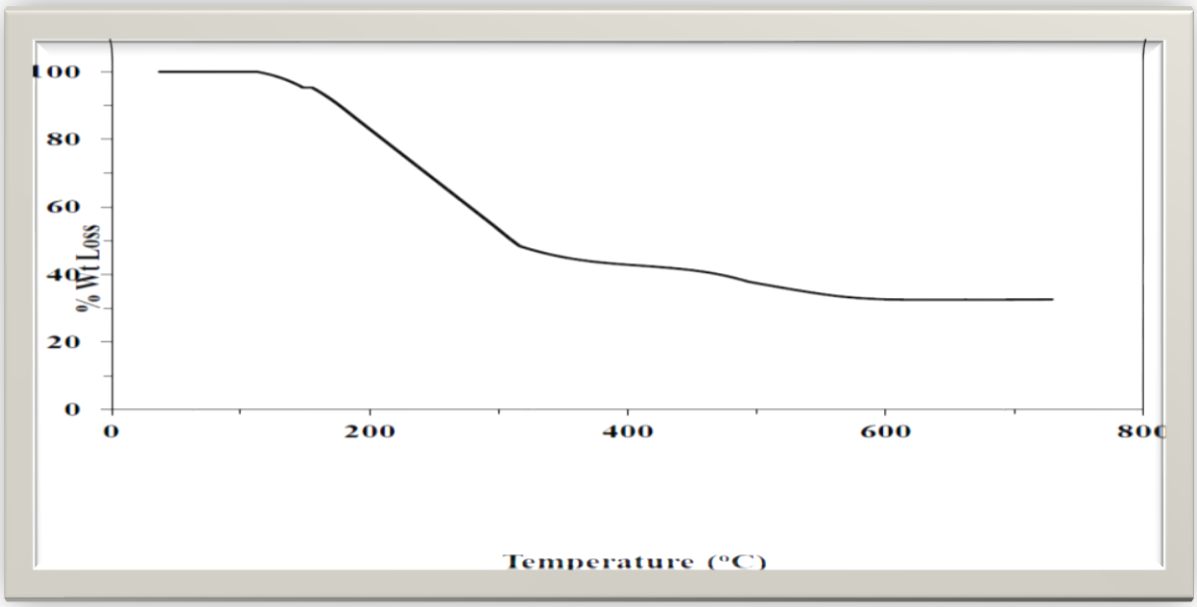


Figure 3.24: Thermogram of Cu-salicylohydroxamic acid

Table (3.7)Thermogravimetric analysis (TGA) of benzohydroxamic acid complexes

	Temprature		
Complexes	100- 240	240- 500	500-900
zinc benzohydroxamate	Loss(4.098%)of hydration water	Deterioration(67%) of chloride , coordinated water and hydroxamic acid molecule.	Decomposition of all molecule and remainingZno
Copper benzohydroxamate	Loss Moisture	Deterioration (55%) of chloride and hydroxamic acid molecule.	Decomposition of all molecule and remainingCuo
Iron benzohydroxamate	Loss(12.04%)of two molecule of hydration water	Deterioration(69%) of chloride and hydroxamic acid molecule.	Decomposition of all molecule and remainingFe_2O_3
Cobalt benzohydroxamate	Loss(8.834%)of hydration water	Deterioration(52.5%) of chloride and hydroxamic acid molecule.	Decomposition of all molecule and remaining Cobalt oxide
Mangenese benzohydroxamate	Loss(10.06%)of hydration water	Deterioration(64%) of chloride and hydroxamic acid molecule	Decomposition of all molecule and remainingMnO

