

NUCLEAR MAGNETIC RESONANCE AND INFRA RED SPECTROSCOPIC STUDIES OF SOME METAL COMPLEXES OF MALEOYL-p-AMINO BENZOIC ACID

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ABSTRACT

Metal complexes of p-Aminobenzoic acid derivative of maleic anhydride were investigated. Thus, N-(4-carboxy-phenyl) maleimide and its sodium salt (sodium N-maleoylbenzoate) were prepared. The sodium salt was complexed with some transition metals (Co^{2+} , Ni^{2+} , Cd^{2+} , Zn^{2+} and Cu^{2+}).

Complexes separated as precipitates from the reaction mixtures and were characterized by spectroscopic studies.

Key words: Maleimide, p-aminobenzoic acid, metal complexes, ligand, maleic anhydride, transition metals.

INTRODUCTION

Several protecting groups have been used to hinder the participation of the amino group ($\sim\text{NH}_2$) of amino-acids from coordination with metal centres (Roge *et al.*, 1983; Sandhu *et al.*, 1985, and Eke, 1987). Protection of the nitrogen atom ensures that coordination chemistry focuses on the carboxylate group only. Prominent amongst the protecting groups are the anhydrides (phthaloyl, succinoyl and maleoyl). In particular, the maleoyl derivatives (maleimides) of amino acids are useful reactive mdeties in biological chemistry (Corrie and Munasinghe, 2003). They are active in the site-selective conjugation of fluorophores and other species to proteins by reaction with cysteine side chains (Means and Feeney, 1971, and Brune *et al.*, 1998).

Maleoylglycinates, especially the organotin (IV) derivatives assume bactericides and fungicidal activities (Ashfaq *et al.*, 2004). Their metal complexes reveal a variety of features and rich diversity of structural motifs. In water purification, maleimide compounds are useful chelants for the removal of several transition metals from water (Camelia *et al.*, 2006).

For us, such diversity in chemistry and application is of interest. In the present study, we have used infrared and nuclear magnetic resonance spectroscopies to study the structural features of metal complexes of maleoyl-p-aminobenzoic acid.

EXPERIMENTAL

Reagents and Materials

Maleic and acetic anhydride used are Aldrich products, The p-aminobenzoic acid was obtained from E. Merck, Darmstadt Germany and were used without further purification.

Solvents (Fluka) were dried and re-distilled before use.

Transition metal compounds (purchased from Chimopar, Romania) were used as received.

Spectroscopic Studies

The IR absorption spectra were recorded on a NICOLET AVATAR FT-IR 330 Spectrophotometer using KBr pellets at the Central Science Laboratory Ladoke Akintola University of Technology Ogbomosho, Oyo State Nigeria.

The ^1H -NMR and ^{13}C -NMR spectra were obtained from D_2O solutions of the sodium salt of the ligand using a mercury 200BB(200 MHz) spectrometer at the Central Science Laboratory Obafemi Awolowo University Ile-Ife Osun State Nigeria.

Physical Measurements

(i) The melting points were determined in open capillaries using Galenkamp electrothermal melting point apparatus (Digital).

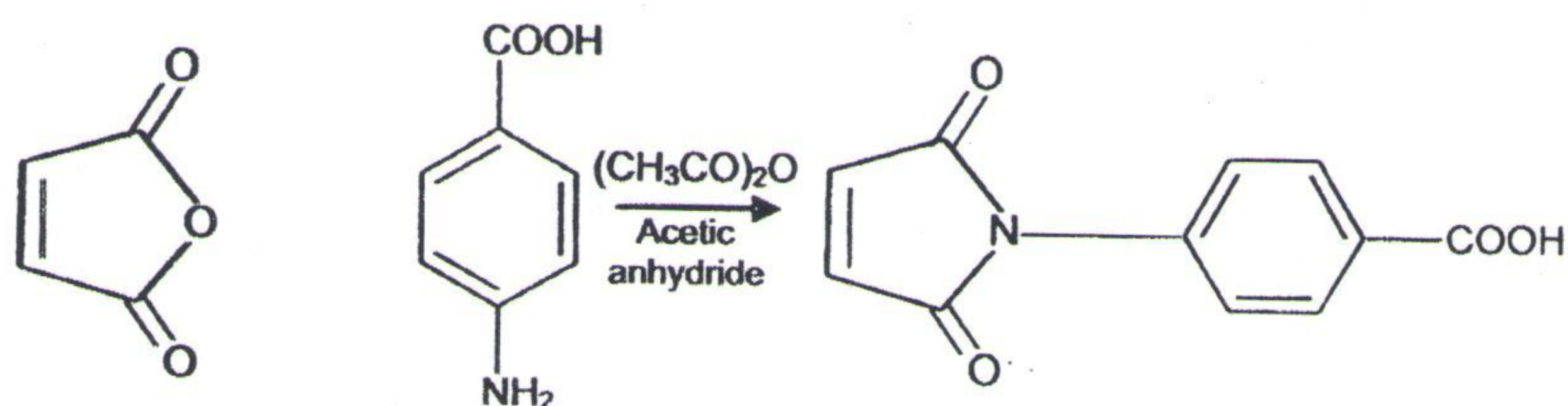
(ii) The solubility of the complexing agent (the ligand) SSCPMI (sodium salt of N-(4-carboxy-phenyl) maleimide and the metal complexes were determined in various solvents including ethanol, methanol, chloroform, dichloromethane and tetrahydrofuran.

