بسم الله الرحمن الرحيم

Sudan University of Science and Technology
College of Science
Department of Scientific laboratory – Chemistry

Dissertation submitted for the partial fulfillment of the requirements of B.Sc (honors) in scientific labs - chemistry

Syntheses, Identification and Complexation of Cinnamohydroxamic Acid Iron (III) Complex

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Oct 2016

آية

بسم الله الرحمن الرحيم
قال تعالى (سنريهم اياتنا في الافاق و في انفسهم حتى يتبين لهم انه الحق أولم يكف
بربك انه علي كل شئ شهيد)

صدق الله العظيم

فصلت آية(53)

DEDICATION

To our beloved parents

Brothers, sister

And to all our friends

Thank you for your support, help and encouragement in

Pursuing our dreams

ACKNOWLEDGEMENTS

First of all our thanks would go to Allah for giving us strength and help to complete this work

We would like to thank our teacher Rehab Abd elgader Ibrahim for her supervision and advices during the performance of this work.

Our appreciation extends to all teaching and laboratory staff in chemistry department in Sudan University of Science and Technology for their continuous help.

Abstract:

Methyl cinnamate was synthesized by acid esterfication of cinnamic acid and methanol.

Hydroxyl amine hydrochlorid was freed by neutralization with equi-molar amount of sodium hydroxide.

cinnamohydroxamic acid was synthesized by coupling the prepared methyl cinnamate with free hydroxylamine.

The compound was identified and characterized by IR spectroscopy.

Iron complexes of cinnamohydroxamic were prepared and showed their characteristic colors.

الخلاصة

تم تحضير سينمات الميثيل عبر الاسترة الحمضية لحمض السيناميك في الميثانول.

تم تحضير هيدروكسيل أمين الطليق بمعالجة هيدروكلوريد هيدروكسيل أمين بإضافة كمية مكافئة من محلول هيدروكسيد الصوديوم.

تم تركيب حمض سيناميو هيدروكسامك بخلط هيدروكسيل أمين الحر مع استر سينمات الميثيل وتم التعرف والتحقق من الحمض بقياس طيف الأشعة تحت الحمراء .

و حضر معقد حمض سينامو هيدروكساميك مع الحديد و اظهر المعقد اللون الاحمر الارجواني المميز.

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1. Introduction

1.1 Organic reagents in analytical chemistry:

Organic reagents are important in analytical chemistry because of the inherent sensitivity and selectivity of their reactions with metal ions. Much of the early work in the field was empirical, being directed toward a search of specific or at least highly selective reagent for metals

Selectivity often can be achieved for a particular purpose by controlling variables such as pH reagent concentration organic oxidizing or reducing agents they are used as indicators precipitants masking a gents photometric reagents and some finding use in gas chromatography as volatile metal. Organic compounds (1).

To achieve adequate selectivity in analytical work it is frequently necessary to exploit differences in physical or chemical properties among reaction products.

Some of the most common properties and their application are as follows

Differences in solubility: these may be made the basis for gravimetric methods of analysis trace constituents may be concentrated by co-precipitation or alternatively by partitioning into water immiscible solvent by following the practice of solvent extraction.

The production of a characteristic color, which is utilized as:

1-reagent in qualitative testing or in spot test

2-indicators in end –point detection in titrimetric methods of analysis

3-direct spectro photometric determination of the species giving rise to the color

Organic reagents have simplified the determination of micro-amounts of elements precipitates formed in gravimetric analysis are voluminous easy to wash and filter and the gravimetric factors very specific than inorganic ones a number of organic precipitates have been developed for gravimetric analysis typical examples are

8-hydroxy quioline which has long being used to separate aluminum as specific reagent, 1-nitroso-2-naphthol which precipitate cobalt and dimethyl glyoxime for nickel (2).

The most important organic reagents are those forming chelate complexes, which involve the formation of one ring or more including the metal atom .such chelates are more stable than the corresponding coordination compounds involving no ring formation and even greater stability is imparted by structures involving two or more fused chelates.

In fact there is no known specific reagent; however by the right choice of masking agent and judicious conditioning of the reaction environment, the reagent can be made very selective or even specific. Moreover, selectivity of reactions often increases as the functional groups which form chelats through two oxygen atoms are changed to choose chelating through one oxygen and one and further when chelation is through two nitrogen atoms(3)

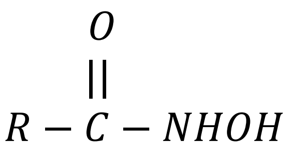
1.2 Hydroxamic acids

Hydroxamic acids, that can be represented by a general formula $RCONR'OH$, where R, R' may be an aryl or substituted aryl moiety, refer to a class of organicacids, which are much weaker than structurally related carboxylic acids (Marmionet al. 2004). Hydroxamic acids have been known since 1869 with the discovery of oxalohydroxamic acid by Lossen (1869). However, the real momentum on studieson the synthesis and structures of hydroxamic acids and their biological activitieswas gained after 1980 (4).

They are characterized by a remarkable versatility as reactant in inorganic and organic chemistry.

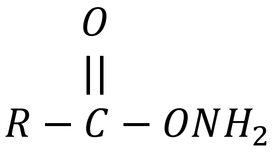
1.2.1 Structure of hydroxamic acid

Hydroxamic acids exist in two forms, N-aryl derivatives (i) and O-aryl derivatives (ii).



$$R-\overset{\overset{O}{\|}}{C}-NHOH$$

(i)

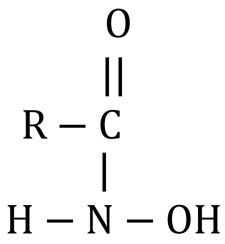


$$R-\overset{\overset{O}{\|}}{C}-ONH_2$$

(ii)

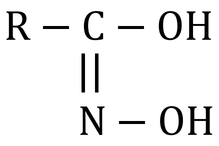
N-aryl and N-aryl tautomeric forms of hydroxamic acid

N-aryl hydroxamic acids may exist in two tautomeric forms, (i) and enol-form (ii)



$$R-\underset{\underset{H-N-OH}{|}}{\overset{\overset{O}{\|}}{C}}$$

(i)Keto-form



$$R-\underset{\underset{N-OH}{\|}}{C}-OH$$

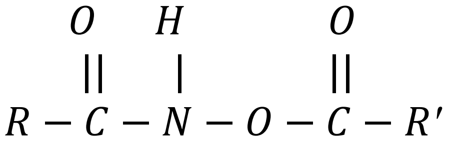
(ii) enol-form

Keto and enol form of hydroxamic acid

The neutral molecule is found predominantly as the ketol-form. Evidence for existenceof tautomers (i) and (ii) was presented by jones and wamer(5), structure(i)has one replaceable hydrogen atom and behave as a monobasic acid, while structure(ii) has two replaceable hydrogens. Such keto-enol tautomerism provides a nimber of sites for chelation.

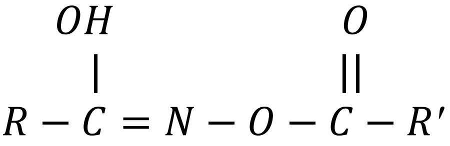
When a monohydroxamic acid is arylated⁽⁶⁾the first aryl group which enters is attached to oxygen, and is present as shown in the tautomeric forms(iii) and (iv).

The second aryl group which enters gives rise to two isomeric compounds (v) and (vi).