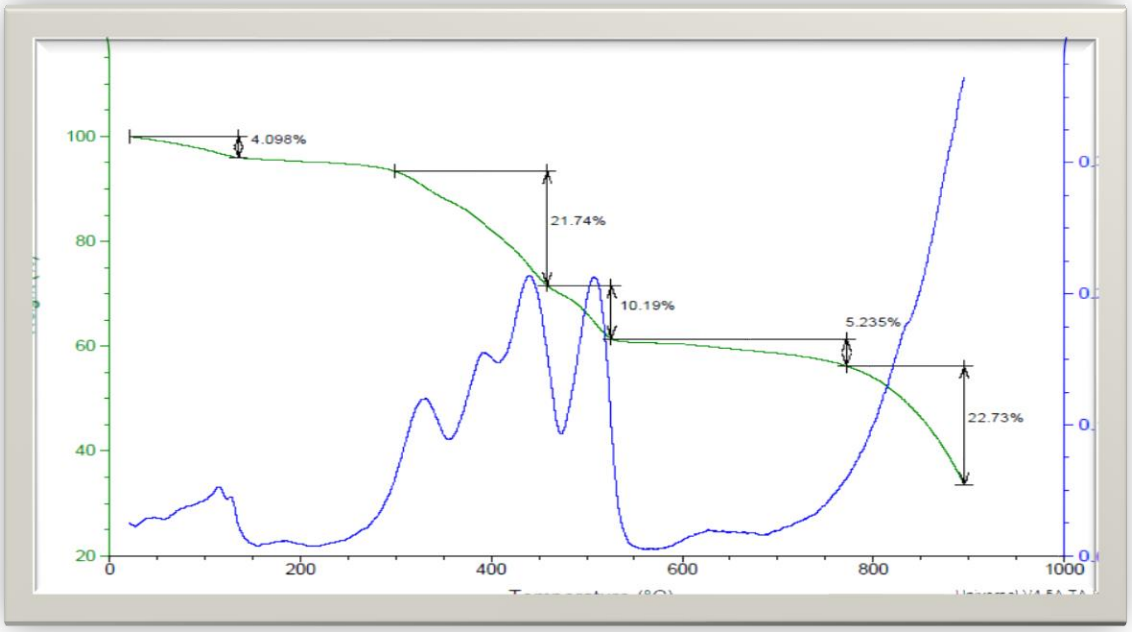


Figure 3.25: Thermogram of Zn-benzohydroxamic

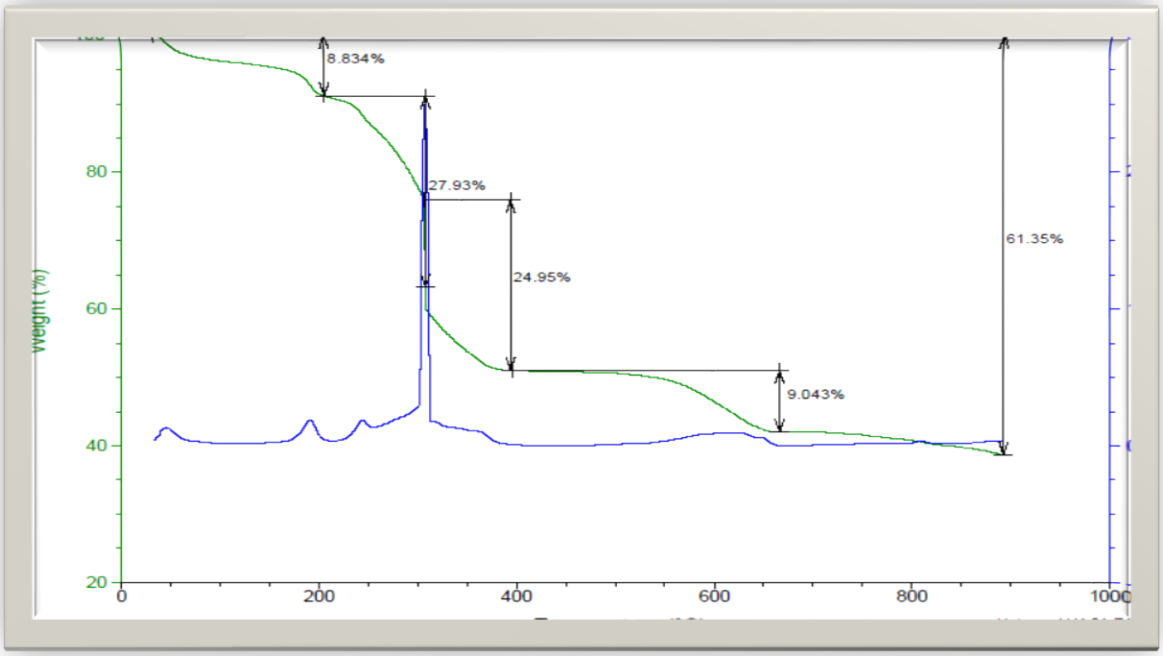


Figure 3.26: Thermogram of Co-benzohydroxamic acid

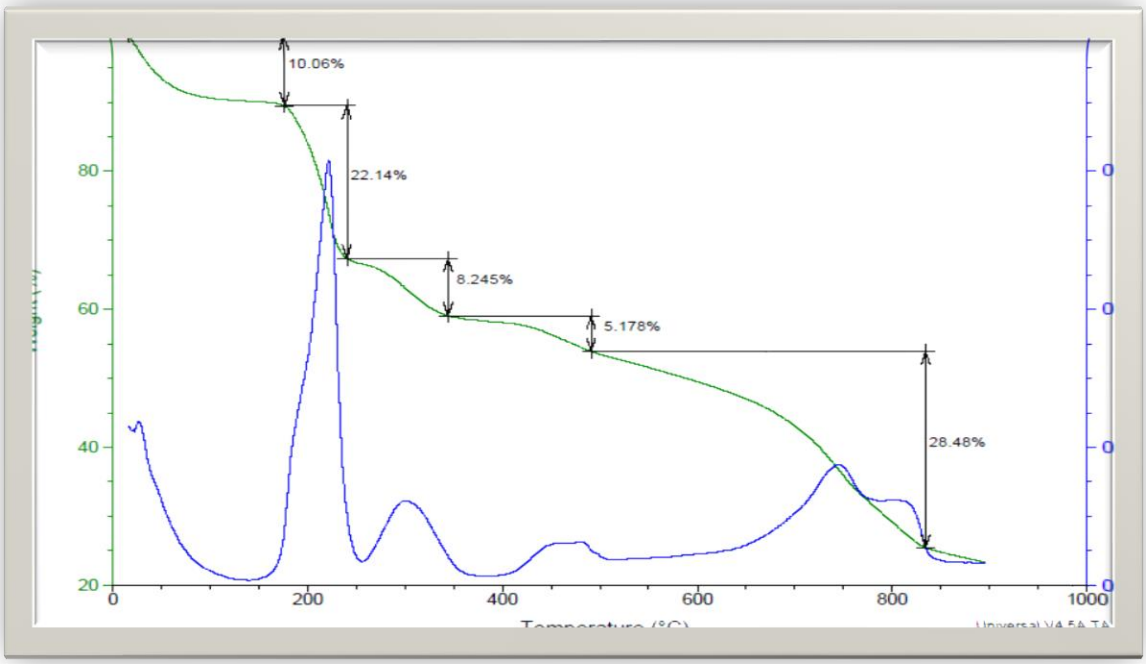


Figure 3.27: Thermogram of Mn-benzohydroxamic acid

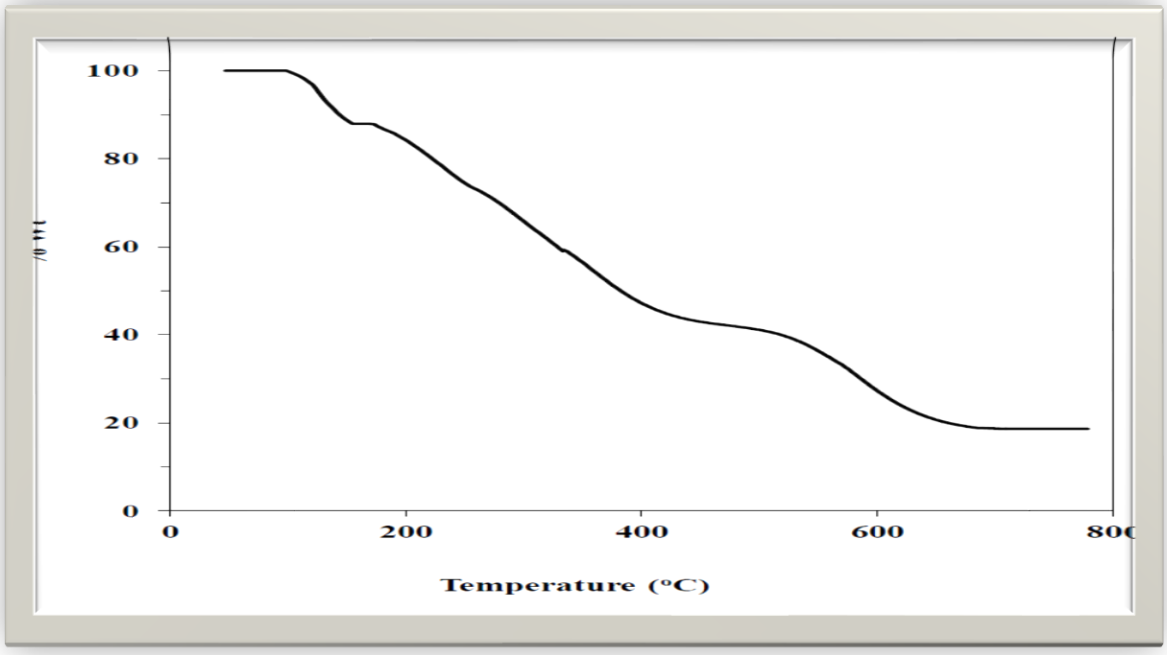


Figure 3.28: Thermogram of Fe-benzohydroxamic acid

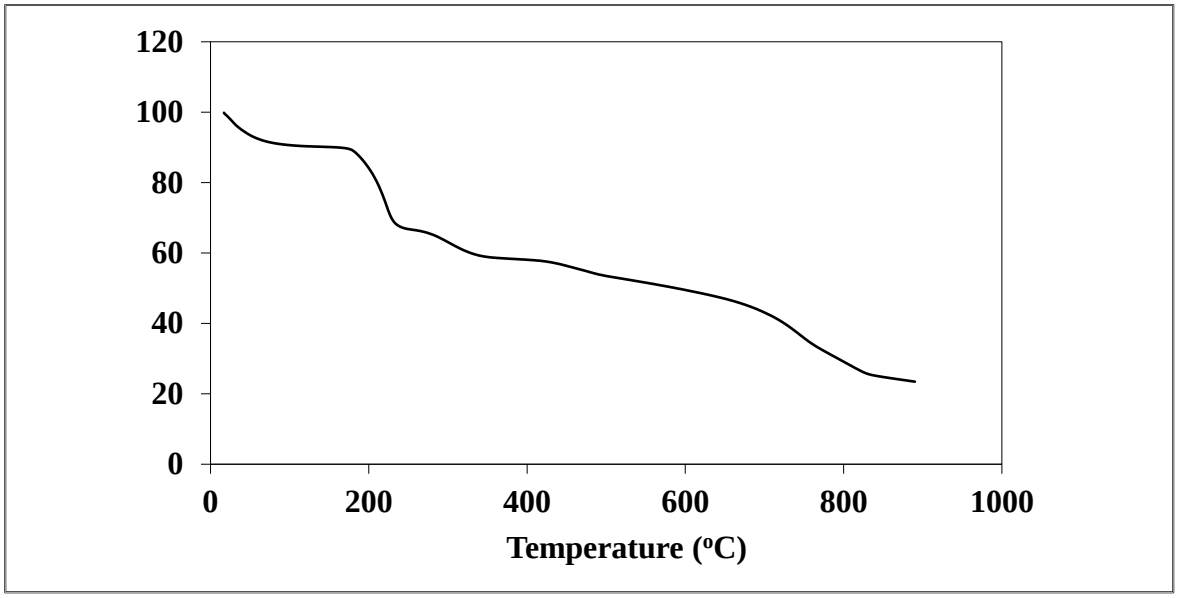


Figure 3.29: Thermogram of Cu-benzohydroxamic acid

3.3.5Magnetic susceptibility of some salicylohydroxamic acid complexes:

Magnetic susceptibilities of complexes were recorded at room temperature on Faraday balance (CAN-7600) using $Hg[Co(CNS)_2]$ as the standard , diamagnetic corrections were made using Pascal's constant . The magnetic moments were calculated using the following relations :

$$X_A = \frac{(R - R_o) \times L \times C}{(W_2 - W_1) \times 10^9}$$

$X_m = X_A \times M.Wt$

$\mu eff = 2.84 \sqrt{T.X_m}$

where :

W_1= weight of empty tube

W_2=weight of tube sample.

L =Length of sample in tube .

C= device constant , (= 1.2714) .

R °= magnetic reading of empty tube, (-31)

R= magnetic (reading) of tube and sample .

T = temperature in Kelvin (t+273 C°) .

X_m= is the molar susceptibility corrected using Pascal's constant for diamagnetism of all atoms in the compounds.

X_A= Magnetic susceptibility

μ = Magnetic moment

(3.8) Magnetic Moment Value of Some Salicylohydroxamic acid complexes

Metal ion complex	W_1	W_2	$R_\circ$	R	L(cm)	$X_A(\times 10^{-6}$ c.g.s)	$\mu_{eff}(B.M$
Co(II)	4.4798	4.5635	-31	687	2.0	3.579	1.8
Fe(III)	4.4803	4.5916	-31	910	2.4	42.327245	6
Mn(II)	0.7653	0.8359	-31	1110	2.1	70.797	6.8

Since the Fe(III), Co(II) and Mn(II) complexes are paramagnetic, The magnetic susceptibility value of Fe(III), Co(II) and Mn(II) complexes we are found 6, 1.8 and 6.8. B.M, respectively.