Synthesis of the maleimide compound; N-(4-caboxy-phenyl)-maleimide

N-(4-carboxy-phenyl)- maleimide (CPMI, equation 1) was obtained by the reaction of maleic anhydride with p-aminobenzoic acid according to a reported procedure (www.Freepatentsonline.com, June 25 2008).

A mixture of maleic anhydride (1.43 g, 0.0146 mol) and *p*-aminobenzoic acid (2.0 g, 0.0146 mol) in glacial acetic acid (6 mL) were heated at 120°C for 2 h.

Acetic anhydride (2 mL) was added to the solution and further heated at reflux for 5 h. The reaction mixture was cooled and poured into cold water. The solid that separated was filtered, washed with water, dried and recrystallized from methanol. The product was yellowish-brown in colour, mp. 270°C (Lit. > 240°C), yield = 2.116 g (0.0097512 mol) 66.83 % (Lit. 70%). (Equation 1)



Maleic anhydride *p*-aminobenzoic acid N - (4-Carboxy Phenyl)
- Maleimide (CPMI)

Synthesis of the sodium salt of N(4-carboxy-phenyl) maleimide, SSCPMI (Sodium N-maleoylbenzote).

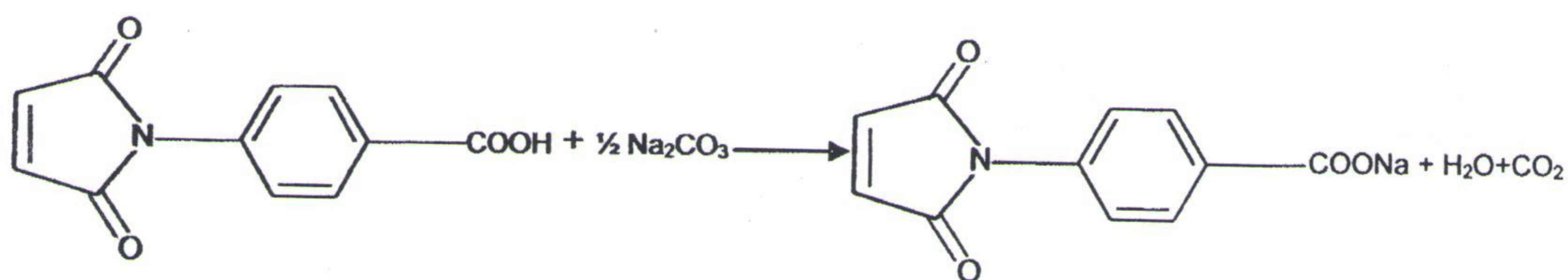
The sodium salt of N-(4-carboxy-phenyl)-maleimide was prepared according to a reported method (Eke, 1987).

A solution of sodium carbonate (18.656 g, 176 mmol), dissolved in 40 mL distilled water was added to a solution of 18.06 g (83.226 mmol) of CPMI in 20 mL distilled water.

The solution was left to stand at room temperature for about 1 h. The solution was tested for neutrality with indicator paper, and evaporated slowly to dryness on a hot plate.

The precipitate obtained was recrystallised from boiling water and the solid was collected under suction on a buchner funnel.