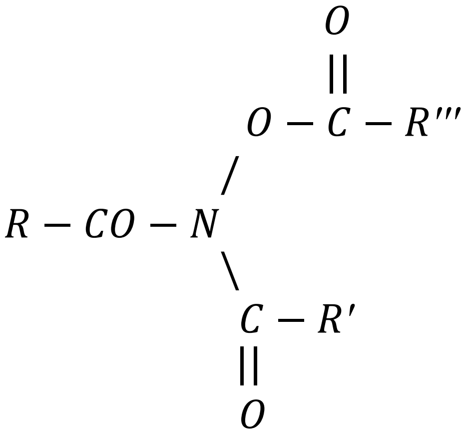
$$R-\overset{\overset{O}{\|}}{C}-\overset{\overset{H}{|}}{N}-O-\overset{\overset{O}{\|}}{C}-R'$$

(iii)

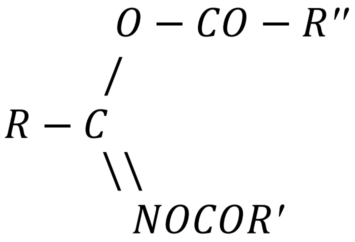


$$R-\overset{\overset{OH}{|}}{C}=N-O-\overset{\overset{O}{\|}}{C}-R'$$

(iv)



(v)

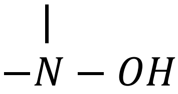


$$R-C\begin{matrix} / O-CO-R'' \\ \backslash\backslash NOCOR' \end{matrix}$$

(vi)

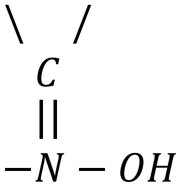
There are various opportunities for hydrogen bonding in crystalline hydroxamic acids. The intramolecular O-H….O=C that is seen in the gas phase may be disrupted in favor of intermolecular interactions, three such have been noted, O-H…..O=C, N-H…..O=C and O-H….O (H) N.

The structural link between hydroxylamine (i), oxime (ii) and hydroxamic acid (iii) is the N-OH group.



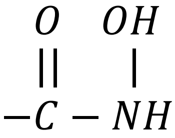
$$\overset{|}{-N}-OH$$

(i)



$$\begin{matrix} \backslash \quad / \\ C \\ || \\ -N-OH \end{matrix}$$

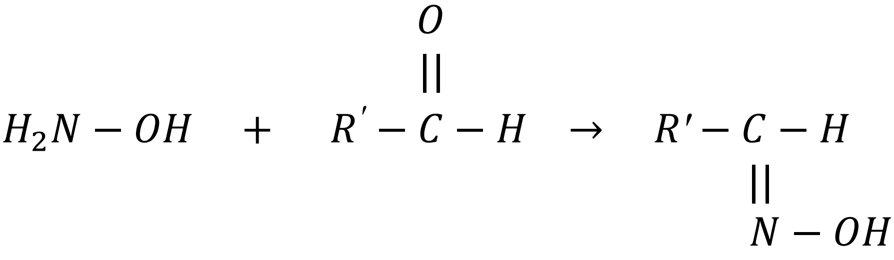
(ii)



$$-\overset{\overset{O}{||}}{C}-\overset{\overset{OH}{|}}{NH}$$

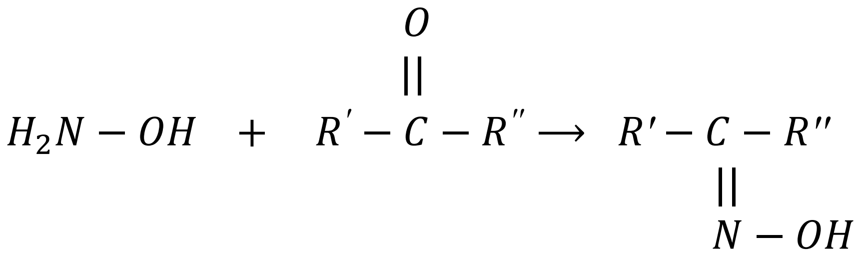
(iii)

Formally they can all be viewed as derivatives of hydroxylamine, NH_2-OH indeed, oximes can be prepared by the addition of hydroxylamine to aldehydes and ketones [equations (i) and (ii)], and hydroxamic acid by its reaction with acyl halides and ester [equation (iii) and (iv)].



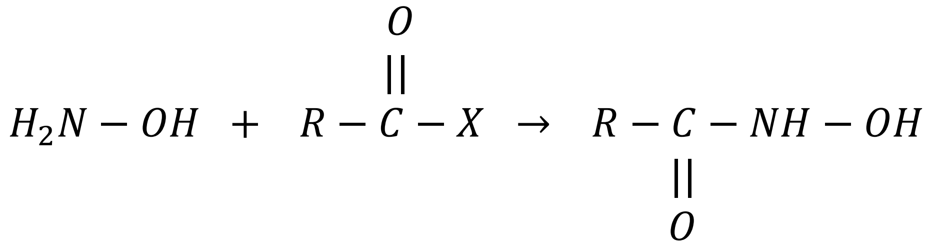
$$H_2N-OH \quad + \quad R'-\overset{\overset{O}{||}}{C}-H \quad \rightarrow \quad R'-\underset{\underset{N-OH}{||}}{C}-H$$

(i)An aldoxime



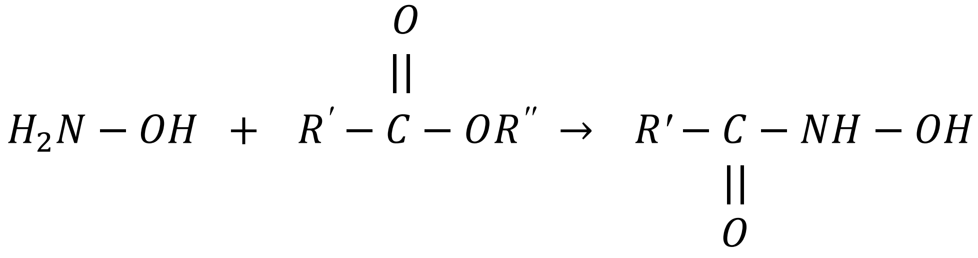
$$H_2N-OH \quad + \quad R'-\overset{\overset{O}{||}}{C}-R'' \longrightarrow R'-\underset{\underset{N-OH}{||}}{C}-R''$$

(ii)A ketoxime



$$H_2N-OH \quad + \quad R-\overset{\overset{O}{||}}{C}-X \quad \rightarrow \quad R-\underset{\underset{O}{||}}{C}-NH-OH$$

(iii)



$$H_2N-OH \quad + \quad R'-\overset{\overset{O}{||}}{C}-OR'' \quad \rightarrow \quad R'-\underset{\underset{O}{||}}{C}-NH-OH$$

(iv)

Differentiate between hydroxylamine acid the C=N double bond in (ii) and the acetyl group in (iii) (8).

1.2.2 Physical properties

Hydorxamic acids are in general, colorless crystalline solid somewhat low melting point (16), except for nitro-substituted derivatives which are light yellow or light pink in color. Their bond is intermediate between that of amides and esters. They are slightly soluble in water but readily soluble in alcohol, benzene, chloroform, dioxin and carbon tetrachloride.they are stable to heat, light and air.

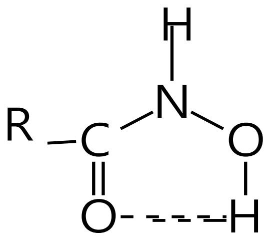
The infrared spectra of hydroxamic acid determine only the absorption spectar of those bands which are associated with the hydroxamic acid functional group,that have been a signed.

$$-N-C(O)-O-H$$

The presence of the (O-H) stretching band is assigned in the region at about 3200cm^{-1} , the lower shift of the (O-H) is due to the intramolecular hydrogen bonding of the type OH……C=O. the (C=O) and (N-O) band are assigned at about 1620cm^{-1}and 920cm^{-1} respectively(17)

1.2.3 Chemical properties

Hydroxamic acids are very weak acids, although they are several times stronger than phenol. The unexpected relatively high acidity is one of their striking properties. The acidity of hydroxamic acids may attribute essentially to the inductive effect of the (OH) hydroxyl group and suppression of the basic character of the central nitrogen, due to its conjugation with the acyl group. Suppression of the acidic character may be attributed to intramolecular hydrogen bonding (7).



In many respects, the reactions of hydroxamic acid resemble those of amides. The presence of second oxygen atom O=C-N-O, in chain of hydroxamic acid, however alters both their nucleophilic reactivity and the pattern of substitution compared to amides. Thus hydroxamic acids are stronger nucleophiles than amides. With the (N)-O,atom being most reactive(18).