3.4 Result of stoichiometric of metals hydroxamic acid complexes at room tempeture:

3.4.1 Result of stoichiometric of salicylohydroxamic acid complexes at room Tempeture:

Table (3.9 to 3.14) and Figures 3.31 to 3.35 show the results of mole fraction of zinc , copper, iron, cobalt , manganese and vanadium salicylohydroxamate complexes vs the absorption of metals salicylohydroxamate complexes to determine the stoichiometry (mole ratio) of complexes. the stoichiometry ratio of salicylohydroxamate and complexes of Zn (II) ,Cu(II) ,Fe(III) ,Co(II) ,Mn(II) ,V(V) were determine by jobs method of continuous variation the mole ratio of the complexes were determined ,in different pH values(4 for Zn, 6 for Cu, 3 for Fe , 7for Co , 5 for Mn ,and V), and found to be in the ratio (M:L) of 1:3 for V for absorption of metals salicylohydroxamate complexes to determine the stoichiometry (mole ratio) of complexes. the stoichiometry ratio of salicylohydroxamate and complexes of Zn (II) ,Cu(II) ,Fe(III) ,Co(II) ,Mn(II) ,V(V) were determine by jobs method of continuous variation the mole ratio were of complexes determined ,in different pH values(4 for Zn, for Cu,for Fe ,for Co .for Mn , for V), and found to be in the ratio (M:L) of 1:3 for V and 1: 2 for Co and Fe,1:1 for Cu and Zn the results of mole fraction of complexes vs absorption of Zn salicylohydroxamate complex to determine the stoichiometry (mole ratio) of complex Co and Fe,1:1 for Cu and Zn

Table 3.9 The results of mole fraction of complexes vs absorption of Zn salicylohydroxamate complex .

M\M+L (Zn) SHA max=430 (PH=4)	Absortion
0. 1	0.020
0.2	0.023
0.3	0.025
0.4	0.032
0.5	0.039
0.6	0.035
0.7	0.030
0.8	0.036
0.9	0.033

Figure3.30:Mole Ratio vs Absorption of Zn-salicylohydroxamic acid

Table (3.10)The results of mole fraction of complexes vs absorption of Fe- salicylohydroxamate complex .

M\M+L (Fe) SHA max=520 (PH=3)	Absortion
0. 1	0.011
0.2	0.016
0.3	0.012
0.4	0.018
0.5	0.019
0.6	0.022
0.7	0.024
0.8	0.019
0.9	0.017

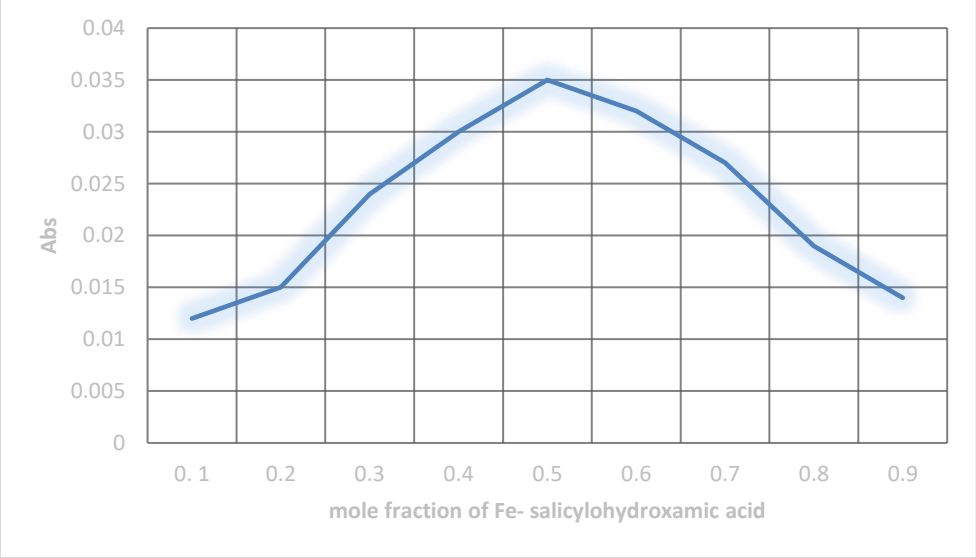


Figure3.31: Mole Ratio / Absorption of Fe-salicylohydroxamic acid

Table (3.11) The results of mole fraction of complexes vs absorption of Co-salicylohydroxamate complex .

M\M+L (Co) SHA max=510 (PH=7)	Absortion
0. 1	0.039
0.2	0.063
0.3	0.082
0.4	0.075
0.5	0.050
0.6	0.053
0.7	0.047
0.8	0.043
0.9	0.041

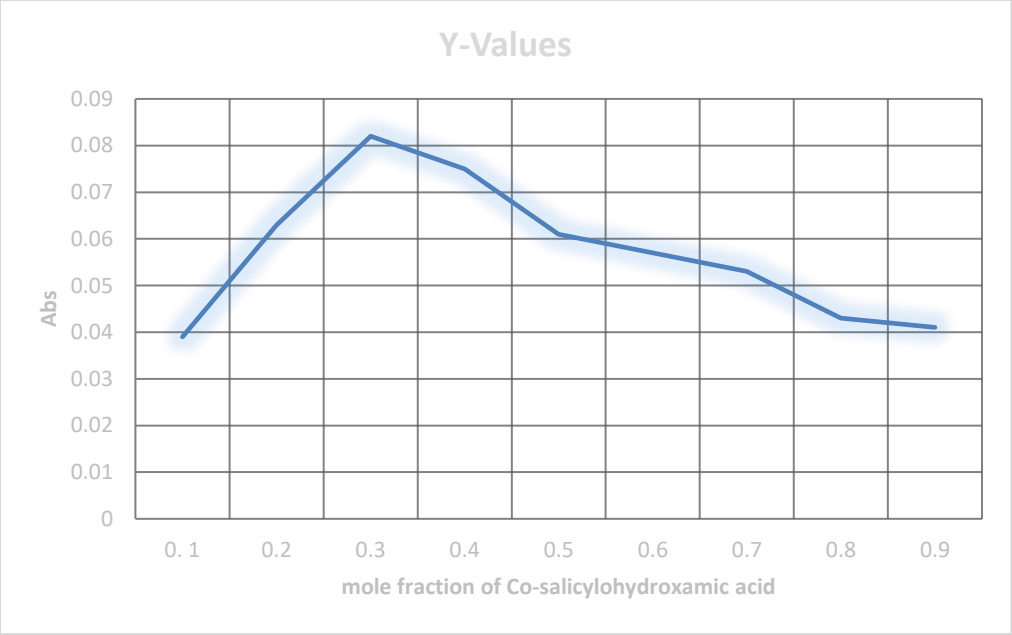


Figure3.32: Mole Ratio / Absorption of Co-salicylohydroxamic acid

Table (3.12)The results of mole fraction of complexes vs absorption of Mn-salicylohydroxamate complex .

M\M+L (Mn) SHA max=440 (PH=5)	Absortion
0. 1	0.029
0.2	0.035
0.3	0.044
0.4	0.049
0.5	0.052
0.6	0.054
0.7	0.046
0.8	0.027
0.9	0.025

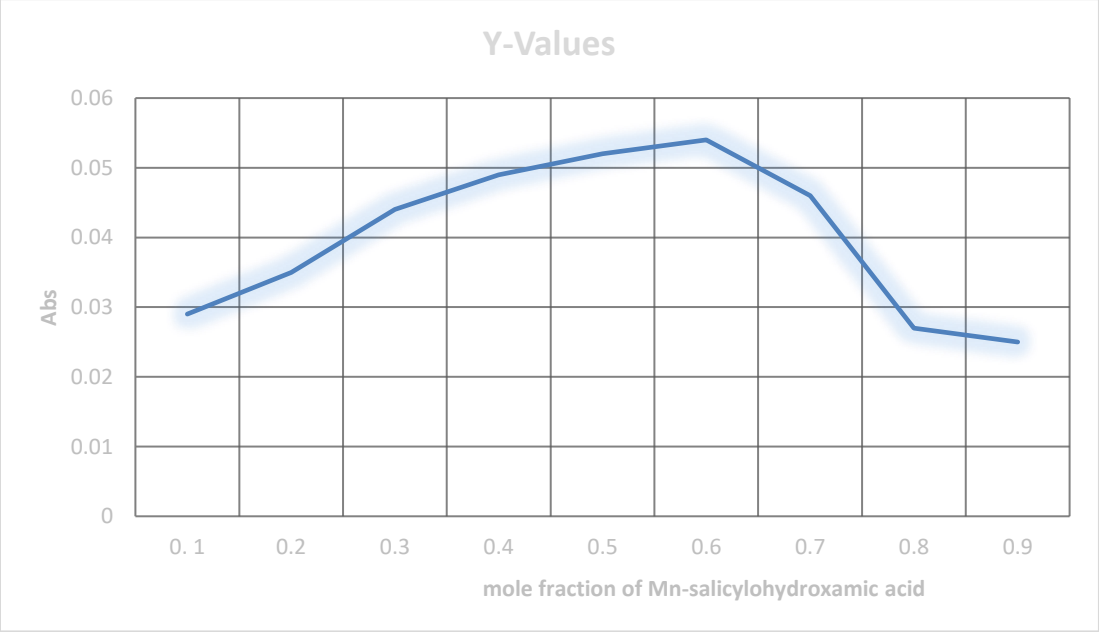


Figure3.33: Mole Ratio / Absorption of Mn-salicylohydroxamic acid

Table (3.13)The results of mole fraction of complexes vs absorption of Cu salicylohydroxamate complex.