The crystals obtained were dried first in an air stream and then in a vacuum oven at 40°C and then stored in a dessicator over CaCl_2 . The product was yellow in colour, m.pt > 300°C (Lit. > 300°C) (Equation 2)



N-(4-Carboxy-Phenyl) – Maleimide (CPMI)

Sodium N-maleoylbenzoate (sodium salt of the CPMI)

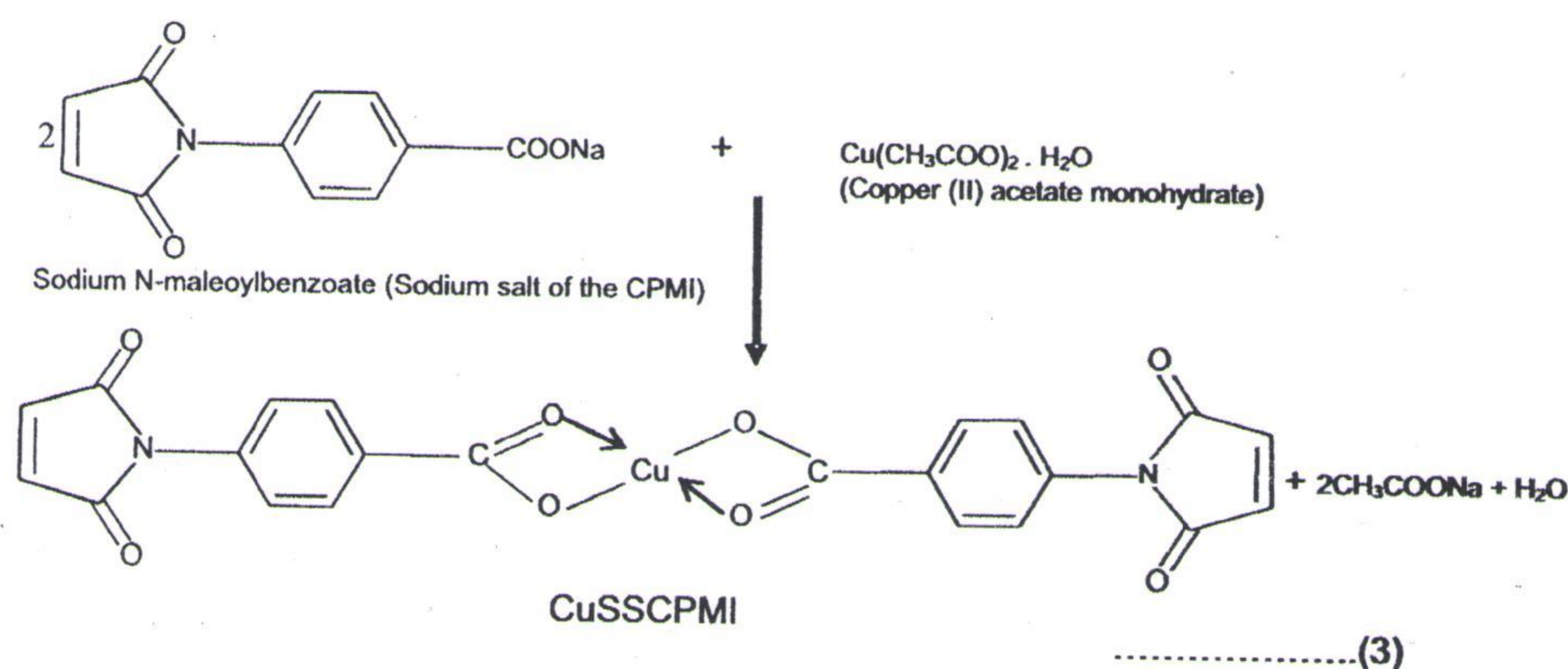
The preparation of metal complexes of the sodium salt of N-(4-carboxy-phenyl) maleimide (SSCPMI)

In a typical procedure, a solution of 1.0 g (2.020 mmol) Copper (II) acetate monohydrate ($\text{Cu}(\text{CH}_3\text{COO})_2 \cdot \text{H}_2\text{O}$) in 30 mL methanol, was added to a solution of 0.71 g (2.971 mmol) SSCPMI in 70 mL methanol in a quick fit round-bottom flask and refluxed for 3 h.

The reaction mixture was cooled, filtered and the precipitate was washed with water, air-dried and stored in a dessicator over CaCl_2 . The same procedure was used for the synthesis of the other transition metal complexes.

(Equation 3)

The physical properties of the complexes are summarized in Table 1.