1.2.4 Nomenclature of hydroxamic acid

Since hydroxamic acids are derivatives of carboxylic acids, their nomenclature must be based on them, thus in naming a specific compound, the practice is to drop the –ic of the related carboxylic acid and substitute the letter O for it, followed by hydroxamic acid (13). This system of nomenclature lead to some problems according to these rules for carpoic acid the corresponding hydroxamic acid is caprohydroxamic acid and for carpic acid, the hydroxamic acid would also be caprohydroxamic acid. Therefore, in these and similar cases, attempt was made to use the systematic names as a basis of nomenclature. Thus carpoic acid derivative is named hexanohydroxamic acid while decanohydroxamic acid is given to carpic acid derivatives.the following examples are of the system of nomenclature used for hydroxamic acid and their derivatives (14).

Benzoylhydroxamic acid	C_6H_5–C (O) –NHOH
Anisoylbenzohydroxamate	C_6H_5–C (O) –NH–O–C–$C_6H_7OCH_3$
Ethylbenzohydroxamic acid	CH–C (O) –NH–O–C–C_2H_5

1.2.5 Synthesis of hydroxamic acid

Hydroxamic acids are generally the products of hydroxylamine (NH_2OH) and carboxylic acids (RCOOH). When an aryl group replaces one of the nitrogenbound hydrogens in the hydroxylamine molecule, a monohydroxamic acid, RCONHOH, is formed. This occurs when an O/N-protected hydroxylamine molecule is allowed to react with an activated acyl group as shown below:

$$RCOX + NH_2OH \rightarrow RCONHOH + HX$$

Devocelle et al. (2003), however, reported a convenient two-step procedure for the parallel synthesis of low molecular weight hydroxamic acids from carboxylic acids and hydroxylamine with the use of polymer supported 1-hydroxybenzotriazole (Marmion et al. 2004).
A simple one pot method for the synthesis of hydroxamic acids in high yields has also been described by Giacomelli et al. (2003). The recent development of more efficient methods for the synthesis of hydroxamic acids can be found in a review by Yang and Lou (2003) (4).

Monohydroxamic acid can be prepared by other method, the blatt method (reaction between an ester and hydroxylamine).other methods although satisfactory in certain instances, have limited applications (9).
1-blatt procedure in this method an alkyl or aryl ester (RCO_2ET)

Reacts with hydroxylamine in the presence of alkyl.the reaction is carried out in absolute alcohol and at randomtemperature.it is rapid particularly in the presence of equimolar of sodiumalkoxide, in the absence of the alkaline reagent,longer time is needed

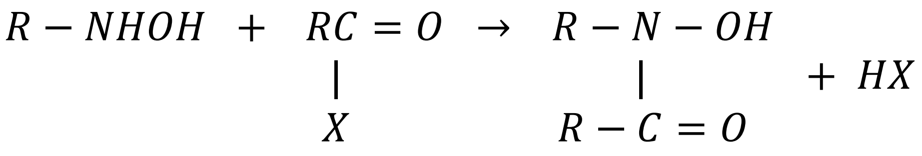
$R\ CO_2ET+NH_2OH+KOH \rightarrow RCONHOK+ETOH+H_2O$

$RCONHOK+HX \rightarrow RCONHOH+KX$

As astade above sodium methoxide can sometimes be used instead of potassium or sodium hydroxide. Duta (11) used the modification of synthesize nicotinohydroxamic acid and quinoldohydroxamic acid. a quite different technique was adopted by wise (12)in which pure acid was recovered by passing the methanol solution of potassium hydroxamate prepare by blatt throught the hydrogen form of cation exchanger (R-H) and removing the excess solvent under vacuum.

b) Acid chloride method:

Aliphatic and aromatic hydroxamic acdis are prepared by the reaction of N-aryl or alky hydroxylamine with an acid chloride.

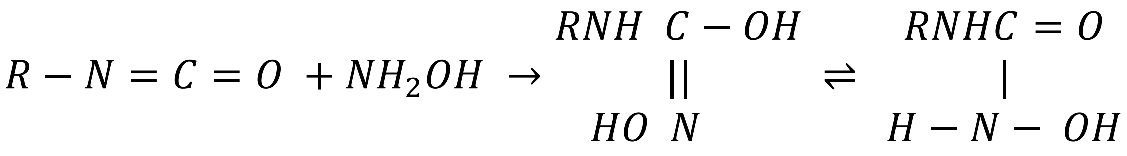


$$R-NHOH \;+\; \begin{array}{c} RC=O \\ | \\ X \end{array} \;\rightarrow\; \begin{array}{c} R-N-OH \\ | \\ R-C=O \end{array} \;+\; HX$$

c) Reaction between carboxylic acid carbodimide and hydroxylamine:

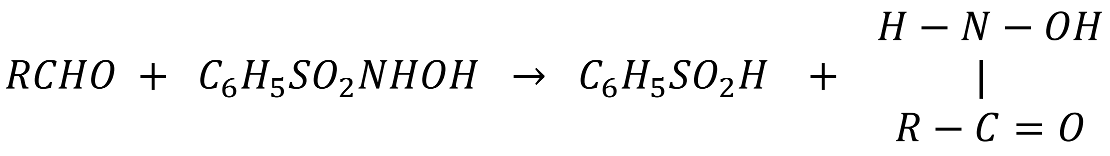
R—COOH +R'N=C=NR″+NH_2OH→RCONHOH+R'NHCONHR"

d) Reaction between isocyanate and hydroxylamine:



$$R-N=C=O \;+NH_2OH \;\rightarrow\; \begin{array}{c} RNH\ \ C-OH \\ || \\ HO\ \ N \end{array} \;\rightleftharpoons\; \begin{array}{c} RNHC=O \\ | \\ H-N-\ OH \end{array}$$

e) Reaction between aldehde and benzene sulphohydroxamic acid:



$$RCHO \;+\; C_6H_5SO_2NHOH \;\rightarrow\; C_6H_5SO_2H \;+\; \begin{array}{c} H-N-OH \\ | \\ R-C=O \end{array}$$

1.2.6 bioliogcal activity

Hydroxamic acids find in many applications in chemistry and biology they are among the most well studied compounds due to their significance in so many fields. Hydroxamic acids exhibit a wide variety of biological activities (Kehl 1982). This has resulted in investigations on their role in biology, besides urease inhibition.

Most of these studies have been directed at AHA. For instance, its interaction with the vanadate ion has been studied both experimentally and theoretically (Duarte et al. 1998; Santos et al. 2003). Vanadate is a phosphate analogous and can act as both an inhibitor of phosphate-metabolizing enzymes as well as an activator. It was found in these studies that AHA plays a role in the V(IV)/V(V) redox reaction.

Hydroxamic acids have also been investigated as siderophores (Santos et al. 1998; Edwardset al. 2005; Domagal-Goldman et al.2009). In this connection, experimental and DFT studies have been performed (Edwards et al. 2005;Domagal-Goldman et al. 2009) on complexes of Fe(III) with desferrioxamine B (DFO-B), the most extensively studied siderophore with respect to mineral dissolution.

DFO-B is a linear trihydroxamic acid composed of 1,5-diaminopentane and succinic acid residues.

Besides inhibition of urease, hydroxamic acids also inhibit a large number of other enzymes. Quantitative Structure Activity Relationship (QSAR) studies, MD, quantum mechanical, and docking studies directed toward the development of hydroxamic acid inhibitors for histone deacetylases (HDACs) (Dallavalle et al.

2009; Guo et al. 2005; Ragno et al. 2008), lipoxygenase (Hadjipavlou-Litina and Pontiki 2002), peptide deformylase (PDF) (Wang et al. 2006, 2008), MMPs (Hu and Shelver 2003; Kumar and Gupta 2003; Tuccinardi et al. 2006), and collagenase (Kumar and Gupta 2003) have been reported(4).

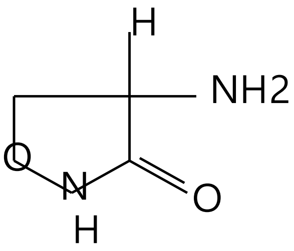
Hydroxamic acids are also use in extractive metallurgy inhibitors for copper corrosion, Anti fungal agent, pharmaceuticals food additives and in nuclear fuel processing.

One of the charactcristics of hydroxamic acid is their ability to form stable complexes with transition metal ions which form the basis of their usefulness as analytical reagen.Under iron deficient conditions micro organism called siderophores. Some naturally occurring hydroxamic acids serve as iron (III) specific chelators, they are involved in microbial iron transport, their specific function is to solublize iron from the environmentand transport it to the cell.