M\M+L(Cu) SAH max=640nm (PH=6)	Absortion
0. 1	0.022
0.2	0.024
0.3	0.033
0.4	0.038
0.5	0.041
0.6	0.044
0.7	0.035
0.8	0.027
0.9	0.018

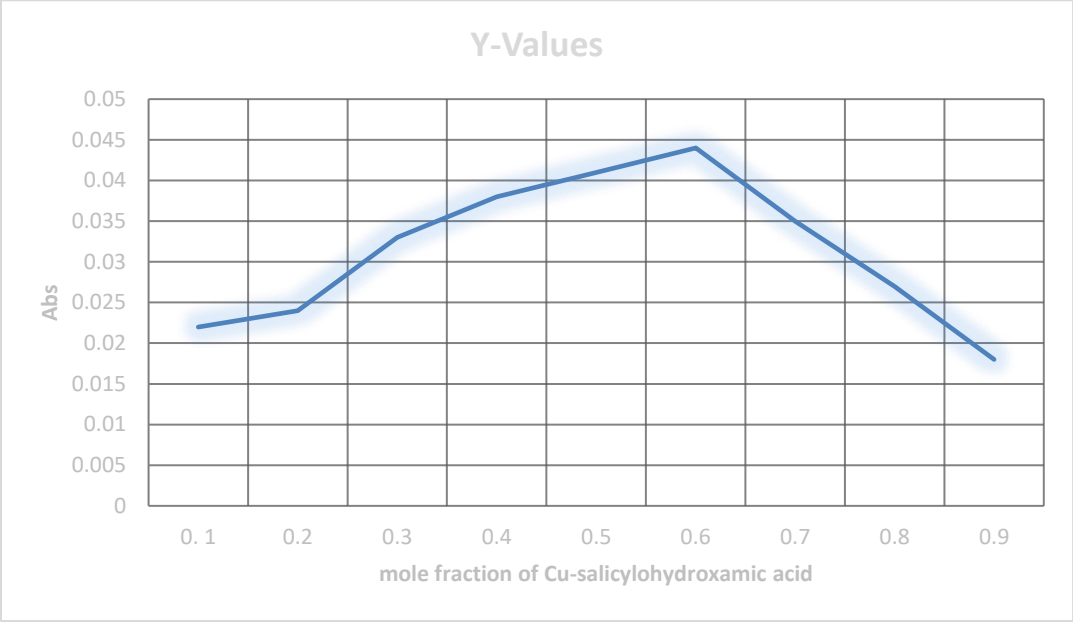


Figure3.34: Mole Ratio / Absorption of Cu-salicylohydroxamic acid

Table (3.14)The results of mole fraction of complexes vs absorption of V salicylohydroxamate complex

M\M+L (V) SHA max=520nm (PH=5)	Absortion
0. 1	0.051
0.2	0.056
0.3	0.062
0.4	0.067
0.5	0.073
0.6	0.075
0.7	0.077
0.8	0.057
0.9	0.052

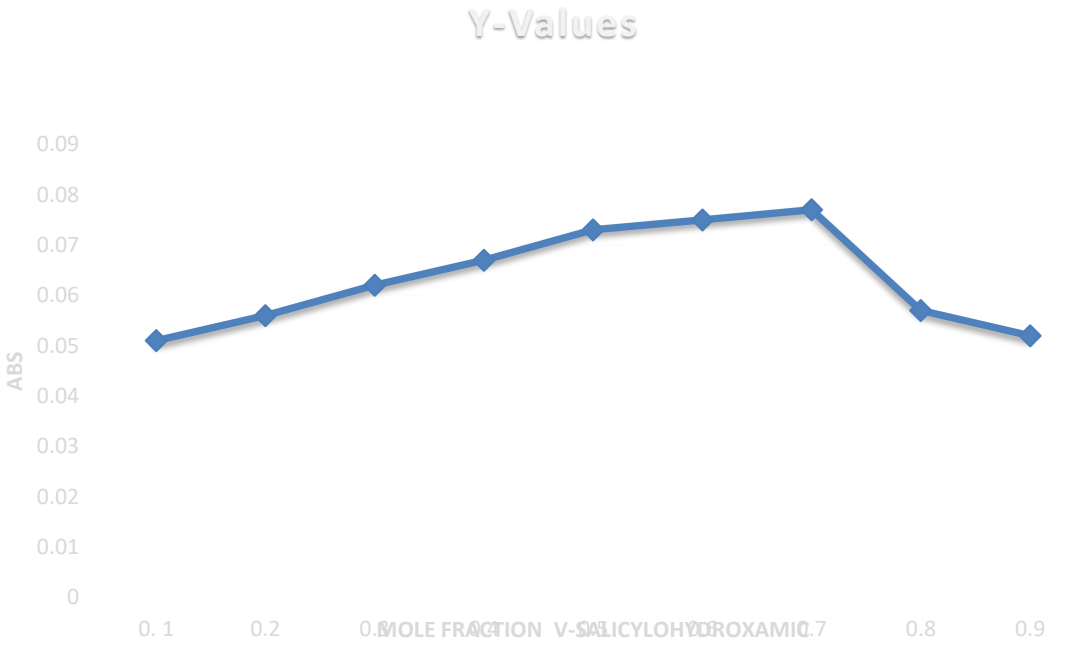


Figure3.35: Mole Ratio / Absorption of V-salicylohydroxamic acid

3.4.2 Result of stoichiometric of benzohydroxamic acid complexes at room tempeture:

Table(3.15 to 3.20) and Figures 3.36 to.3.41 show the results of mole fraction of zinc , copper, iron, cobalt , manganese and vanadium benzohydroxamate complexes vs absorption of metals benzohydroxamate complexes to determine the stoichiometry (mole ratio) of complexes. the stoichiometry ratio of salicylohydroxamate and complexes of Zn (II) ,Cu(II) ,Fe(III) ,Co(II) ,Mn(II) ,V(V) were determine by jobs method of continuous variation the mole ratio were of complexes determined ,in different pH values(5 for Zn, 6 for Cu, 5for Fe , 6 for Co . 5for Mn , 7for V), and found to be in the ratio (M:L) of 1:3 for V and 1: 2 for Co and Fe,1:1 for Cu and Zn

Table (3.15)The results of mole fraction of complexes vs absorption of Zn benzohydroxamate complex

M\M+L (Zn) BHA max=430 (PH=5)	Absortion
0.1	0.022
0.2	0.028
0.3	0.031
0.4	0.035
0.5	0.038
0.6	0.034
0.7	0.033
0.8	0.020
0.9	0.021

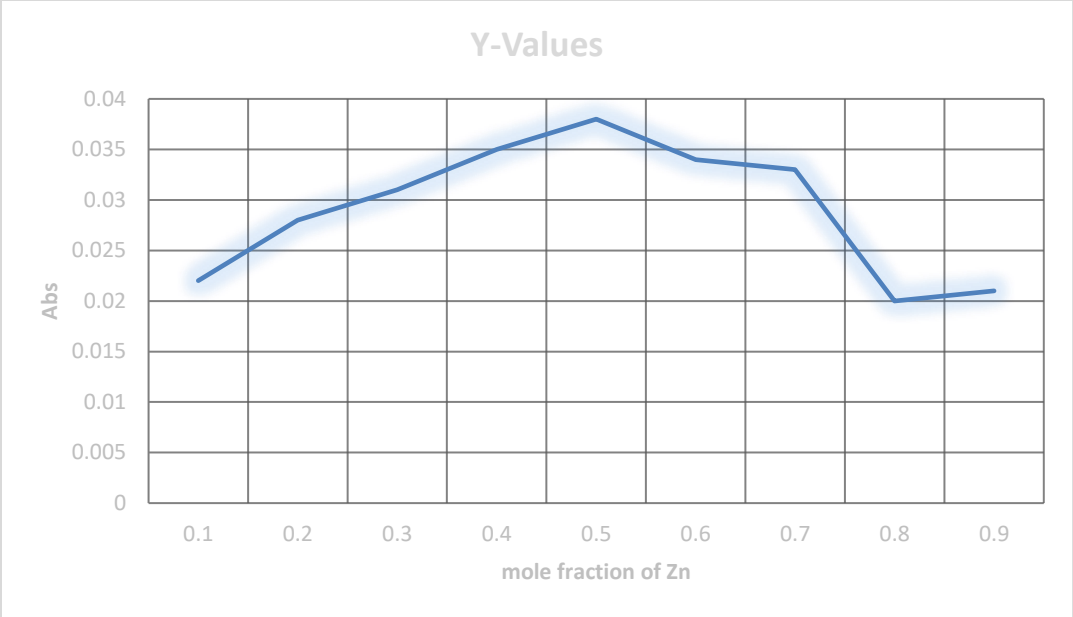


Figure3.36: Mole Ratio vs Absorption of Zn-benzohydroxamic acid

Table (3.16) The results of mole fraction of complexes vs absorption of Cu- benzohydroxamate complex .