RESULTS AND DISCUSSION

The metal complexes

The metal complexes of the ligand (sodium salt of N-(4-carboxy-phenyl)-maleimide (SSCPMI)) were prepared by reacting the ligand with some transition metal compounds (acetate, chloride, bromide, and nitrate) in solution at reflux. The complexes precipitated and were insoluble in the reaction medium. Some physical properties and percentage yields of the complexes are presented in Table 1.

Table 1. Some Physical Properties Of The Transition Metal Complexes

Sample code	Ligand	Metal	Yield (%)	Colour	Melting point (°C)
CuSSCPMI	SSCPMI	Cu	88.31	Light blue powder	>300°C
NiSSCPMI	SSCPMI	Ni	58.60	Green powder	>300°C
CoSSCPMI	SSCPMI	Co	87.80	Brown powder	>300°C
ZnSSCPMI	SSCPMI	Zn	69.98	White (cream) powder	>300°C
CdSSCPMI	SSCPMI	Cd	19.20	White powder	>300°C

Transition metals give highly coloured compounds which is evident in these metal complexes. The melting points of the ligand (SSCPMI) sodium salt of N-(4-carboxy-phenyl)-maleimide and the metal complexes do not melt even at 300°C. There was also no discernible change in colour of the compounds at this temperature. We therefore assume that their melting points may be beyond 300°C.

Some of the metal complexes isolated were soluble in some organic solvents as shown in Table 2.

Table 2. The solubilities of the ligand (SSCPMI) and transition metal complexes					
Sample	CHCl ₃	CH ₃ OH	C ₂ H ₅ OH	CH ₂ Cl ₂	THF
SSCPMI	-	++	++	++	++
CuSSCPMI	+-	-	-	++	+-
NiSSCPMI	+-	-	-	++	-
CoSSCPMI	-	-	-	++	-
ZnSSCPMI	+-	-	-	++	+-
CdSSCPMI	+-	-	-	++	-

Key: - Insoluble; +- partially soluble; ++ soluble.

SPECTRAL STUDIES

Infrared Studies

The structural changes that took place when the ligand (SSCPMI) coordinated to the metal centres was revealed by the IR spectra of the transition metal complexes, where in all cases a new absorption band appears between 1650-1540 cm⁻¹ which was assigned to a carboxylate group(CO₂) formed as a result of the reaction (Camelia *et al.*, 2006).

The IR spectra of the transition metal complexes (Cu, Co, Ni, Zn, Cd) of SSCPMI prepared in this study present similar spectral characteristics. Their characteristics closely resemble those of copper of same ligand earlier prepared by Camelia *et al.*, (2006). The absorption band in the range of 3400-2900 cm^{-1} for the metal maleimides of this study reveal the presence of water Camelia *et al.*, (2006). The water may be in the crystal lattice or in the coordination sphere.

The absence of absorption band in the 3600 cm^{-1} region indicate the deprotonation of the $\sim\text{COOH}$ group (Scheimann, 1973) in all the metal maleimides.

In the investigation of novel bio-diorganotin (IV) esters of N-maleoylglycine by Ashfaq *et al.*, (2004), The infrared spectrum shows that the spectral of OH absorption of the ligand (N-maleoylglycine) disappeared in the spectra of the complexes. This is as a result of the deprotonation of the carboxylic acid upon formation of the sodium salt which reacted subsequently with the transition metal salt.

The Infrared spectrum of sodium salt of the ligand (437, 488, 603, 631 cm^{-1}) and that of the copper complex (497, 616, 689 cm^{-1}) differ a lot in the 690-400 cm^{-1} region. This is an indication, that each of the transition metals reacted with the ligand forming metal-ligand bonds in this region of the infrared spectrum.

NMR Studies

The ^1H NMR and ^{13}C NMR data and analyses of the ligand (sodium salt of N-(4-Carboxy-phenyl)-maleimide) are presented in Table 3. The NMR studies of the transition metal complexes could not be carried out because they were insufficiently soluble in any common solvent. Due to the poor solubility of the sodium salt of the ligand in common organic solvents, purification of the compound was difficult. Consequently, the quality of the NMR (^1H , ^{13}C) spectra is poor and contain impurities.