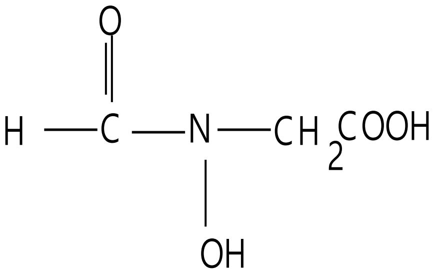
The specificity siderophores for chelating iron (III), among the physiologically important metal ions and their high stability constants, has led to the investigation of their use in the treatment of iron overload in humans (23).

One of the important applications in biological activities is the attempt to synthesize a hydroxamic acid analogue of aspirin.

Much of hydroxamic acid biological activity seems to be related to their ability to chelate iron specifically. Notably among these are the antibiotic cycloserine (I). The antitumor antibiotic hadacindin (ii) and heteroaromatic antibiotic aspergillie acid (iii)

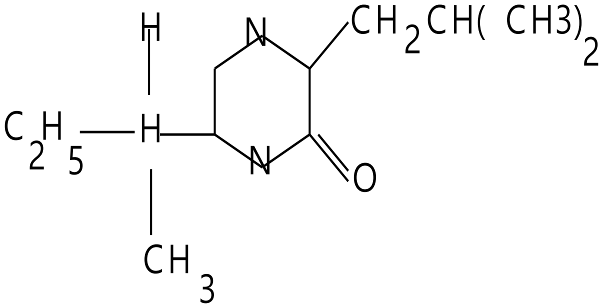


(i)



$H-C(=O)-N(OH)-CH_2COOH$

(ii)



(iii)

A series of o-, m- and p-alkoxybenzohydroxamic acids were found to be highly effective against pathogenic fungi.

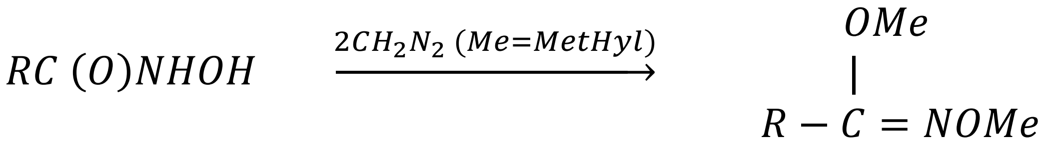
Aseries of terephthalohydroxamic acid and other dicarbhydroxamic acid have been investigated as anti- malarial (24).

1.2.7 Reactions of hydroxamic acaids

1.2.7.1 Hydrolysis

Hydrolysis of hydroxamic acid to carboxylic acid and hydroxylamine proceeds readily under both acidic and alkaline condition. At moderate acidities(19)(0.1-0.6M) the rate is usually proportional to the acid concentration, but then passes throught a maximum at higher acidities equivalent to complete protonation of the substrateless is both first and second order dependence on hydroxyl ion concentration.

1.2.7.2 nucleophilic reactions



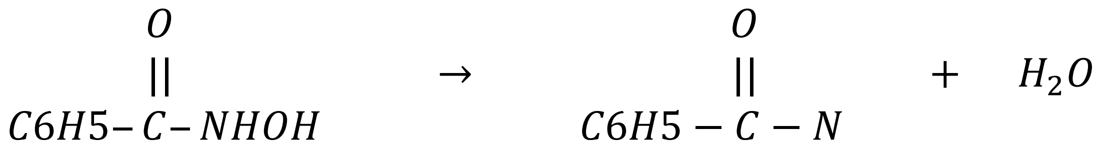
$$RC\ (O)NHOH \xrightarrow{2CH_2N_2\ (Me=MetHyl)} R-\overset{\overset{OMe}{|}}{C}=NOMe$$

More attention has been given to alkylation under basic conditions where the hydroxamate anicons are the reactive entity. Acylation reaction of hydroxamic acid with acid halides or anhydrides produce mixedanhydrides. More reactive acid halids such as sulfonyl or phosphoryl halides include an almost halides spontaneous lossen rearrangement (20).

1.2.7.3 Laossen rearrangement (21)

In its interpretion,occurs as a result of the thermal decomposition of hydroxamic acidsor their derivatives. As a sequence, a group attached to carbon originally foumd joined to nitrogen in the final product.

The reation mechanism involves (N-O) bind fission with synchronous migration of alkyl or aryl group involved, from the carbonyl carbon atom to nitrogen. The isocyanate then undergoes hydrolysis to aniline and carbon dioxide.



$$\overset{\overset{O}{||}}{C6H5-C-NHOH} \rightarrow \overset{\overset{O}{||}}{C6H5-C-N} + H_2O$$

C_6H_5–N=C=O + H_2O → $C_6H_5NH_2$ + CO_2

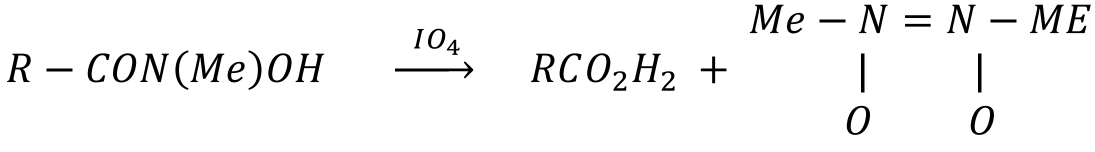
According to this mechanism, a depletion of electrons around the nitrogen atom occurred first, necessitating the migration of the alkyl or aryl gromp with its pair of electronsfrom the adjacent carbon atom.

1.2.7.4 Oxidation and reduction (22)

The hydroxamic acid bond may be made to suffer both oxidation and reduction. The oxidation of hydroxamic acid via their radical anion, R-CO-N-O gives R-CO-NH-O-OR. diacylhydroxylamine in high yields. It is suggested that an unstable diamer of (CR-CO-N-O), gives by intramolccular NH-CO-COR.

Oxidation of unsubstituted hydroxamic acid to amides can be affected by caro's acid or hydrogen peroxide.Other oxidant such as periodate or bromine in presence of a secondary amine give tertiary amide via an intermediate nitroso compound.

N–methyl substituted hydroxamic acids underg C (O)-N, bond fission to carboxylic acids and nitro methane dimer when treated with periodate



$$R-CON(Me)OH \xrightarrow{IO_4} RCO_2H_2 + \underset{\underset{O}{|}}{Me-N}=\underset{\underset{O}{|}}{N-ME}$$

Reduction of hydroxamic acid or their O- or N-alkyl derivatives to amides can be accomplished both by hydrogenation over raney nickel or sodium analgum.

$$R-CO-N-R'-OR'' \xrightarrow{H_{2,Raney\ Ni}} RCONHR'$$

1.2.8 Analytical applications of hydroxamic acids

1.2.8.1 Qualitative organic analysis (26)

Since esters are hydroxlaminolysed,even partial conversion is easily detected by means of hydroxamic acid/ferric chloride pink coloration. This reaction serves as an excellent qualitative test for many organic esters. Alcohols, aldehydes, ethers, carboxylic acids,sulfonic acids,oximes, nitro-compounds, amides and cyanates can be detected on the same bases with slight modifications.

1.2.8.2 Gravimetric methods

Most of the common hydroxamie acid has been investigated as precipitating agents formetal ions (27) The formation of precipitates issomewhat pH sensitive.

However the pH range of complete precipitation is usually broad enough toprovide convenient application in most cases, gravimetric determination is possible even in presence of other ions.

shome (28) used N-benzoylphenylhdroxamic acid to determine Cu, Fe and Al.

The N-substituted hydroxamic acid have been the most popular for gravimetric application. Tin may be advantageously determined in brass using N- benzoylphenyihydroxamic acid. The precipitate,$Sn(c_{13}H_{11}O_2N)_2Cl_2$ is obtained from solutions containing 1-8% concentrated hydrochloric acid.