M\M+L (Cu) BHA max=780 (PH=6)	Absortion
0. 1	0.012
0.2	0.015
0.3	0.024
0.4	0.030
0.5	0.035
0.6	0.032
0.7	0.027
0.8	0.019
0.9	0.014

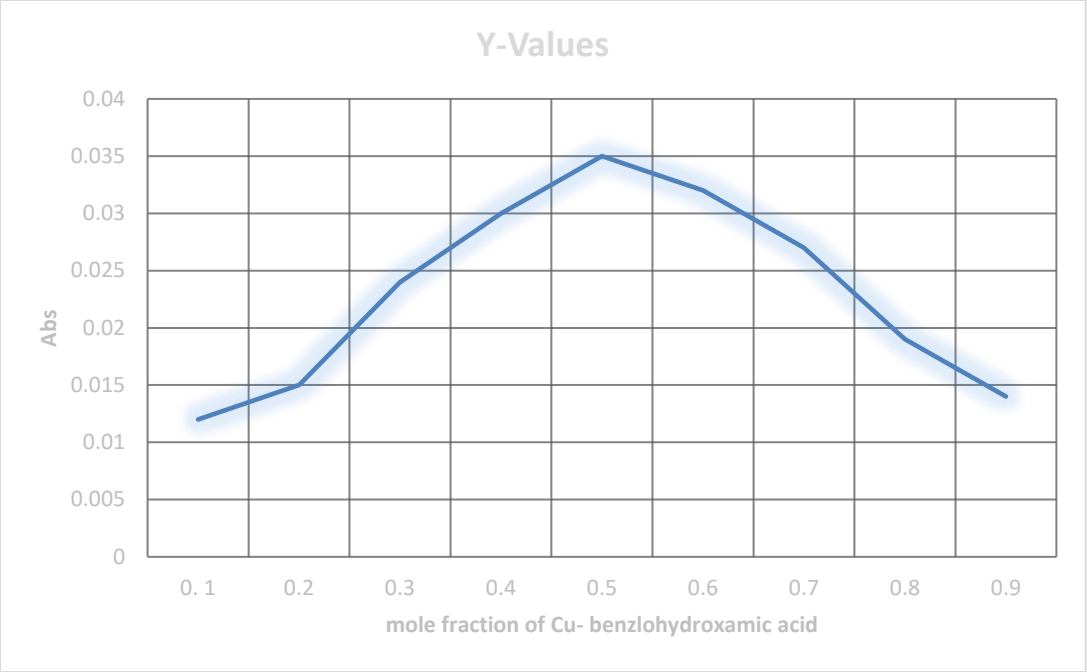


Figure 3.37: Mole Ratio vs Absorption of Cu-benzohydroxamic acid

Table (3.17)The results of mole fraction of complexes vs absorption of Fe benzohydroxamate complex .

M\M+L (Fe) BHA max=510 (PH=5)	Absortion
0. 1	0.020
0.2	0.024
0.3	0.029
0.4	0.031
0.5	0.037
0.6	0.028
0.7	0.021
0.8	0.019
0.9	0.017

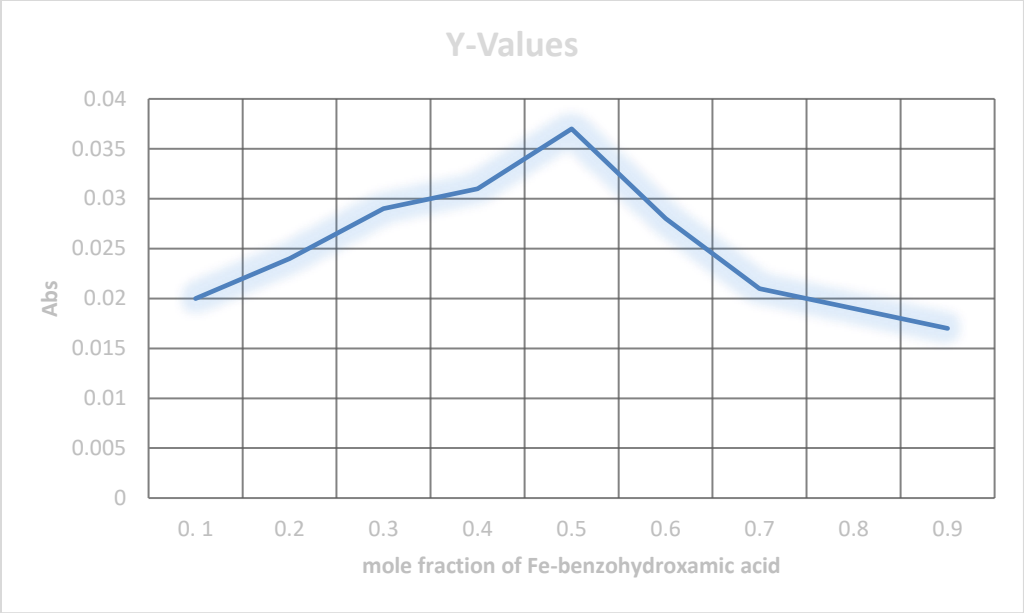


Figure3.38: Mole Ratio vs Absorption of Fe-benzohydroxamic acid

Table (3.18)The results of mole fraction of complexes vs absorption of Co-benzohydroxamate complex .

M\M+L (Co) BHA max=510 (PH=6)	Absortion
0. 1	0.019
0.2	0.031
0.3	0.039
0.4	0.042
0.5	0.047
0.6	0.081
0.7	0.063
0.8	0.041
0.9	0.016

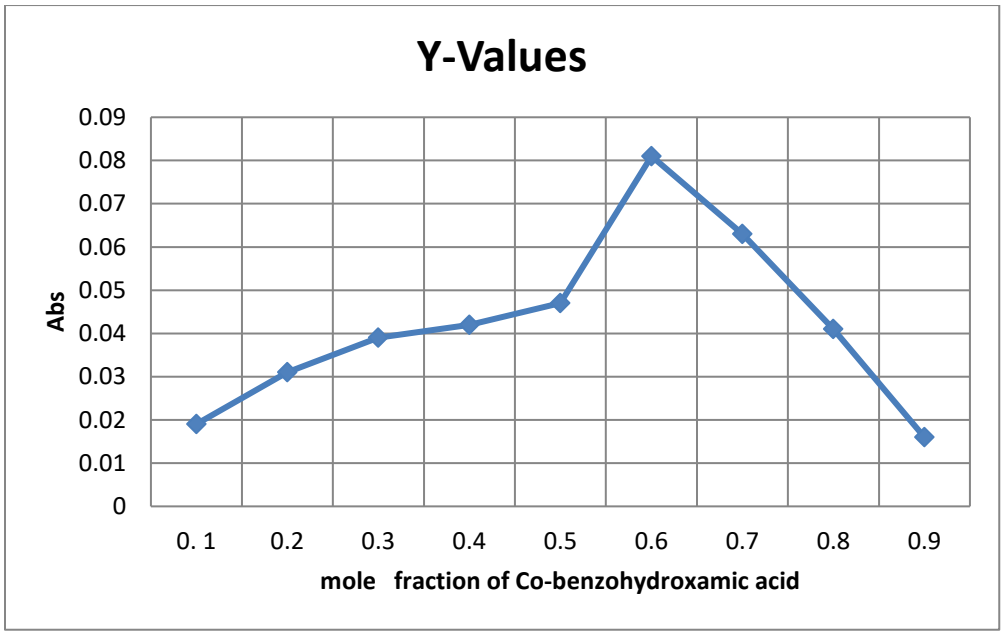


Figure3.39: Mole Ratio vs Absorption of Co-benzohydroxamic acid

Table (3.19)The results of mole fraction of complexes vs absorption of Mn benzohydroxamate complex .

M\M+L (Mn) BHA max=420 (PH=5)	Absortion
0. 1	0.017
0.2	0.022
0.3	0.021
0.4	0.030
0.5	0.033
0.6	0.039
0.7	0.040
0.8	0.035
0.9	0.030

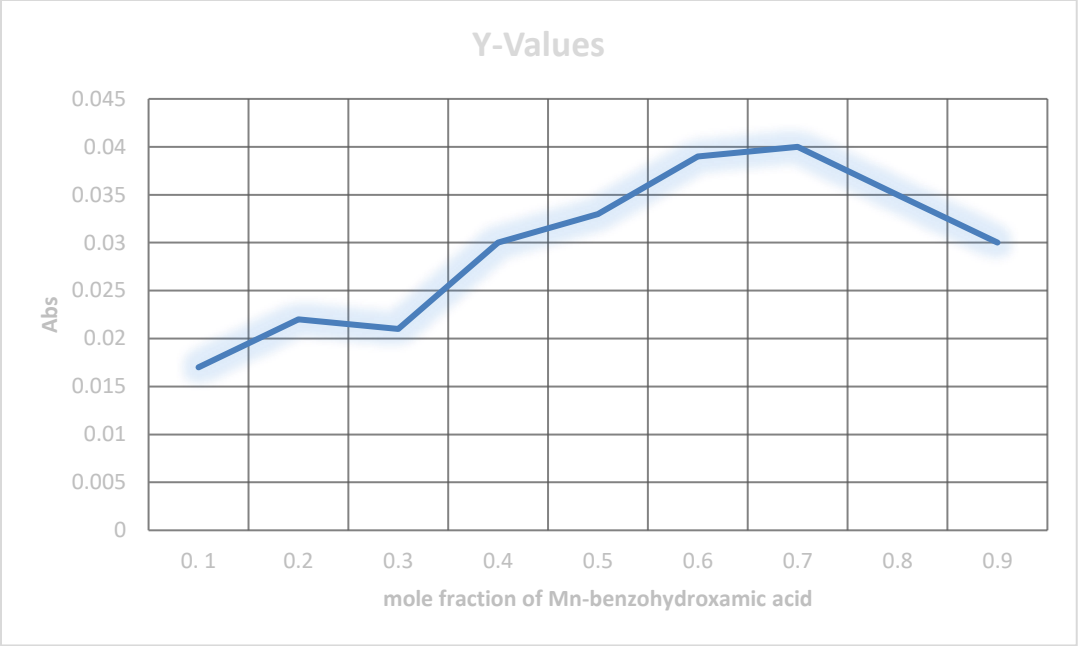


Figure3.40: Mole Ratio vs Absorption of Mn-benzohydroxamic acid

Table (3.20)The results of mole fraction of complexes vs absorption of V-benzohydroxamate complex .