However, the major resonances are observable at 7.75-7.20 ppm as a multiplet. This signal is attributed to the aromatic protons. The vinyl proton is at 5.9 ppm as a doublet (Silverteiu and Webster, 1998). In the ^{13}C spectrum, these signals are seen at 112.5, 120.8, 124.7 and 131.1 ppm. The C=O, C=C, C-N and C-C group signals are at 175.1, 139.8, 57.3 and 41.4 ppm respectively

Table 3. ^1H and ^{13}C NMR(D_2O , TMS, ppm) Chemical Shifts for the Sodium Salt of (N-4-Carboxy-Phenyl)-Maleimide

^1H -NMR	7.75 7.20 (m, 4H, Ar-H), 5.9 (d, 2H, vinyl)
	112.5, 120.8, 124.7, 131.1 (Aromatic carbon).
^{13}C -NMR	175.1 (C=O), 139.8 (C=C), 57.3 (C-N), 41.4 (C C)

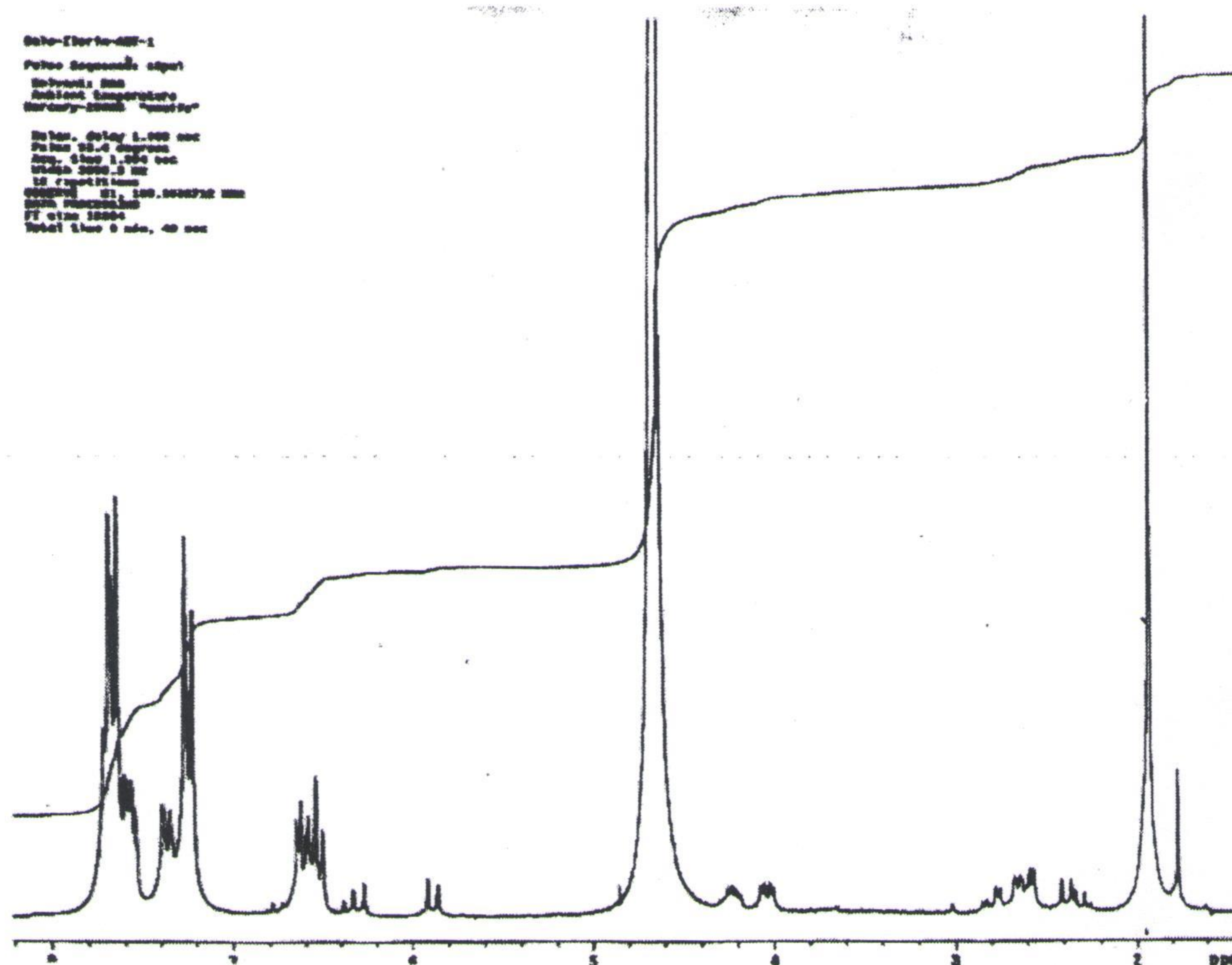


Fig. 3 ^1H -NMR Spectrum of Sodium N-maleoylbenzoate (Sodium Salt of CPMI)