Ellesfen(29) investigated the usefulness of N-benzoylhydrocamic acid as insitu generation reagent for homogenous precipitation of Cu (II). This was done by adding buffer solution at pH 4.5(acetic acid/ sodium acetate) containing 1.25 mg Cu to an ethanolic solution of N-benzoylphenihydroxylannine acetate and heating to near boiling.

1.2.8.3 Colorimetric applications of hydroxamic acids

Most colorimetric applications of hydroxamic acid deal with those metals which exist as anions in dilute solutions. Usually colors areintensified by extraction into immiscible solvents.

Ferric iron(30) with hydroxamic acids arise to strongly red-colored complexes of which the water soluble ferric acetohydroxanate is obtained as red crystals by the action of ferric chloride in acetonc on acetohydroxamic acid in ethyl alcohol.

Hydroxamic Acid from both naturally occurrine and synthetic souces have strong affinity for Fe (III) and large variety of synthetic hydroxamic acids have been used for extractive-spectrophotometric determinations.

More recently some strongly chelating hydroxamic acids have been described.The complex species formed with copper (II) in aqueous solution arc examined spectrophotometry so that accurate determination of the species can be obtained.

The colorimetric reaction of vanadium with benzohydroxamic acid provides one of the most useful reactions. (31)

Shome (32) obtained a red precipitate on N-benzoylphenylhydroxamic acid with vanadate, the precipitate is soluble in several organic solvents.

Das Gupta and singh (33) noted several colors at various pH values of vanadium with benzohydroxamic acid. He utilized aqueous methanol medium to determine as little as 0.01mg/ml of vanadium.

The reagent is more basic than benzoylphenylhydroxamic acid and forms stronger complex with the metal ion. The complex is more soluble in common organic solvents. It has also favorable distribution in chloroform-water mixture.

1.2.8.4 Titrimmetric and Paper Chromatographic Applications (34)

Most of hydroxamic acids can be titrated against alkalis is in non-aqueous media with phenophthalien as an indicator; however no sharp end-point is obtained. For titrating weak acids,the titrant must be as basic as possible and soluble in organic solvent. Potassium methoxide in 1: 10 methanol/benzerne ratio is highly basic and gives satisfactory end-point in the titration of hydroxamic acids. The solvent dissolving the weak acid should be as protophilie as possible. Both dimethylform-amide and pyridine are sufficiently protophilic and are good solvents for hydroxamic acids.

p-substituted hydroxamic acids were titrated visually in non-aqueous with 0.1 M tetrabutylammonium hydroxide with o nitroanaline as indicator.When visual media titrations were not successful, potentiometric titration were carried out using platinum electrode.

Non-aqueous visual titrations of a wide variety of N-arylhydroxamic acids have been described using cinchophen (2-phenylcinchoninic acid) as a primary standard The titrations were performed in dimethylformamide and pyridine media using azo violet as anindicator.

The color producing character of N-benzoyl-phenylhydroxamic acid asa chelating agent finds application as an indicator, in acetone, ethanol or chloroform solutions for more precise extractive end-point detectionin complexmetric titrations. The Fe (III) complex is also used as metallochromic indicator for EDTA titration of metal ions.

Papers impregnated with N-benzoylpenylhydroxamic acid have beenused for the study chromatographic behavior of thirty-five different metalion using developing liquids with acidities ranging from 6.0 M hydrochloric acid or 5.0 M perchloric acid to pH 3. Knowing the R_f values of the leading and trailing edges of the spots, a few separations have been achieved.

1.2.8.5 Hydroxamic acid chelating exchange resins (35)

Metal chelating resins are insoluble organic support which contains functional groups capable of exchanging metal ions from solution via complexation.

They possess the following advantages:-

a) Increased selectivity.

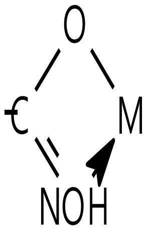
b) Elimination of the extraction step commonly associated hydroxamic acid chelates.

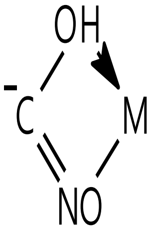
c) Separation of the cheiated ion on the column itself.

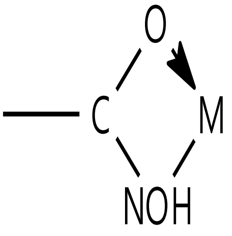
The chelating hydroxarnic acid resins have been found of great industrial benefits especially in metal recovery and hydrometallurgy.

1.2.9 Hydroxamic acid complexes

Hydroxamic acids act as bidentate ligands and since there exist two tautomeric forms of the acid, the structure of their metal complexes may be represented in three different ways as shown below:



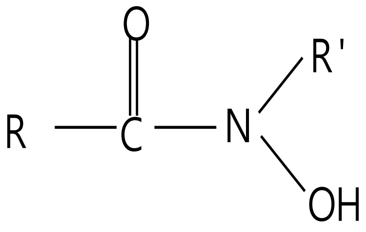


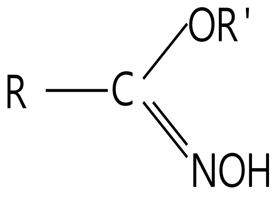


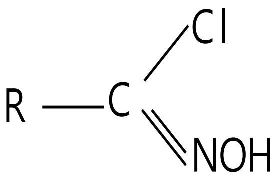
Other possible structures are excluded, as they would lead to the formation of unstablefour member rings involving the metal nitrogen linkage (36).

The complex formation is believed to take place by replacement of the hydroxyl amino hydrogen by the metal ion and ring closure through thecarbonyl oxygen.

The resultant complex is generally neutral and precipitates from aqucous solution, providing a method for gravimetric analysis or can be extracted by organic solvents. The most characteristic reaction is the intenseviolet color produced by ferric chloride. Since it is known that derivatives of the general formulas RCONHOR' or RC (OH) = NOR'do not give color reactions with ferric chloride, while compounds of the structures



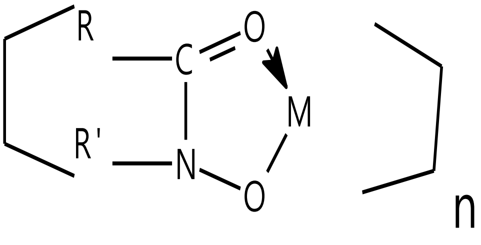




Do, it is apparent that the =NOH grouping is necessary for the formation of the compound.

The copper salts are green in color and very insoluble in water. Their principle use is in the isolation and purification of monohydroxamic acids.

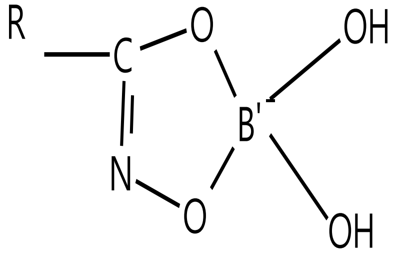
Complexes of monohydroxannic acid (37) with Fe (III), Co (II) and Cu (II) are shown to co-ordinate via oxygen atoms of the ligand.



(n=oxidation state of metal)

Spectral and magnetic properties of Fe (III), Co (II) and Ni (II) complex indicate octahedral co- ordination with the latter tow metal ions forming polymeric species Cu (II) forms square planar complexes.

Recently another type of complex, 1:1 stoichiometry between unsubstituted hydroxamic acids and borate (38) ion has been demonstrated with a probable structure below, formed by elimination of one molecule of water.



1.3 Cinnamic acid

Cinnamic acid is an organic compound with the formula $C_6H_5CHCHCO_2H$.Ii is a white crystalline compound that is slightly soluble in water and freelysoluble in many organic solvents, m p. 133°C .

Classified as an unsaturated carboxylic acid, it occurs naturally in a numberof plants. It exists as both a cis and trans isomer although the latter is more common (25).

1.4 methyl cinnamate

Is the methyl ester of cinnamic acid and is a white or transparent solid with a strong aromatic odor. It is found naturally in a variety of plants, and someculinary spices and some varieties of basil**.**

1.5 factors influencing the formation and stability of complexes

Many factors influence the formation and stability of coordination compounds.The main factors are the central metal and the ligand (39).