M\M+L (V) BHA max=460 (PH=7)	Absortion
0. 1	0.027
0.2	0.029
0.3	0.031
0.4	0.033
0.5	0.037
0.6	0.039
0.7	0.040
0.8	0.034
0.9	0.028

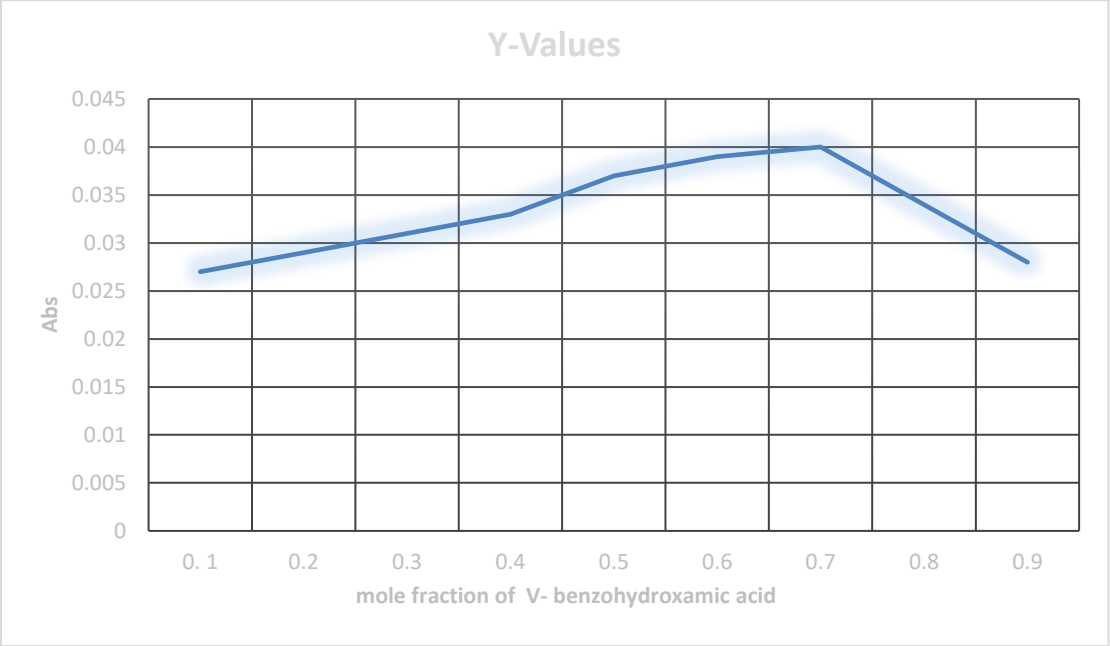


Figure3.41: Mole Ratio vs Absorption of V-benzohydroxamic acid

3.5 Result of stoichiometric of metals hydroxamic acid complexes at 15C°

3.5.1 Result of stoichiometric of salicylohydroxamic acid complexes at 15C°

Table (21 to 23) shown the results of mole fraction of iron ,cobalt ,and copper salicylohydroxamic acid, complexes vs absorption of metals salicylohydroxamate complexes to determine the stoichiometry (mole ratio) of complexes. the stoichiometry ratio of salicylohydroxamate and complexes of Cu(II) ,Fe(III) and Co(II) were determine by jobs method of continuous variation the mole ratio of complexes were determined ,in different pH values 6 Cu , 3for Fe , 7for Co), and found to be in the ratio (M:L) 1: 2 for Co and Fe,1:1 for Cu .

Table (3.21)The results of mole fraction of complexes vs absorption of Co- salicylohydroxamate complex .

M\M+L (Co) SHA max=510 (PH=7)	Absortion
0. 1	0.021
0.2	0.031
0.3	0.037
0.4	0.041
0.5	0.040
0.6	0.035
0.7	0.029
0.8	0.027
0.9	0.021

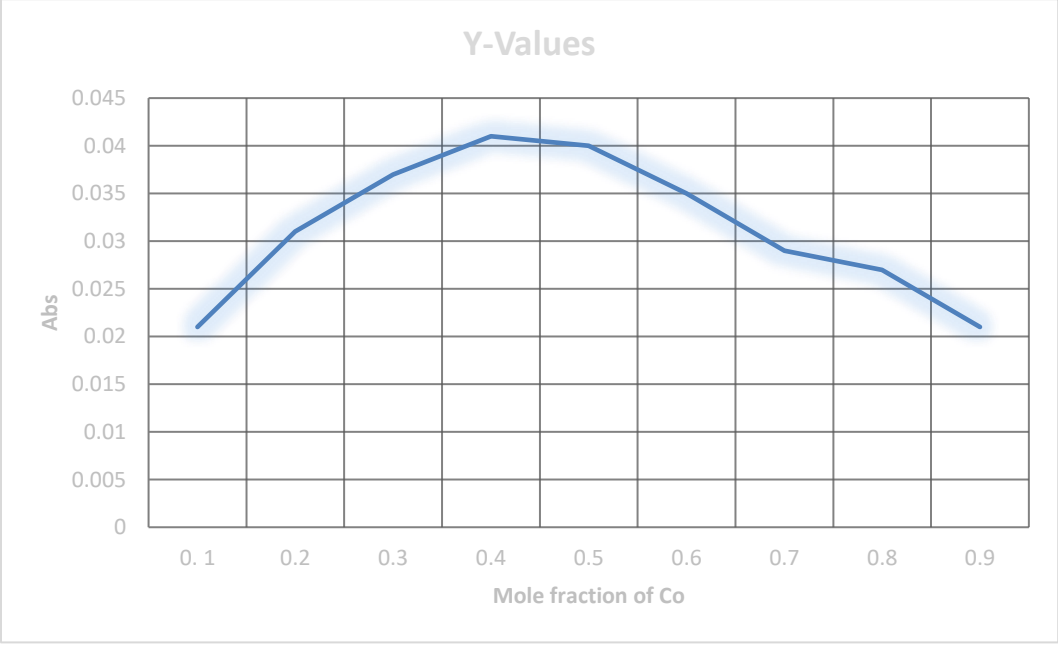


Figure3.42: Mole Ratio vs Absorption of Co-salicylohydroxamic acid

Table (3.22)The results of mole fraction of complexes vs absorption of Fe- salicylohydroxamate complex .

M\M+L (Fe) SHA max=520 (PH=3)	Absortion
0. 1	0.019
0.2	0.024
0.3	0.030
0.4	0.033
0.5	0.031
0.6	0.028
0.7	0.035
0.8	0.021
0.9	0.019

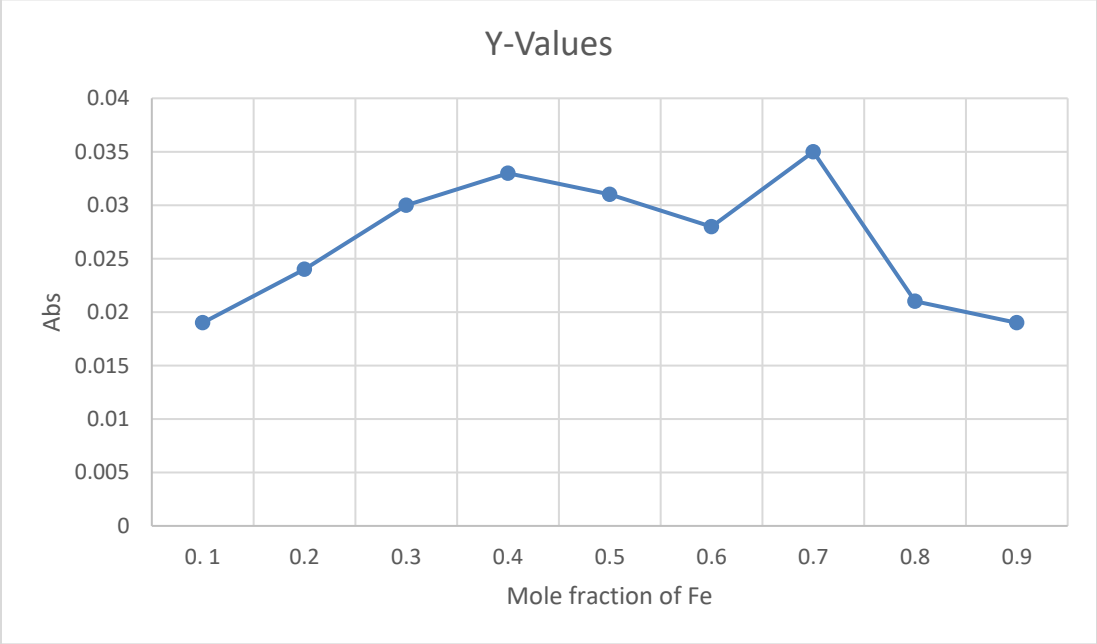


Figure3.43: Mole Ratio vs Absorption of Fe-salicylohydroxamic acid

Table (3.23)The results of mole fraction of complexes vs absorption of Cu- salicylohydroxamate complex .