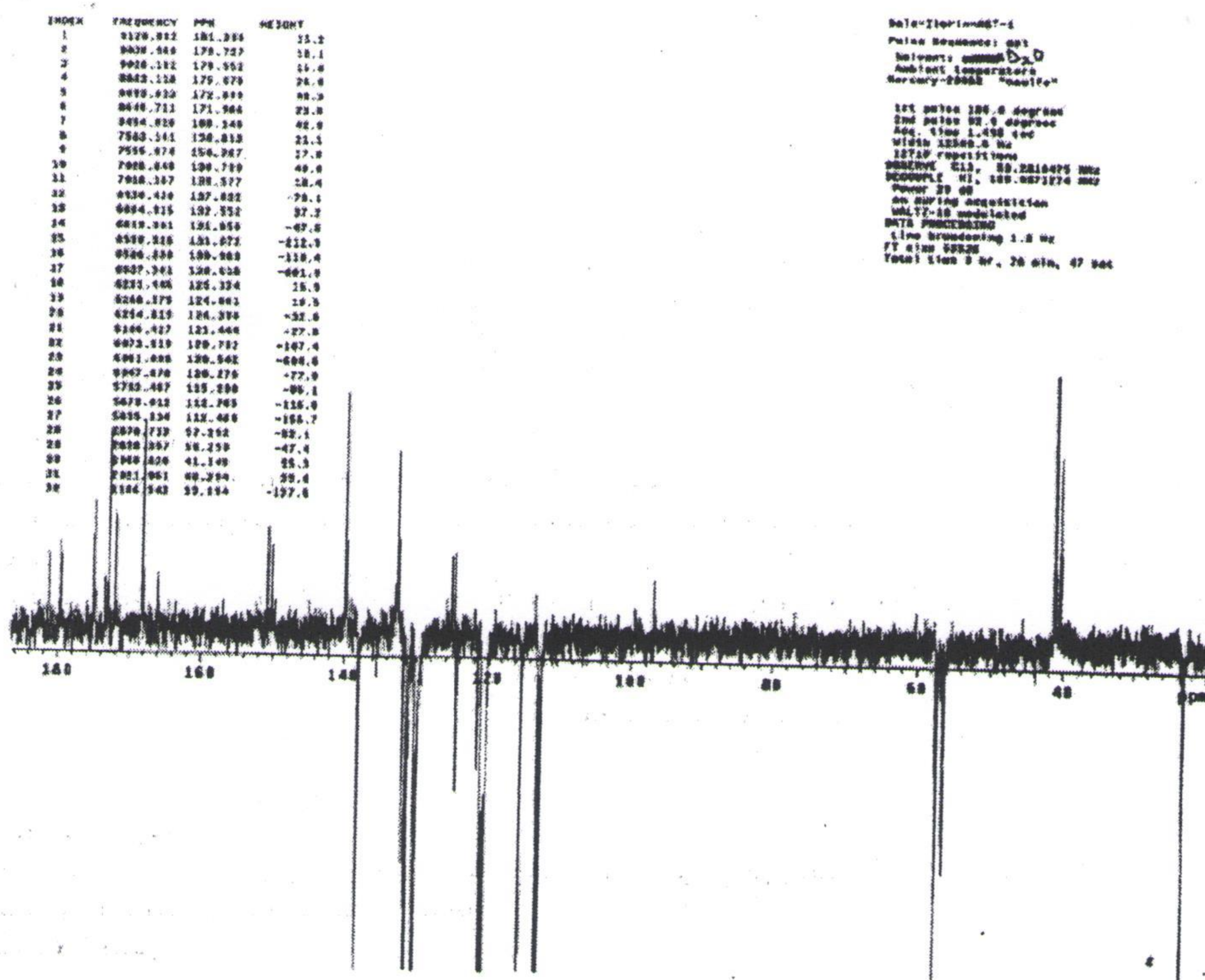
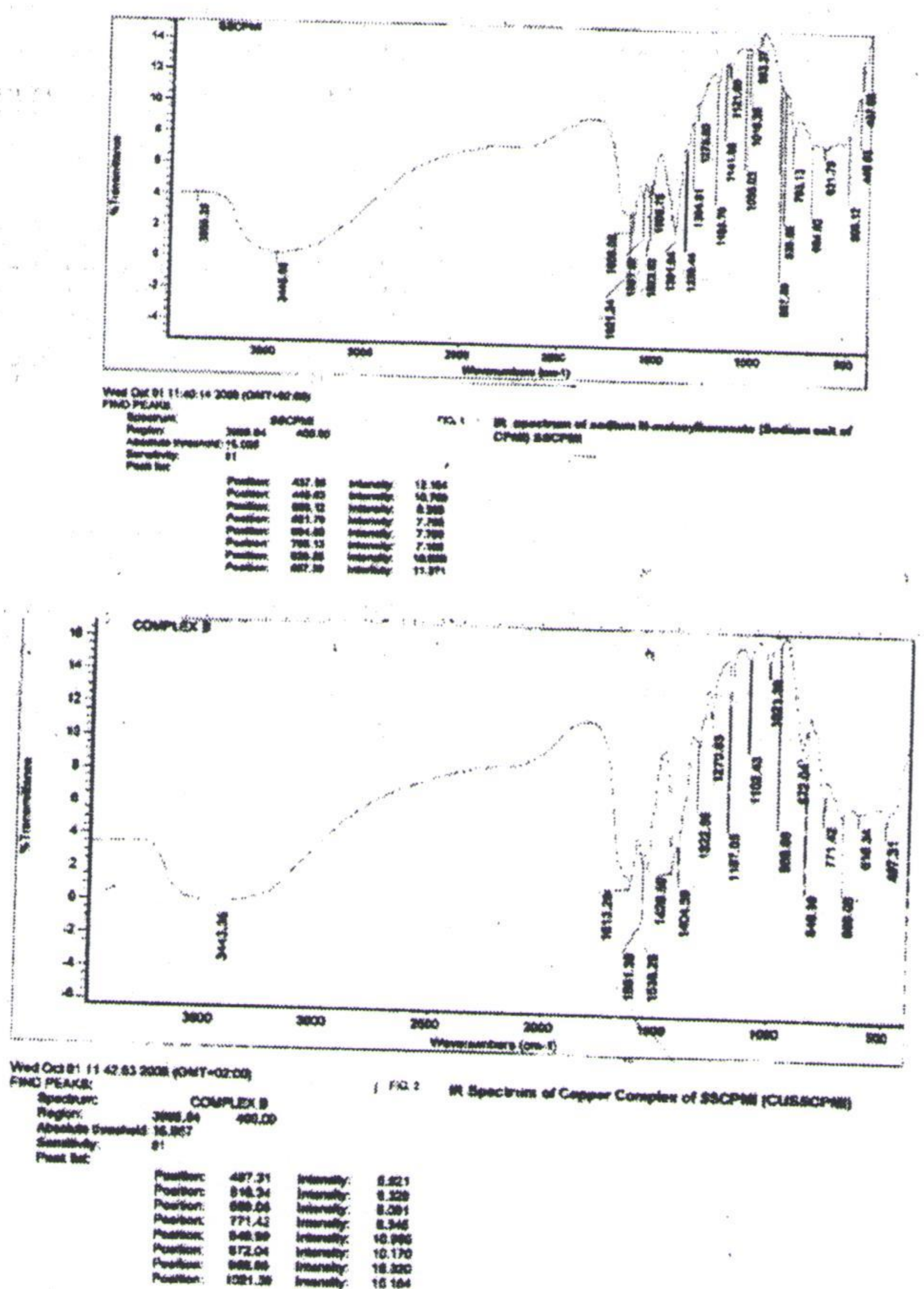


Fig. 3 ¹³C-NMR Spectrum of Sodium N-maleoylbenzoate (Sodium Salt of CPMI)



CONCLUSION

N-(4-carboxy-phenyl)-maleimide (CPMI), sodium salt of the CPMI (SSCPMI) sodium N-maleoylbenzoate were prepared with the sodium salt of the CPMI used as ligand for complexation with transition metals. The ligand (SSCPMI) and the metal complexes are solids having high melting points greater than 300°. Only the copper and zinc complexes were appreciably soluble in some common organic solvents, whereas those of cobalt, nickel and cadmium were only partially soluble or insoluble.

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