1.5.1The metal ion

The transition elements may be strictly defined as elements which havepartly filled d- or f - shells in atoms or in any of their commonly occurring oxidation states. All of these transition elements have certain general properties in common. They are strong, high-boiling, high-boiling metals, which conduct heat and electricity well.the exhibit variable valances and their icons and compounds are colored in one if not all oxidation states. They have strong tendency to form complexes.

The bond between a metal ion and ligand shows high dependency on the properties, such as the size of the metal atom, its ionic charge, atomicnumber, properties govern the relative tendencies for various metals to combine with a given donor atom .

a)Size and ionic charge:

For a given ligand, the strength of the metal-ligand bond depends on the size of the metal ion and the magnitude of the ionic charge.

Mollor and Maley have pointed out that the stability of complexes of bivalent metal ions, follow the order Pb> Cu >Ni Co> Zn> Cd> Fe> Mn,irrespective of the ligand involved. This sometimes called the natural order of stability.The convenient criterion for the estimation of the complexing ability of metal ion is charge-radius ratio,the greater ratio, the greater ability to form stable complex.

b) Electronic configuration and effective atomic number:

The tendency of an atom to attain the electronic configuration of the nearest inert gas is well known. An atom or an ion may accept or share ina sufficient number of electrons supplied by the donor atom to have theelectronic configuration,or the effective atomic number of the nearest inert gas.

It has been observed and recognized that the compound in which each atom can, by electron sharing with other atome, gather around itself a number of electrons equal to that found in a near rare gas, tends to be very stable.

1.5.2 The ligand

A number of factors related to the ligand, have a great influence on the formations and stability of complex compounds and chelations , The most important of which are:-

a) The nature of donor atom:

It has been observed that the greater the basic strength of a ligand, the greater the tendency of ligand to form stable complexes.

b) Effect of ring formation:

The cyclic compounds, in which a metal is joined to two or more dono group of a single molecule or ion, are particularly important since theyhave exceptionally high stability and, in many cases, have remarkable properties.

c) Chelate effect:

Thermodynamic data have confirmed that chelate complexes are more stable than their non-chelating analogous.Chelating agents or multidentate ligands in general,form stable complexes that monodentate ligands, this phenomenon is known as the"chelate effect", and it is explained interm of the favorable entropy for the chelation process.

d) Ring size (40):

Complexes with five and six- membered chelate ring are most stable chelate complexes with four-membered rines are rare while chelate ringswith more than six members are generally less stable. Of the former two, aliphatic chelate complexes with five-membered rings appear to be more stable owing to favorable entropy changes.

The six membered rings with conjugated double bonds or aromatic ligands are sometimes more stable compared to the five-membered rings, because perhaps of the release in strain by wider bond angles and resonance. The stability decreases with the decrease in the double bond orderof the chelate ring.

1.6 Spectral elucidation of complexes (41)

Many inorganic substances are transparent toward ultraviolet-visible radiation. However through the use of appropriate ligands many of the inorganics can be converted to complexes which will not be transparent in the ultraviolet-visible region. This feature of certain complexes allows the analytical chemist to analyze for traces of ions in a multitude of system.

Complex formation can be generally described as the tendency of metal ions and ligands to bond in a manner such that the coordination sphere of the particular ion is filled. By the use of specific ligand and metal ions, colored solutions are obtained, as in the equilibrium described by:

$$M^{n+} + mL^{-} \rightleftharpoons ML_{m}^{n-m}$$

Colorless colored

The absorption spectrum of a complex generally originates from three type of transitions:

(a)Excitation within the ligand:

Since most ligands are organic molecules, the discussion pertaining to the spectra of organic molecules will also apply in this section. Transitions such as $n \rightarrow \pi^*$, $n \rightarrow \sigma^*$, $\pi \rightarrow \pi^*$ and $\sigma \rightarrow \sigma^*$, can be observed in ultraviolet-visible region of the electromagnetic spectrum. Upon complexation, a shift in the wavelength of maximum absorption and molar absorptivity can be expected to occur. Although slight in most cases, these changes can be observed and are similar to alteration due to protonation of the ligand.

(b) Excitation of the metal ion:

When a metal ion binds to ligand, it can be expected that the degeneracy of the energylevel of the metal ion will be liffted and transition between these energy levels become possible.These transitions, which normally have molar absorptivity of the order of 1 to 100, are not used in quantitative analytical chemistry. These absorption bands can, however, still be used for structure elucidation.

(c) Charge transfer excitation:

A transition of this type may be described as the movement of an electron from the ligand to the metal or from the metal to ligand in the complex. Frequently, the intense color that a complex possesses is the result of a charge transfer transition. This intense color of the complex is of great value to the analytical chemist for trace analysis.

Charge transfer transition are very intense (€= 10^4 to 10^5) and are found in the ultraviolet and visible region. The position of the wavelength of maximum absorption is determined by the ease at which the electron can undergo transition. In other words, the energy of absorption is a function of how ease the ligand and metal ion are oxidized or reduced.

1.7 Methods of stoichiometric determination (42)

1.7.1 Mole ratio method

In this method the concentration of metal ion is held fixed, while the concentration of the reagent (ligand) increased stepwise.Once the graph of absorbance vs. moles of reagent added, the intersection of the extrapolated linear segments determines the ratio: moles of reagent / moles of metal.

1.7.2 Slope - ratio method

In this method two series of solutions are prepared. In the first series various amounts of metal ion are added to a large excess of the reagent, while in the second series different quantities of reagent are added to a large excess of metal ion. The absorbance of the solution in each series is measured and plotted vs. the concentration of the variable component. The combining ratio of the components in the complex is equal to the ratio of the slope of the two straight lines.

1.7.3 Continuous variation method (job's method)

The discovery of this method is attributed to Job who first applied it to complex formation; it is a simple and effective approach to the determination of chemical reaction stoichiometry.

In this method, cation and ligand solutions with identical analytical cocentrations are mixed in such a way that the total volume and the total moles of reactants in each mixture ic constant but the mole ratio of reactant / varies systematically (for example, 9:1, 8:2, 7:3, and so forth). The absorbance of each solution is then measured at a suitable wave lenght and corrected and corrected for any absorbance the mixture might exhibit if no reaction had occurred. The corrected absorbance is plotted against the volume fraction of one reactant, that is, V_M / (V_M+V_L), where V_M is the volume of cation solution and V_L is the volum of the ligand solution.

The resulting curve will show a maximum at the mole fraction corresbonding to that in the complex. When the curvature is pronounced and the maximum is not apparent, the apex may be obtained by drawing tangents.

Chapter two

Experimental and Results

2. Material and methods

2.1 Instruments used

UV/VIS. Spectrophotometer, Jenway, UK

Sp IR3000 spectrophotometer, Thermo Nicolet, USA

Balance ,BEL Engineering, Italian

Water bath

2.2 Chemicals

- Cinnamic acid GR 2042 Bombay -400002, india

1, 4-dioxan extra pure stabilized with 2,5 ppm of 2,6-di-tert-butyl-4-methyl phenol F-E-RO.S.A (La Jotam,86008016-Barcelona, SPAIN med in Eurpean Union

- Ferric chloride, loba chemie PVT.Ltd 107, wode house Road, Mumbai 400005.India
- Hydroxyl amine hydrochloride, central drud house (p) Lted (INDIA)
- Sulfuric acid,loba chemie PVT.Ltd 107, wode house Road, Mumbai 400005.India
- Hydroxyl amine hydrochloride, LOBA chemie, india
- Sodium hydroxide, central drud house (p) Lted (INDIA)
- Methanol (dried), [ALPHA Chemika medein, INDIA]
- Acitic acid [ALPHA Chemika medein, INDIA]

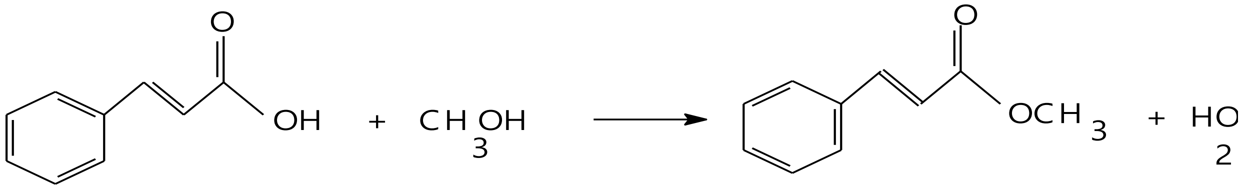
2.3 Apparutas

Beaker – conical flask – volumetric flask – pipette – glass rod – spatula – funnel – ice bath – reflex condenser – filter paper .