M\M+L (Cu) SAH max=640 (PH=6)	Absortion
0. 1	0.028
0.2	0.032
0.3	0.028
0.4	0.035
0.5	0.034
0.6	0.026
0.7	0.033
0.8	0.020
0.9	0.021

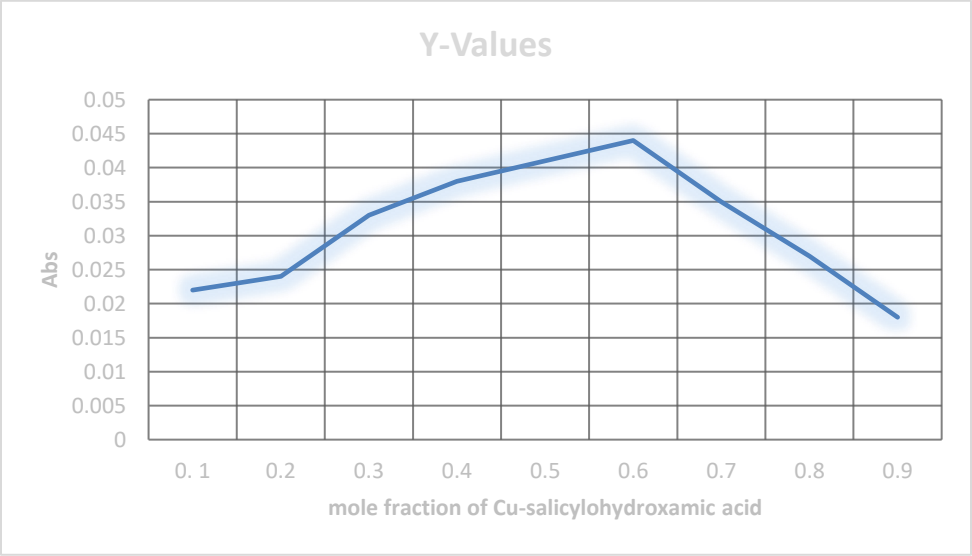


Figure3.44: Mole Ratio vs Absorption of Cu-salicylohydroxamic acid

3.5.2 Result of stoichiometric of benzohydroxamic acid complexes at 15C°

Table (3.24 to 3.26) and Figures 3.45 to 3.47 shown the results of mole fraction of iron ,cobalt, and copper benzohydroxamate, complexes vs absorption of metals benzohydroxamate complexes to determine the stoichiometry (mole ratio) of complexes. the stoichiometry ratio of benzohydroxamate and complexes of Cu(II) ,Fe(III) and Co(II) were determine by jobs method of continuous variation the mole ratio of complexes were determined ,in different pH values 6 for Cu , 5for Fe ,6 for Co), and found to be in the ratio (M:L) 1: 2 for Co and Fe,1:1 for Cu.

Table (3.24)The results of mole fraction of complexes vs absorption of Co- benzohydroxamate complex .

M\M+L (Co) BHA max=510 (PH=6)	Absortion
0. 1	0.029
0.2	0.030
0.3	0.032
0.4	0.032
0.5	0.036
0.6	0.045
0.7	0.039
0.8	0.035
0.9	0.022

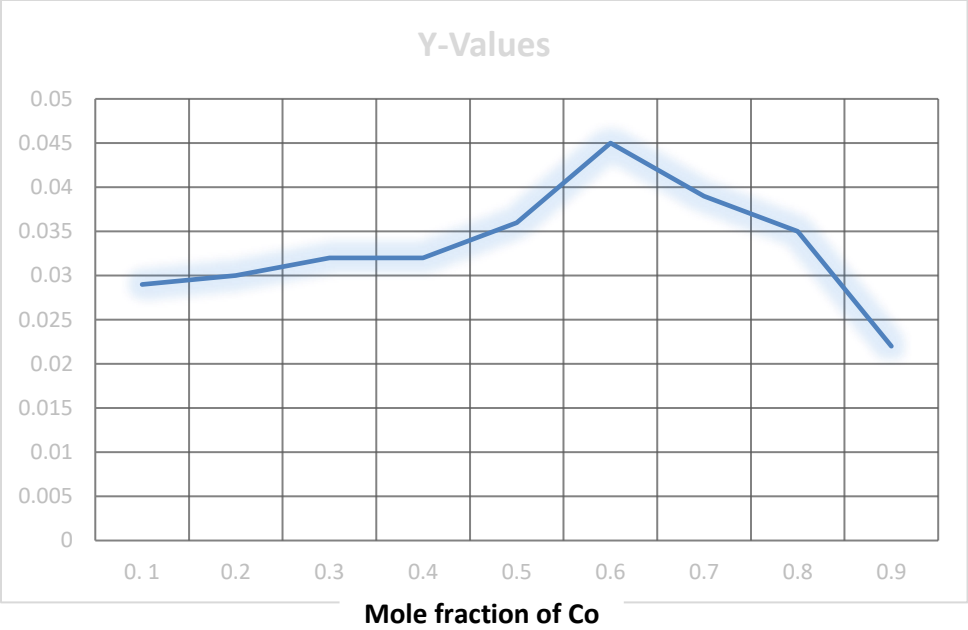


Figure3.45: Mole Ratio vs Absorption of Co-benzohydroxamic acid

Table (3.25)The results of mole fraction of complexes vs absorption of Fe- benzohydroxamate complex .

M\M+L (Fe) BHA max=510 (PH=5)	Absortion
0. 1	0.030
0.2	0.033
0.3	0.038
0.4	0.041
0.5	0.044
0.6	0.056
0.7	0.048
0.8	0.028
0.9	0.026

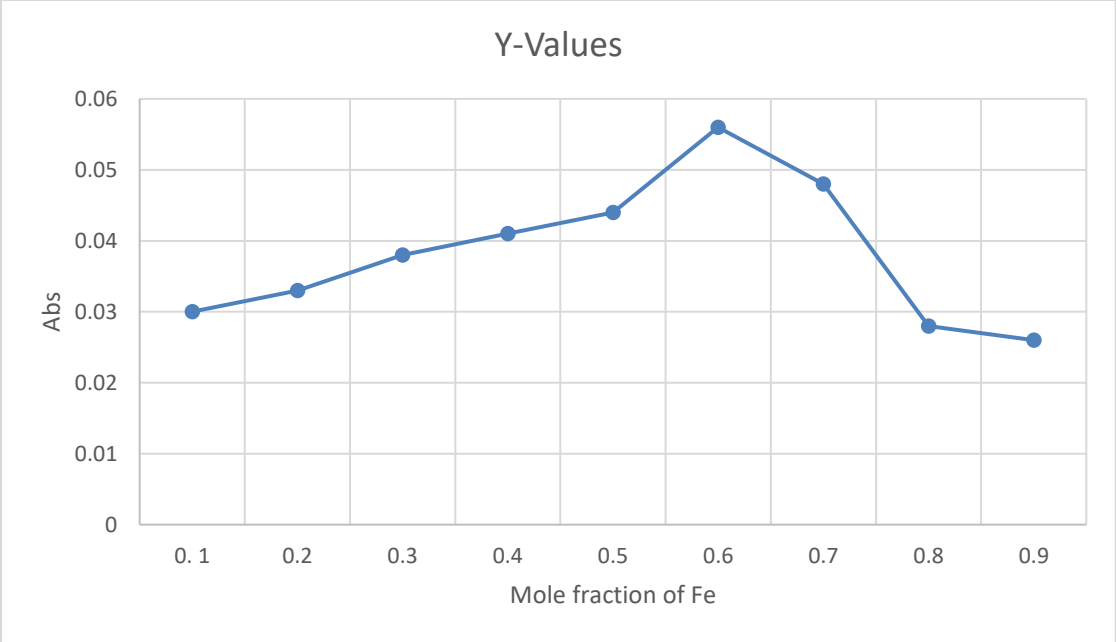


Figure3.46: Mole Ratio vs Absorption of Fe- benzohydroxamic acid

Table (3.26)The results of mole fraction of complexes vs absorption of Cu- benzohydroxamate complex .