2.4 Preparation of cinnamohydroxamic acid

2.4.1 Preparation of Methyl cinnamate:

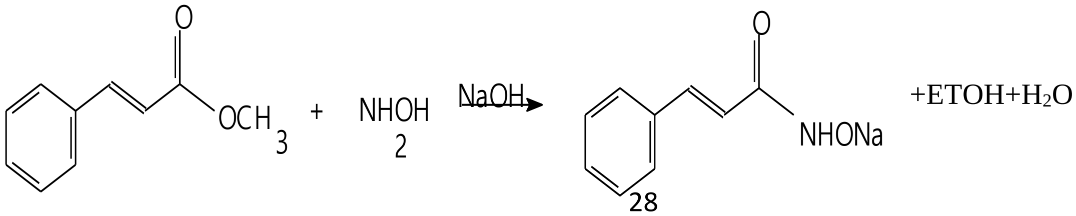
59.g (0.4 mol) of cinnamic acid, 128g (162 ml , 4mol) of absolute methanol were added to 6ml of concentrated sulphuric acid the mixture was refluxed for 5 hours and the excess methanol was removed, the residue was poured into about 500 ml of water and 300ml of ether was added on a rotary evaporator; the residue was crystalised on cooling, yielding 50g (77%) of methl cinnamatte ,m.p(33-34C°).To obtain a pure specimen, m.p 36C° the sample was dissolve d in minimum of methanol maintained at 30C°d the in water bath, the water was added slowly from a dropping pipette with stirring until the oily ester just begins to separate. The solution was transfer rapidly to an ice bath with a glass rod, scratching the side of the vessel vigorously with glass rod.The result colorless needles was filtered rapidly.

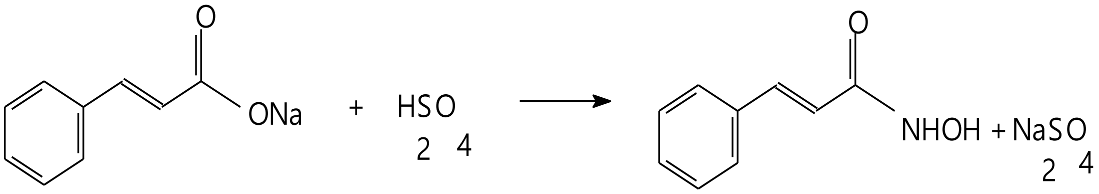


2.4.2 Preparation of cinnamohydroxamic acid

(14g, 0.2 mol) of hydroxylamine were added to 200 cm^3 of 12% solution caustic soda and cooled to room temperature. Then (16.219 g, 0.1 mol) of methyl cinnamate were added in small portions with vigorous shaking after each addition to insure complete dissolution. The mixture was allowed to stand over a period of two days until the solution become yellow, and then acidified with 2M sulfuric acid. The white precipitate filtered. Washed and recrystalized from water containing little acetic acid.

Yield (10 g, 61.28%).





Characterization of cinnamohydroxamic acid:

IR Spectrum; the spectra showing absorption band: 1664.57cm^{-1}(OH), 3260.37 cm^{-1} (NH), 3041.74(OH, n-H bond), 1351.1cm^{-1} (N-O), 1601.9, 1443 cm^{-1}(aromatic ring).

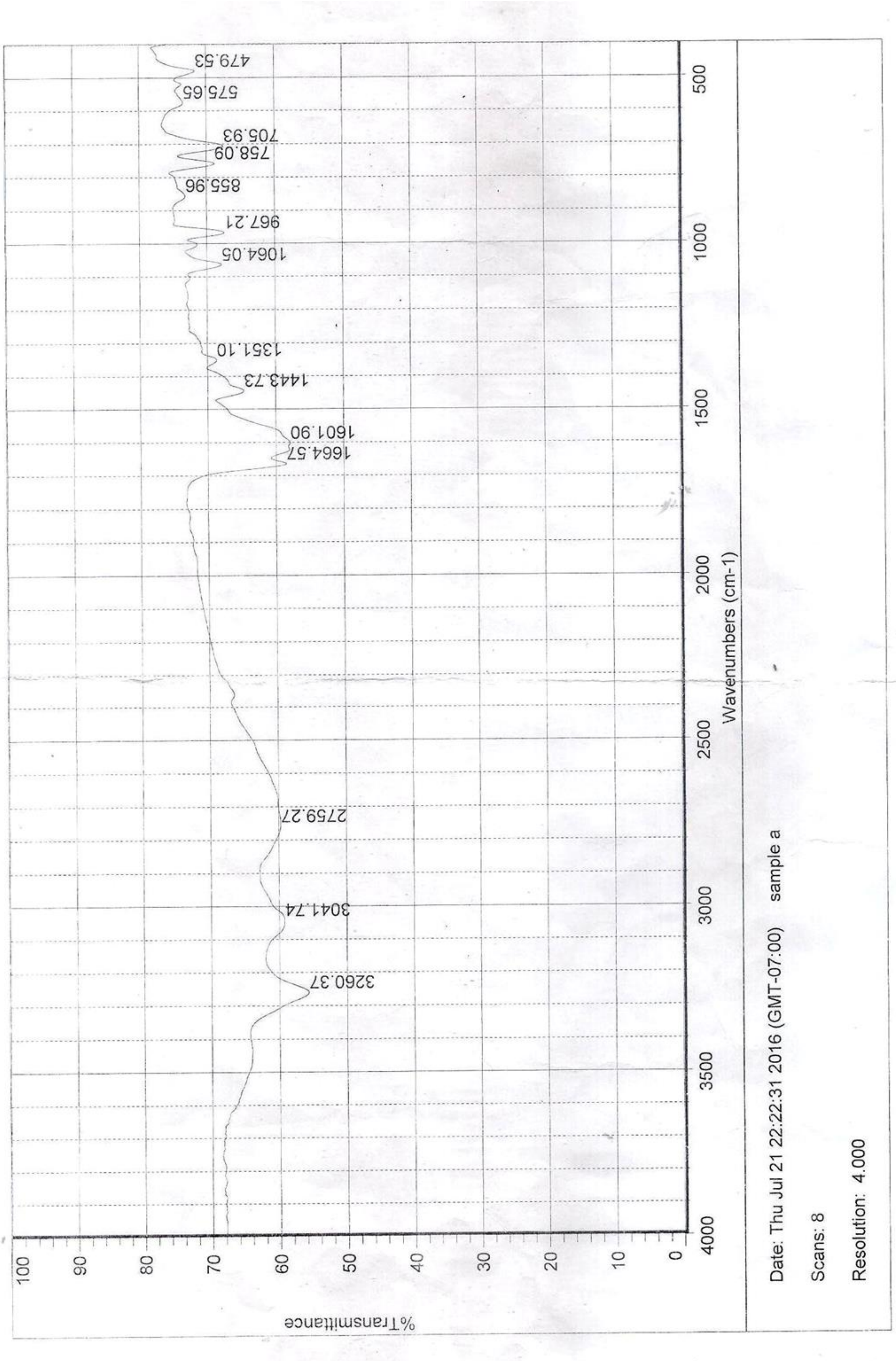


Fig 1: IR Spectrophotometer curve of cinnamohydroxamic acid

2.5 Spectrophotometric evaluation of complexes of cinnamohydroxamic acid with Fe (III)

2.5.1 Preparation of stock solution of cinnamohydroxamic acid

0.012 M of cinnamohydroxamic acid was prepared by wighting 0.158g, dissolved in 5 ml 1, 4-dioxan extra pure stabilized with 2,5 ppm, transferred to100 cm^3 volumetric flask , the volume was completed to the mark with distilled water.

2.5.2Preparation of stock solution for metal cations

Solution of Fe (III) were prepared by wighting 0.03g $FeSO_4$ accuratly dissolved in distilled water transferred into 100cm^3 volumtric flask and completed up to the mark distilled water.

2.5.3Preparation of standard solution of complex

2-4-6-8-10-12 ppm standard solution of metal stock solution into 10 cm^3 volumetric flask, then 1 cm^3 of 0.01 cinnamohydroxamic acid was added, the volum was completed to the mark with distilled water.

The analytical standerd curves determined spectroophotometricaly for these complex at their specific λ_{max} and the results are shown.

2.5.4 Preparationo of blank solution

1 cm^3 of 0.01 M of cinnamohydroxamic acid was takan, transferred to 10cm^3 volumetric flask and completed up to the mark with distelled water.

2.5.5 λ_{max} determination

1cm^3 of 0.01 M cinnamohydroxamic acid was taken into 10cm^3 volumetric flask and then 1cm^3 of $FeCl_3$ was added and completed up to mark with distilled water and λ_{max} occurred at 275 nm

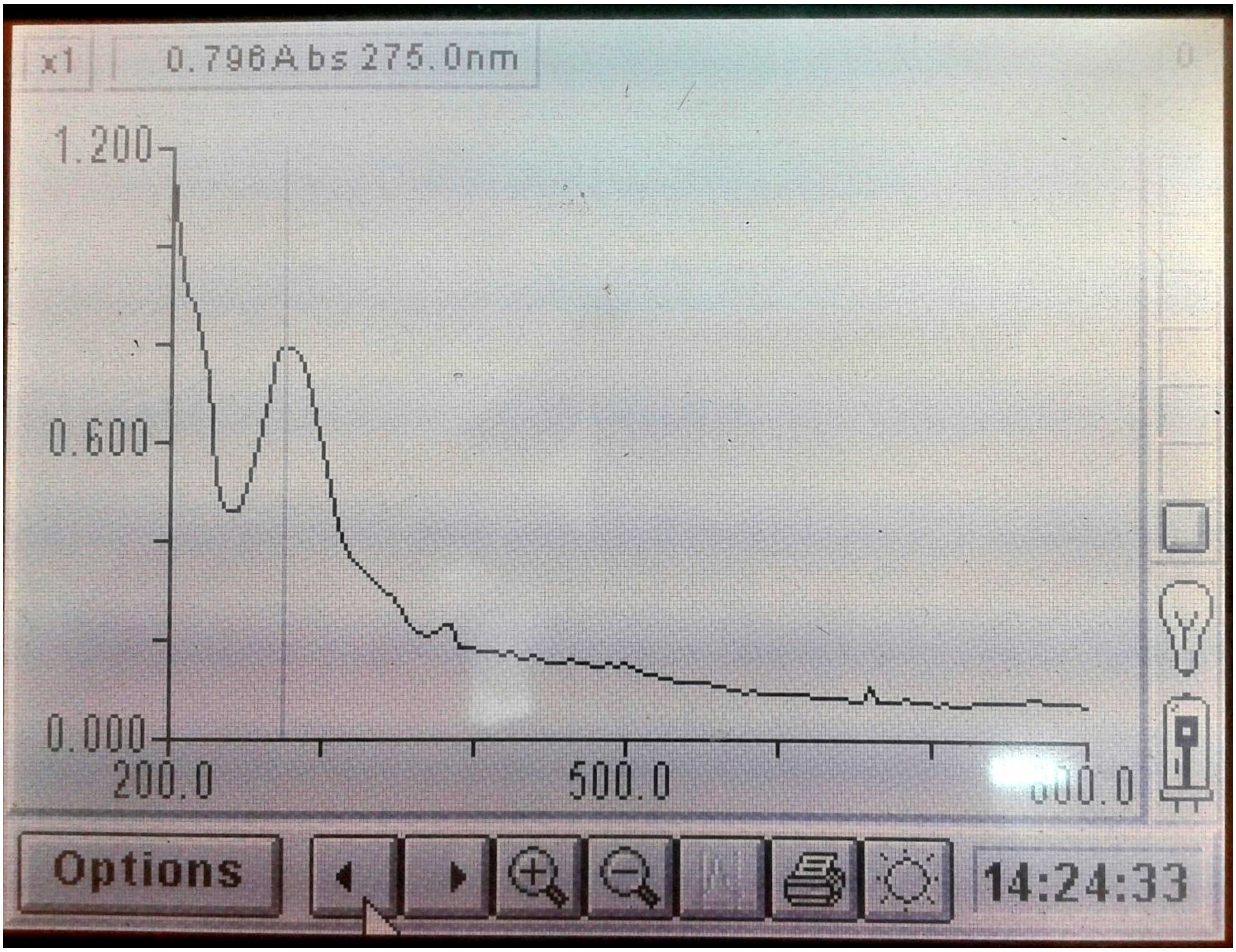


Fig 2 : λ_{max} determination curve

Concentration ppm	Absorbency nm
2	0.094
4	0.171
6	0.303
8	0.439
10	0.575
12	0.691

Table 3: concentration of iron vs. absorbance

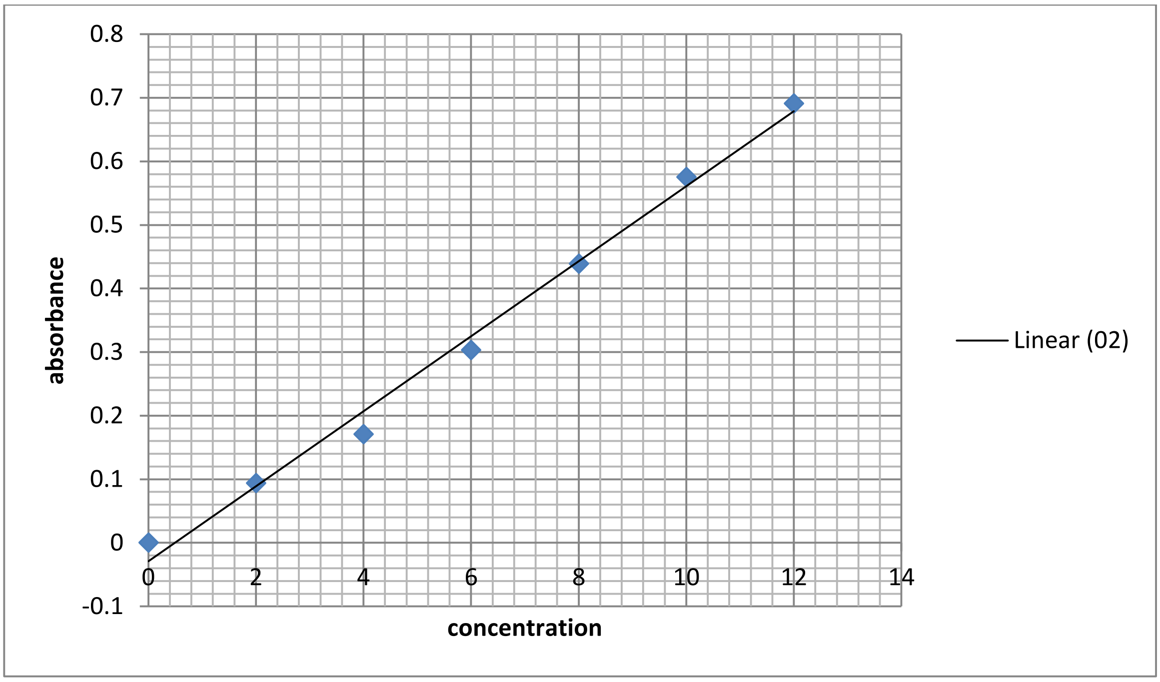


Fig 3 : calibration curve of iron cinnamohydroxamic complex

Chapter three

References and conclusion

Chapter three

Discussion and conclusion

Cinnamohydroxamic acid was smoothly synthesized through the esterfication route.

It is recrystalized from water containing drops of acetic acid. It was characterized by spectroscopic measurements to show the literature values (infra red).

Iron cinnamichydroxamate (purple red), complex was prepared in aqueous acidic media.

UV - Visible spectroscopic measurements of the ligand with iron complex at different concentrations show strict linearity.this confirms that the ligand and the metal cations are complexed uniformly.

Suggestion for further work

Application of the acid for spectroptometric determination of these metal ions in real sample.

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