M\M+L (Cu) BHA max=780 (PH=6)	Absortion
0. 1	0.017
0.2	0.023
0.3	0.021
0.4	0.030
0.5	0.033
0.6	0.029
0.7	0.023
0.8	0.025
0.9	0.019

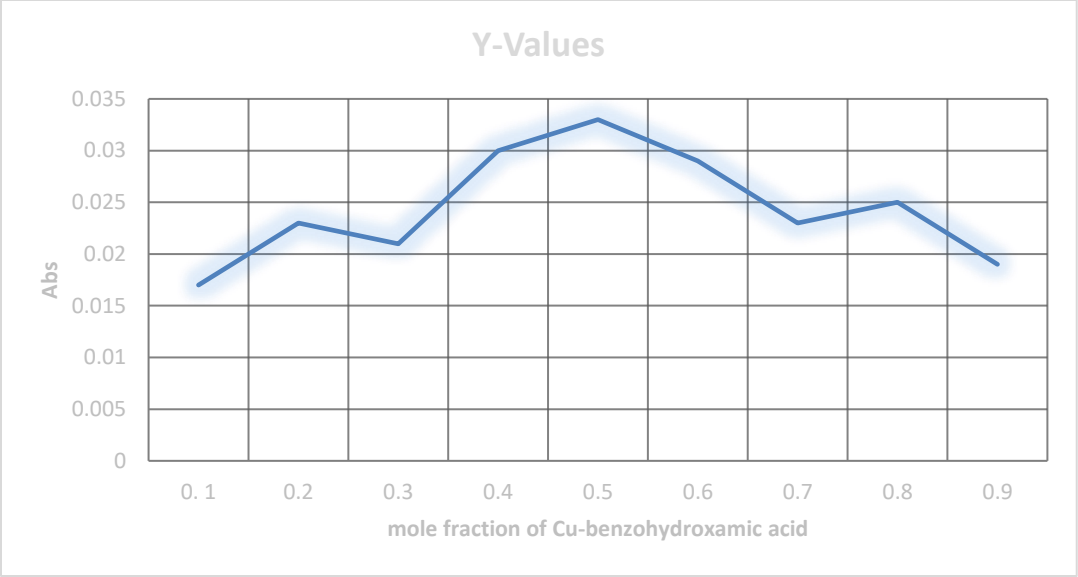


Figure3.47: Mole Ratio vs Absorption of Cu- benzohydroxamic acid

3.6 Stability Constants of hydroxmate Complexes

The stability constant of Zn(II) ,Cu(II),Fe(III), Co(II), Mn(II) and Ni(II), metal ions with the investigated hydroxamic acids (benzohydroxamic acid; BHA, and salicylhydroxamic acid; SHA have been studied applying continues variation measurements at different temperature in solution by modified jop methods of calculation.

The values in the table of SHA complexes indicating high stability of the complexes. than the value of stability of BHA complexes , This high stability in SHA complexes can be attributed to resonance, from the benzene rings where there could be delocalization of electrons between the ligand-metal π-bonding there by providing extra stability In addition, there is an OH group driving the electrons, which has an inductive effect .As shown in the tables (3.27) and (3.28)

Vanadium ion and iron ion is more stable complex with the two ligands

It is stable from the rest of the other metal ions, and this is due to that the extra charge carried by the positive iron ion makes it to have high polarizing potential for the ligand to coordinate with it . In addition to the size of the metal ion, it plays a role in the stability of the complex state, where from the tables(3.27,3.28), the stability is arranged as follows, with respect to the complexes Cu$< Zn < Mn < C0 < Fe < V$ of the metal complexes.

3.7 Calculation of stability Constant for Metal Complexe;

The objective is to the study the continuous varaiation to find the ratio of ligand to metal and also benefit from it in calculating the stability constant by taking the resulting absorption values of the solutions of mixing the ligand with the metal ion that want to perform stability, and therefore it was used:

$M + n L \_\_\_\_\_ ML_n$ .....(1)

$K=\frac{[ML]}{[M][L]}$**.....(2)**

K= stability constant

n =number of ligand

$\alpha =\frac{A_{m-As}}{Am}$**.....(3)**

A_m = The highest absorbance of complex

As= The less highest absorbance of complex

α =The degree of bonding between the ligand and ion

C= Concentration of complex

Were (n=1)uses this relation;

$K=\frac{(1-\alpha)}{\alpha 2 .C}$ **……..(4)**

Were (n=2,3)uses this relation;

$K = \frac{(1-\alpha)}{4\alpha^3 C2}$**……..(5)**

When stability values are found,it is easy to calculate the change in free energy from relation;

$\Delta G = -RT \ln K$ **……..(6)**

Table (3.27)Stability constant of metal ions complexes of salicylohydroxamic acid at room tempreture:

Metal ion complex	A_m	A_s	α	K
Zn(II)	0.039	0.020	0.48	1.73×10^2
Cu(II)	0.047	0.023	0.51	1.5×10^2
Fe(III)	0.024	0.012	0.5	5.9×10^3
Co(II)	0.082	0. 039	0.52	5.2×10^3
Mn(II)	0.054	0.025	0.53	1.3×10^3
V(V)	0.077	0.051	0.33	2.8×10^4

Table (3.28)Stability constant of metal ions complexes of benzohydroxamic acid at room tempreture

Metal ion complex	A_m	A_s	α	K
Zn(II)	0.038	0.020	0.47	1.71×10^2
Cu(II)	0.035	0.012	0.65	59.1
Fe(III)	0.037	0.017	0.54	3.7×10^3
Co(II)	0.024	0. 016	0.33	2.7×10^3
Mn(II)	0.040	0.017	0.57	94
V(V)	0.040	0.027	0.32	2.6×10^4

Table (3.29)Stability constant of metal ions complexes of salicylohydroxamic acid 15C°

Metal ion complex	A_m	A_s	α	K
Co(II)	0.041	0.021	0.48	6.9×10^3
Fe(III)	0.035	0.019	0.45	8.9×10^3
Cu(II)	0.035	0.020	0.42	2.5×10^2

Table (3.30)Stability constant of metal ions complexes of benzohydroxamic acid 15C°

Metal ion complex	A_m	A_s	α	K
Co(II)	0.045	0.022	0.51	4.7×10^3
Fe(III)	0.056	0.026	0.56	4.1×10^3
Cu(II)	0.033	0.017	0.48	1.6×10^2

3.8 Calculation of thermodynamic peremeter for Metal Complexes

The extra stability in the hydroxamic acid complexes can be measured by other parameters such as ΔH^o, ΔS^o and ΔG^o, the thermodynamic parameters for hydroxamic acid complexes evaluated by studying the stability constants at (15-25C) , In both hydroxamic acid complexes, stability constants increased with decreasing in temperature Table (29,30). and evaluate the enthalpy change (ΔH^o) for this complexes by Van't Hoff's from the relation;

$$\text{Ln}\frac{K2}{K1} = \frac{\Delta H}{R}\left(\frac{1}{T2} - \frac{1}{T1}\right) \text{.....(7)}$$

Values of change the entropy ΔS, were obtained from the relation;

$\Delta G = \Delta H - T\,\Delta S$ **..... (8)**

$\Delta S = (\Delta H - \Delta G)/T$**.....(9)**

Table (3.31) Thermodynamic parameters of the benzohydroxamic Complexes

Metal ion complex	TK at 288					TK at 298			
	α	K	$\Delta G -$ KJ.mol^{-1}	ΔH KJ.mol^{-1}	ΔS J.mol^{-1}	α	K KJ.mol^{-1}	$\Delta G -$ KJ.mol^{-1}	ΔS J.mol^{-1}
Co(II)	0.51	4.7×10^3	20.2	39.5	207.2	0.33	2.7×10^3	19.5	197.9
Fe(III)	0.56	4.1×10^3	19.9	7.3	94.4	0.54	3.7×10^3	20.3	92.6
Cu(II)	0.48	1.6×10^2	12.1	70	285.1	0.65	59.1	10.1	268.7

Table (3.32)Thermodynamic parameters of the salicylohydroxamic Complexes

Metal ion complex	TK at 288					TK at 298			
	α	K $KJ.mol^{-1}$	ΔG- $KJ.mol^{-1}$	ΔH $KJ.mol^{-1}$	ΔS $J.mol^{-1}$	α	K $KJ.mol^{-1}$	$\Delta G -$ KJ. mol-	ΔS $J.$ mol
Co(II)	0.51	6.9×10^{3}	20.830	19.81	141	0.52	5.2×10^{3}	21.199	137.6
Fe(III)	0.56	8.9×10^{3}	21.519	28.9	175	0.50	5.9×10^{3}	21.512	169.1
Cu(II)	0.48	2.5×10^{2}	12.686	33. 5	166	0.50	$1.\times 10^{2}$	12.243	153.4

From the thermodynamic parameters of the dissociation process are recorded in table 3.31, 3.32. It can be pointed out that:

(i) a positive value of ΔH^{o} indicates that its reaction of complexation in both(BHA,SHA) is endothermic.

(ii) a negaitive value of ΔG^{o} point that the process is spontantaneous

(iii) ΔS values were all large and positive, indicating spontaneous complexation reactions

3.9 Conclusion

complexes with zinc (II),copper (II), iron (III), cobalt (II) , manganese (II) and nickel(II) was studied. hydroxamic acid had been prepared by the reaction of ester and free hydroxylamine and was characterized using its melting point, FT-IR Spectroscopic, mass spectra and 1H NMR spectrum. hydroxamate were prepared by reacting hydroxamic acids with corresponding metal salts. The compounds were characterized using elemental analysis, spectral infrared, TGA and magnetic susceptibility. The purity of the complexes was confirmed by CHN analysis. The spectral study analysis reveals that all complexes coordinated to the metal via oxygen atoms (O, O) for complexes.The resulting complex from the coordination of the metal ions with the ligand (hydroxamic acid) are thermodynamically stable. Based on complex formation, following continuous variation method; iron, cobalt shows 1:2 stoichiometric. Zinc, mangenese and copper shows 1 :1 stoichiometric ratio and vanadium shows 1 :3 The higher value of K, for this compound can be attributed to resonance, the value of ($\Delta G^{o,}$ ΔH^{o}, ΔS) indicates that the reactions are spontaneous and endothermic.

3.10 Recommendations

From the findings of this study, the following recommendations are suggested:

To study of separation of a metals from a mixture , kinetic studies, equilibration rate and the biological activity of synthesized hydroxamic acids.

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